ERICACEOUS GROUND COVER ON CUTOVER SITES IN SOUTHWESTERN NOVA SCOTIA

by

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ABSTRACT

On recently logged lands occupied by black spruce, balsam fir, and red maple in southwestern Nova Scotia, there has been a marked increase in incidence and density of lambkill, blueberry, bracken, and bunchberry within three years after harvest. Other vegetation, including tree seedlings showed little increase but advance regeneration of conifers and coppice growth of red maple increased slightly. Lambkill and bracken appeared likely to dominate most sites while huckleberry was present in most locations and showed a modest increase. Bunchberry increased mainly on microsites not occupied by the lambkill-bracken-huckleberry-blueberry association. Density of lambkill increased more on open microsites than under a residual tree canopy, and more on sites already occupied by lambkill and bracken than on unvegetated sites. Lambkill increased slowly under dense slash piles and was favored by a light slash cover.

Lambkill and huckleberry, the two dominant ericaceous shrubs, were readily propagated on moist sand or peat from rhizome cuttings and, to a lesser extent, from cuttings of above-ground stems. Seeds of huckleberry could not be germinated under laboratory conditions.

Several attempts at mass inoculation of lambkill and huckleberry with cultures of local disease-causing fungi failed to increase disease incidence or severity. Experimental field inoculations were performed with leaf spot fungi from lambkill, a *Cytospora* sp. from cankers on huckleberry, *Exobasidium vaccinii* from leaf galls on huckleberry, and *Dothidella kalmiae* from witches' brooms on lambkill.

Attempts at diversification of ground cover through broadcast seeding of grasses, clovers, lupine, sweet fern, pilewort and vetches resulted in little establishment except on wet sites or on plots previously treated with limestone. Spot-seeding trials with the various species indicated that surface conditions were generally too dry for establishment through broadcast seeding. Although limestone aided seedling establishment slightly, its application alone did not alter the prevailing ground cover.

It was concluded that logging in black spruce stands in this region would result in progressively greater dominance of the site by lambkill unless preventative steps were taken. Preventative measures at least for the time being, would have to be more drastic than those attempted experimentally in this study and should possibly include scarification, slash dispersal, and tree planting.

RESUME

Sur des coupes récentes d'Epinette noire, de Sapin baumier et d'Erable rouge dans le sud-ouest de la Nouvelle-Ecosse, il s'est produit une augmentation notable de l'incidence et de la densité du Kalmia, du Bleuet, de Ptéridium et du Cornouiller du Canada au cours des trois années consécutives à l'exploitation. Hormis une régénération précoce des Résineux et une légère croissance d'Erable rouge dans le sous-étage, les autres végétations, y compris les semis d'arbres, n'ont accusé qu'un faible accroissement. Le Kalmia et le Ptéridium dominaient vraisemblablement la plupart des stations tandis que le Gaylussacia était présent presque partout et manifestait un modeste accroissement. Le Cornouiller du Canada progressait surtout sur les microstations non occupées par le groupe Kalmia-Ptéridium-Gaylussacia-Bleuet. La densité du Kalmia se manifestait davantage dans les microstations découvertes que sous le couvert des arbres résiduels, et davantage dans les stations déjà peuplées de Kalmia et de Ptéridium que dans les stations dépourvues de végétation. Le Kalmia progressait lentement sous les amas de rémanents, et mieux si ceux-ci constituaient un léger couvert.

Les deux arbustes dominants, le Kalmia et le Gaylussacia, étaient déjà répandus sur les stations de sable humide ou dans la tourbe provenant des boutures de rhizomes et, à un moindre degré, de celles des tiges hors sol. Il était impossible de faire germer les graines de Gaylussacia en laboratoire.

Plusieurs tentatives d'inoculation massive de Kalmia et de Gaylussacia avec des cultures de Champignons pathogènes locaux n'ont pas réussi à augmenter la présence ou la gravité de la maladie. On effectua des inoculations expérimentales sur place avec un Champignon de la Tache des feuilles provenant du Kalmia, une espèce de _Cytospora_ extraites de chancres recueillis sur le Gaylussacia, un Rouge (_Exobasidium vaccinii_) provenant de galles du Gaylussacia, et un balai de sorcière (_Dothidella kalmiae_) prélevé sur le Kalmia.

Des tentatives en vue de diversifier le tapis végétal au moyen de semis à la volée d'Herbes, de Trèfle, de Lupin, de Fougère odorante de Ficaire et de Vesces résultèrent en un léger établissement sauf dans les stations humides ou dans les placeaux préalablement traités à la chaux. Des essais de semis par places avec diverses espèces indiquèrent que les conditions de surface étaient généralement trop sèches pour permettre l'établissement par semis à la volée. Bien que la chaux fût quelque peu favorable à l'établissement de semis, sa seule application n'a rien changé à la couverture vivante dominante.

L'auteur conclut que l'exploitation de peuplements d'Epinette noire dans cette région aurait pour résultat une station progressivement dominée par le Kalmia, à moins de prendre les mesures préventives nécessaires. De telles mesures, du moins pour l'instant, devraient être beaucoup plus énergiques que celles essayées dans cette étude. Elles devraient éventuellement inclure le scarifiage, la dispersion des rémanents et la plantation d'arbres.

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INTRODUCTION

About 200 000 ha of once forested land in southwestern Nova Scotia is considered to be nonproductive because it is occupied by low quality hardwoods and scrub. In addition, there are about 30 000 ha of barrens, mainly in Shelburne and Yarmouth counties[1]. Although there are large acreages of potentially productive forest lands, they are interspersed with lands which could easily fall into the nonproductive class after cutting or fire. Lands in the latter category may have soils of low fertility or poor drainage, or support a light tree cover as a result of past disturbances; many are characterized by ericaceous ground vegetation similar to that of the barrens and nearby scrub land. Strang[1] associated ericaceous ground cover, mainly lambkill and huckleberry with poor natural regeneration of softwoods. Peterson (1965) associated poor tree growth with lambkill ground cover and demonstrated a possible causal relationship. Damman (1971) demonstrated the long-term immobilization of nutrients in lambkill heathlands as compared to similar areas under tree cover.

At present the major question concerning these less productive forest lands is their suitability for continued wood production. Will they regenerate to stands of acceptable productivity after logging or will they remain for long periods as hardwood scrub or heathland? Many of these areas now support merchantable stands of spruce and are being

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1 Strang, R.M. 1971. Reestablishment of productive forests in southwestern Nova Scotia. Dept. Fish. For., Can. For. Serv., Int. Rep. M-65. 24p.

harvested for the local pulp and paper industry. Early examination after logging might reveal postharvest changes that can be manipulated to provide a better forest cover. Knowledge of secondary successional trends could be used to predict the final outcome of present logging practices — forest or heathland, softwood or hardwood, merchantable timber or scrub.

Many silvicultural tools are available to facilitate successful regeneration after cutting. Scarification dislodges shrub cover and provides a better seedbed; herbicides may be used to prevent re-encroachment of competing vegetation; and planting can supplement natural regeneration. However, these measures may not always be appropriate, or feasible on a large scale, on the rocky lands of southwestern Nova Scotia, and information is therefore needed on the potential of biological methods of site improvement. When a site becomes dominated by a limited group of species, diversification is a desirable goal which might be accomplished by introducing ground cover species not normally present on the site or by killing some of the dominant vegetation and allowing natural replacements. Dominant vegetation might be suppressed through manipulation of local biotic agents, such as fungus diseases or insects.

This report outlines early successional trends on cutover black spruce and mixed-wood stands with ericaceous ground cover and presents results of initial attempts at species diversification through replacement or inoculation with disease organisms. Locations of the various study areas are depicted in Fig. 1.

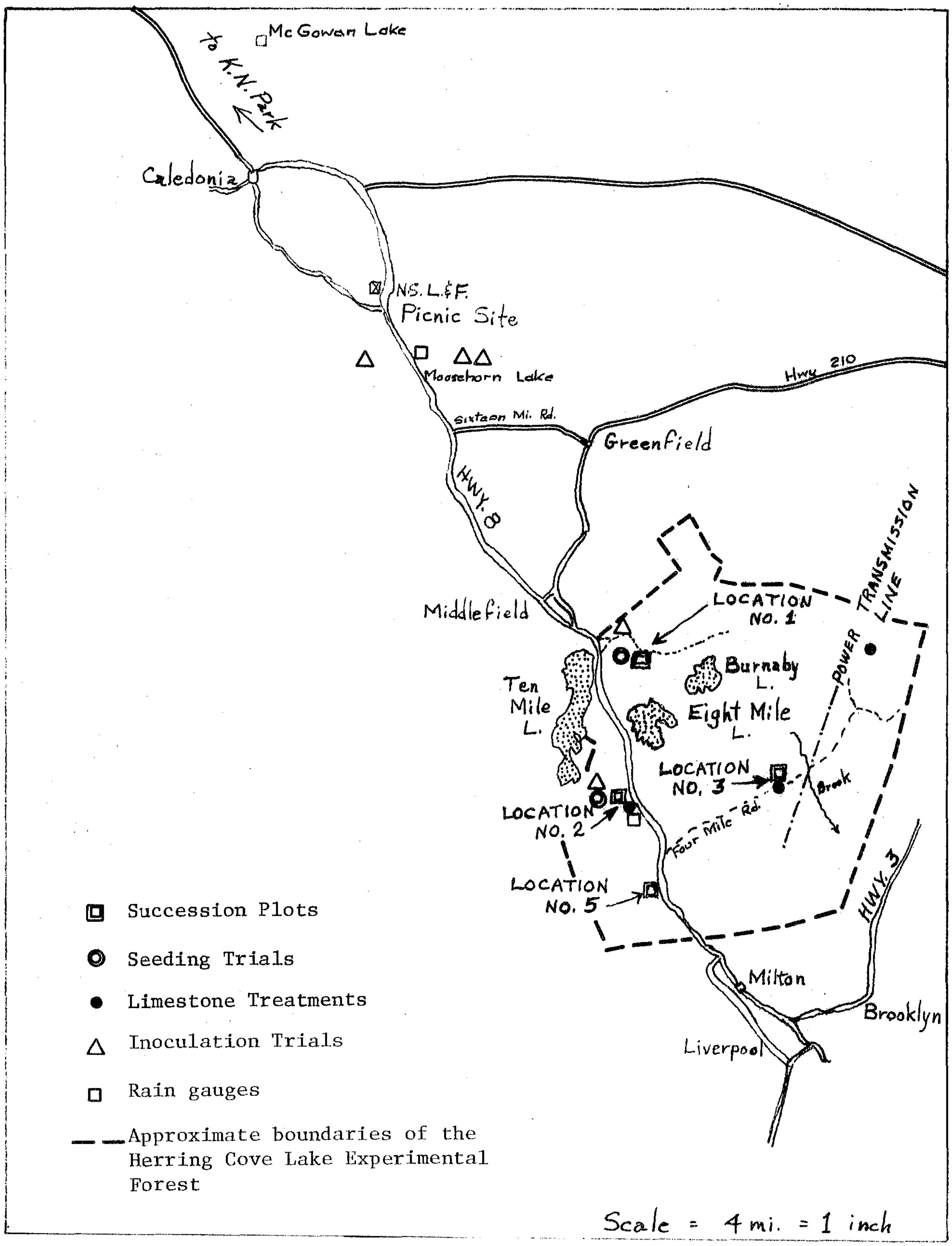

Figure 1. Map of Queens County, Nova Scotia, showing locations of study areas.

Much of the inland area of southwestern Nova Scotia is classified by Loucks (1962) in the Clyde River-Halifax ecoregion which is characterized by an association of red spruce[2], hemlock, white pine, balsam fir, and red maple on coarse boulder-strewn soils. The outstanding climatic feature is a high evapotranspiration rate. In the center of this ecoregion is the LaHave forest district with a dominant cover of tolerant hardwoods and somewhat better soils. Along the Atlantic shore, coastal winds, cool temperatures, and poor soil produce very sparse vegetation dominated by white spruce, black spruce, and balsam fir.

Most of the studies outlined in this report were conducted in the Mersey River District which is part of the Clyde River-Halifax ecoregion but has some affinities with the nearby Lahave and Atlantic shore forest districts. The better drained soils in the Mersey River district support good stands of red spruce, hemlock, and white pine which usually regenerate well after disturbance, but there are many other stand types in the area where forest practices and fire appear to be causing serious deterioration of the forest cover. The latter include the mixed hardwood stands which are more characteristic of the LaHave district to the north and the black spruce-balsam fir-red maple stands growing on the more poorly drained soils. Both stand types have light canopies, a dense ground vegetation of ericaceous shrubs which impedes tree planting, and coarse rocky soils which further discourage silvicultural practices.

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[2] See Appendix for scientific names of species used in this report.

While the above description implies the existence of fairly distinct forest types with predictable responses to disturbance, the actual situation in the Mersey River District and over the whole southwestern Nova Scotia region is far more complex. Bedrocks of granites, slates, and argillite were mixed by glaciation resulting in highly variable parent soil materials. Climate varies considerably across the province. Hurricanes, frequent fires, and changing logging practices have resulted in a complex forest history. The location of the present study — in the black spruce-balsam fir-red maple stands of the lower Mersey-Medway watershed — probably represents an intermediate type between the barrens and scrub lands of the extreme southwestern portion of the province and the highly productive forests of the upper Medway and LaHave watersheds. The soils are better developed and more fertile than the granitic soils found further west but are coarser and have poorer drainage than the drumlins of the LaHave district.

Inoculation Trials With Disease Organisms

Numerous attempts were made from 1971-1974 to reproduce diseases of lambkill and huckleberry by inoculating them with cultures of their associated fungi. Inoculation methods were simple and were not preceded by studies of infection requirements.

Leaf spots of lambkill. Numerous cultures of fungi were isolated from leaf spots during the summer and fall of 1971. Ten representative isolates were cultured on 200 mℓ aliquots of sterile oat-sand medium in April 1972, and in early May these were scattered over 1 m^2 plots of lambkill near the Burnaby Lake Road. Three replicate blocks were inoculated. During the following year, plots were examined for symptoms differing from those on surrounding uninoculated lambkill.

Cytospora canker of huckleberry. In August 1971, a stem canker was observed on huckleberry near Port Joli. Isolations from the margins of cankers consistantly gave rise to a species of Cytospora. Isolates were transferred to moist sterile stem segments of huckleberry in test tubes. Infected segments were fastened with masking tape to the surfaces of fresh wounds on 30 huckleberry plants growing near the Burnaby Lake Road in May, 1972. During the following year, the inoculated shrubs were examined for bark discoloration and mortality of the distal portions of the shoot.

Leaf gall of huckleberry. Inoculation trials with Exobasidium vaccinii are summarized on Table 7. Inoculations were made initially with freshly collected or frozen diseased tissues macerated in a Waring blender and were applied to moist leaves as a dust or as a water or mineral oil suspension. When pure culture techniques had been developed,

PART I

VEGETATIVE CHANGES AFTER LOGGING

liquid shake cultures grown on mineral-salts dextrose medium[5] were sprayed onto the foliage, or lyophilized cells in talc were sprayed or dusted onto wet foliage. Wetting agents (Tween 20, Triton X-100, AL1034, AL411F), energy sources (glycerin), antibacterial agents (streptomycin) or antifungal agents (benomyl) were added in low concentrations in some treatments. Through laboratory bioassays, Exobasidium was found to be tolerant to all of these agents.

Inoculations were generally done in the evening, preferably when showers were forecast for the following day. In one trial (Table 7, No. 8), water was sprayed onto the foliage for several hours after inoculation to keep it moist.

The fungus cultures used for inoculation were collected from several locations (disease sources) in southwestern Nova Scotia.

Witches' broom of lambkill. Ascospores washed from diseased stem sections were suspended in distilled water and were sprayed onto quadruplicate 10 m^2 plots on 10 May, and 25 May, 1973. On 25 May, suspensions of liquid cultures of the fungus also were applied to lambkill foliage in four plots each at Moosehorn Lake and Six Mile Road. All of the diseased material had been collected on the Burnaby Lake Road, the only disease source found in Nova Scotia at that time.

In 1974, a high incidence of this disease was found at the Acadia Forest Experiment Station in New Brunswick. Diseased tissues were collected from Acadia and from the Burnaby Lake site and suspended with fine thread at 10-50-cm intervals over 10 m^2 disease-free plots of

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[5] Monopotassium phosphate - 0.25g, calcium chloride - 0.25g, magnesium sulfate - 0.07, ammonium nitrate - 0.1g, asparagine - 0.1g, dextrose - 1.0g, thiemine - 0.001g, distilled water - 1000 ml.

One of the primary questions within the overall problem of ericaceous vegetation development and consequent site deterioration is the effect of present cutting practices. Past disturbances were caused mainly by fire, hurricanes, or selective logging for lumber or poles, whereas present disturbances are predominantly from clear-cutting operations for pulpwood. Although the variable nature of forest cover does not permit the huge clearcuts typical of other regions, openings of several acres are found throughout southwestern Nova Scotia, mostly in stands of black spruce. Hardwoods usually are left standing, while large white pine, hemlock, and red spruce, if present, are sometimes removed for sawlogs a few months before or after the main cutting operation. Consequently there is little or no uniformity in size and shape of openings. Time of cutting is also difficult to establish since successive harvests on adjacent areas often overlap and extraction of different species takes place at different times. Cutting is usually done manually and the wood is removed to the roadside by light machinery.

The following study was established to determine successional trends after clearcut logging as affected by microsite, residual tree cover, slash dispersal, and surface conditions. An attempt also was made to detect associations among ground cover species and their effects on natural regeneration of tree species.

THE STUDY AREAS

The study areas were established in Queens County, Nova Scotia on the Herring Cove Lake Experimental Forest north of Liverpool (Fig. 1). The major merchantable species prior to cutting was black spruce, with varying mixtures of balsam fir, red maple, and paper birch. The forest type was classified in the Mersey River district of the Clyde River-Halifax ecoregion of Loucks (1962). Soils were predominantly of the Halifax series as described by Cann and Hilchey (1959) with small pockets of shallow peat over bedrock. The study areas were located mainly on the poorly drained areas, described by Crampton[3] as gleyed humo-ferric podsols and fera gleysols, although some extended into adjacent upland areas supporting white pine, hemlock, and red spruce.

Location 1 was situated 0.8 km east of Highway 8 on the Burnaby Lake Road (Fig. 1). Before cutting in the winter of 1970-71, it supported about 1200 stems/ha, consisting of black spruce (52%), balsam fir (25%), red maple (9%), paper birch (4%), and occasional red spruce, red oak, and large-tooth aspen. After cutting, there remained a residual stocking of 200 stems/ha, primarily red maple, spruce, fir, birch, and oak. The area immediately west of the plots was harvested in the late 1960's.

Location 2 was on the west side of Highway 8 near Six Mile bog. Before logging in the spring of 1972, it was stocked with 1300 stems/ha, consisting of red maple (30%), black spruce (30%), fir (30%), white pine (3%) and occasional paper birch, grey birch, trembling aspen, and red oak.

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[3] Crampton, C.B. 1971. A survey of the soil landscape of four forest study areas in the Maritime Provinces. Dept. Fish. and For., Can. For. Int. Rep. M-64. 23 p.

After logging, a cover of red maple, balsam fir, black spruce, white pine, birch, and aspen remained, with an average stocking of 60 stems/ha. The area immediately north and west of the study area was harvested during 1970 and 1971.

Location 3 was situated on the Four Mile Road, 3 miles northeast of Highway 8. Before logging in 1971-72, it had 1200 stems/ha, consisting of black spruce (65%), red maple (13%), and scattered fir, paper birch, white pine, larch, aspen, and hemlock. After logging, 130 stems/ha remained, mainly of maple, spruce, fir, larch, hemlock, aspen, and birch. The immediate surroundings were not logged but a large burn had occurred during the past decade several hundred metres to the east.

Stand ages, as derived from ring counts on the stumps, were very uneven, suggesting retarded development since the last major disturbance and a complex history of cutting, fire, wind damage, and other minor disturbances. Ages of spruce ranged from 51-80 years at location 1, 51-95 years at location 2, and 67-77 years at location 3. Mean diameters at stump height were 19.4, 21.7, and 18.7 cm, respectively.

METHODS

Within a few months after logging 0.25 m^2 permanent plots were established at equidistant intervals — 10 m apart in rows of 5 plots each spaced at 10 m intervals — within the three study areas. Because of the irregular patterns of cutting, some plots were established in uncut portions of the stand or under large slash piles, on uprooted trees, and on bare rock surfaces. Subsequent clean-up operations changed the original surface characteristics of some plots but generally most plots did not receive any further disturbance. Two hundred and fifteen plots were originally established, 45 in location 1, 100 in location 2, and 70 in location 3. Ten plots in location 2 were later discarded because of a nearby plantation establishment.

Plots were marked with 1-m wooden stakes and vegetation changes were recorded in the southeast 0.25 m^2 quadrat. Vegetation and other cover was recorded as; 1) number of stems arising from the ground surface, 2) percent cover, estimated visually, and 3) maximum height. Original tree cover and tree regeneration beyond the plot were determined by the 'closest individual' method of Cottam and Curtis (1956), using each plot stake as a point. Percent stocking of regeneration was based on a 1 milacre sample unit, i.e. the presence or absence of regeneration within 1.14 m of the plot center.

Ground cover was recorded during the period 15 June-15 September in 1972, 1973, and 1975. Two recordings were made in 1972, one in late June or early July and the other in late August, but to minimize disturbance from trampling, only one recording was made in subsequent growing seasons.

To establish the effects of various site conditions on plant succession, plots were grouped in various ways according to tree cover prior to cutting, residual tree cover, slash cover, dominance of certain shrubs or herbaceous species, and surface conditions on the first recording date. Subsequent changes in ground cover were related to initial conditions through simple correlations, frequency tables, and graphs.

RESULTS

In all three locations, there was a general increase between 1972 and 1975 in the incidence of vascular species, except most tree seedlings, wintergreen, creeping snowberry, and wild lily-of-the valley (Table 1). Mosses, liverworts, and lichens decreased. The incidence of bunchberry, star-flower, and lambkill increased markedly. Increases in some species were reflected in density (Table 2), although separation of stems was often difficult. The increase in lambkill could be measured as estimated percentage cover (Table 3). Huckleberry, although more dominant in height, did not increase significantly during the 4-year period. Blueberry increased in numbers, but remained part of the lambkill association and was dominated by it. Bracken was also associated with lambkill and increased slightly in incidence and density over the 4-year period.

Lambkill was the dominant ground vegetation at the time of cutting and increased at a greater rate than other species after logging. Initially, it was present throughout each study area, with a slightly greater frequency in former stand openings and under hardwood cover than under softwood cover (Table 4). To determine the factors influencing its increase and to predict the likelihood of it taking over a site, the changes in lambkill cover were followed on several different microsites. Characterization of microsites was based on the immediate plot area and did not reflect conditions short distances from the plots. Lambkill was more plentiful on litter or feather moss sites than on sphagnum sites or on exposed soil (Fig. 2). The exposed soil was mainly on roadways and had probably been subjected to compaction. More marked was the relationship between lambkill cover and residual tree cover, slash cover, and other vegetation. Lambkill did not increase under tree cover but increased slightly under slash piles (Figs. 3 and 4). Lambkill only slowly invaded non-vegetated areas and most exposed microsites remained relatively free of it during the 3-year period (Figs. 3 and 5).

The effects of slash cover on the increase in certain species were followed in the largest study area (Fig. 4). Bracken, bunchberry, blueberry, and lambkill were favored by light cover. Spruce and huckleberry appeared to develop better under heavy slash cover but their densities were too low to establish reliable trends. Heavy slash was definitely detrimental to bunchberry.

The effects of initial densities of lambkill on subsequent species increase also was analyzed for location 2. Pine, spruce, birch, blackberry, raspberry, and bunchberry were present only on plots with an initially low lambkill cover (< 10%). On the other hand, bracken, blueberry, and huckleberry increased in numbers as much on plots with dense lambkill cover as on those with low cover. There were consistent positive correlations between initial lambkill cover and density of bracken (maximum r=0.29), wintergreen (maximum r=0.54), blueberry (maximum r=0.22), and huckleberry (maximum r=0.35). In the other two study areas, these correlations were not as consistently positive. Correlations were generally negative, but not significantly so, between lambkill cover and bunchberry, and between lambkill cover and tree regeneration.

Tree regeneration, measured on larger plots or by distance measurements could be considered moderately to well-stocked after 3 years if the criteria of Candy (1951) are used (Table 5). Black spruce was the most common, averaging 1000-3000 seedlings per hectare with 50-75% stocking. The remaining regeneration consisted of fir, maple, birch, oak, and white pine. Most of the regeneration was coppice growth of hardwoods or advance regeneration of spruce or fir. Layering of black spruce was frequently observed. Coppice growth of red maple exceeded 1 m in height by 1975 and appeared likely to form a partial canopy within a few years. Seedlings of all tree species appeared and disappeared on the plots with almost equal rapidity. During the dryer growing seasons (1971, 1975) it was not difficult to find dead seedlings of balsam fir, maple, or birch on exposed microsites.

Table 1. Species occurrence on recent cutovers in 1972 and 1975, Herring Cove Lake Experimental Forest, Nova Scotia

Group and Species	Occurrence, %[a]							
	Loc. 1		Loc. 2		Loc. 3		All Locations	
	1972	1975	1972	1975	1972	1975	1972	1975
<u>Conifer regeneration</u>								
Balsam fir	16	16	7	3			6	5
Spruce	11	16	4	11	16	20	10	15
White pine			1	1	3		2	1
<u>Hardwood regeneration</u>								
Aspen	2		1				1	
Birch		2	4	4	1		2	2
Red maple	4	9	10	3	6	3	7	4
Red oak		2						1
<u>Shrubs</u>								
Alder			1	1	1	3	1	2
Blackberry				3				1
Blueberry	36	29	40	46	57	63	45	48
Huckleberry	9	11	17	20	27	30	19	22
Lambkill	69	76	59	69	80	86	68	76
Raspberry				4				2
Rhodora						1		1
Serviceberry		2						1
Sweet-fern	2						1	
Witch hazel	11	9					2	2
Witherod	2	4		2			1	2
<u>Ferns</u>								
Bracken	36	67	12	24	33	43	24	40
Cinnamon fern		2	7	9	9	10	6	8
Dryopteris			1				1	
Hay-scented fern			1				1	
<u>Herbs</u>								
Bunchberry	29	40	8	18	16	24	15	25
Clovers			7[b]				3[b]	
Creeping snowberry			4	4	1		2	2
Gold-thread					1		1	
Honeysuckle				1				1

Table 1. Cont.

Group and Species	Occurrence, %[a]							
	Loc. 1		Loc. 2		Loc. 3		All Locations	
	1972	1975	1972	1975	1972	1975	1972	1975
Herbs (cont'd)								
Partridge berry	2		1				1	
Sarsaparilla			1				1	
Star-flower	11	27	18	22	4	7	12	18
Trailing arbutus	4	2				1	1	1
Wintergreen	18	7	6	7	13	6	11	6
Monocotyledons								
Clintonia	2						1	
Grasses	2		6[b]	9[b]	1		3	4
Sedges		2		6				3
Wild lily-of-the valley			3	2			2	1
Bryophytes and Lichens								
Dicranum	36	24	28	30	46	20	36	25
Hair-cap moss	29	18	1	2	4		8	5
Hypnum	11	9	12	3	11	6	12	5
Leucobryum	4		2				2	
Lichens			11	1	4	4	6	2
Liverwort	13	2	30	12	17	3	22	6
Schreber's moss	42	33	17	4	44	44	32	24
Sphagnum			14	13	6	1	8	6

[a] Percentage of plots where species were recorded.

[b] Seeded artificially on 30 plots in the spring of 1972 and 1973 (see Part IV).

Table 2. Density of major ground cover species in three cutover areas in the Herring Cove Lake Experimental Forest, 1972-1975

Species	Stems/m^2			
Location 1	**July 6, 1972**	**Aug. 24, 1972**	**Aug. 29, 1973**	**June 20, 1975**
Balsam fir	0.6	0.6	0.6	0.8
Blueberry	4.3	4.6	4.0	7.3
Bracken	2.0	2.8	5.5	6.7
Bunchberry	5.3	6.6	6.6	12.9
Huckleberry	1.4	0.9	1.7	1.6
Lambkill	36.6	28.9	37.1	39.6
Red maple	0.2	0.3	0.3	0.3
Spruce	0.8	0.4	0.8	0.7
Star-flower	1.2	0.9	0.8	2.2
Location 2	**June 22, 1972**	**Aug. 22, 1972**	**Sept. 10, 1973**	**June 19, 1975**
Balsam fir	0.3	0.3	0.1	0.1
Blueberry	4.2	4.5	4.7	10.6
Bracken	0.8	1.3	3.2	2.8
Bunchberry	0.8	1.1	2.7	6.8
Huckleberry	2.1	3.3	4.4	4.1
Lambkill	14.4	19.6	26.1[a]	29.5[a]
Red maple	0.4	0.3	0.2	0.1
Spruce	0.2	0.5	0.6	0.7
Star-flower	2.5	0.9	0.2	3.6
Location 3	**July 15, 1972**	**Aug. 27, 1972**		**June 23, 1975**
Balsam fir		0.1		
Blueberry	8.7	9.1		18.4
Bracken	1.7	1.4		3.6
Bunchberry	2.0	4.5		3.9
Huckleberry	5.3	3.4		6.4
Lambkill	28.2	32.8		41.5[a]
Red maple	0.3	0.4		0.3
Spruce	1.3	1.2		1.2
Star-flower	0.2	0.5		0.7

[a] Significantly different from July, 1972 density at P = 0.05.

Table 3. Percentage cover, by visual estimates, of major ground cover in three cutover areas, Herring Cove Lake Experimental Forest, 1972-1975

	Percent Cover[1]				
	Slash	Non-ericaceous shrubs, tree regeneration	Bracken	Huckleberry	Lambkill
Location 1					
July 6, 1972	25.0[ab]	0.6[a]	1.5[a]	0.2[a]	7.8[a]
Aug. 24, 1972	36.3[a]	0.5[a]	3.1[a]	0.3[a]	7.8[a]
Aug. 29, 1973	15.9[bc]	0.8[a]	2.7[a]	0.3[a]	9.8[a]
June 20, 1975	8.5[c]	1.0[a]	3.4[a]	0.4[a]	9.4[a]
Location 2					
June 22, 1972	30.7[a]	0.4[a]	0.7[a]	0.5[a]	2.7[a]
Aug. 22, 1972	28.6[a]	0.6[a]	0.9[a]	0.6[a]	2.7[a]
Sept. 10, 1973	27.6[a]	1.5[a]	1.7[a]	0.9[a]	4.9[a]
June 19, 1975	7.2[b]	1.6[a]	0.8[a]	0.9[a]	8.5[b]
Location 3					
July 15, 1972	20.1[a]	1.5[a]	0.7[a]	0.7[a]	7.8[a]
Aug. 27, 1972	27.3[a]	3.0[a]	1.4[a]	0.7[a]	10.0[ab]
June 23, 1975	8.8[b]	2.1[a]	1.6[a]	1.2[a]	15.1[b]

[1]Within groups, data followed by the same letter are not significantly different at 5% level (Duncan's Multiple Range Test).

Table 4. Frequency and density of lambkill in July 1972 in parts of study areas formerly occupied by softwood or hardwood, or in previously open areas

	Frequency % (density, stems/m^2)			
	Loc 1	Loc 2	Loc 3	All locations
Cut softwood (94 plots)	64 (34)	47 (10)	80 (27)	56 (20)
Uncut softwood (40 plots)	55 (34)	78 (28)	74 (35)	65 (33)
Hardwood[a] (45 plots)	100 (49)	68 (16)	83 (24)	78 (24)
Stand openings[b] (25 plots)	83 (33)	91 (17)	88 (24)	88 (23)

[a] Mainly standing.

[b] No trees or freshly cut stumps within 3-m radius.

Table 5. Restocking by tree species on three study areas in 1975

	Location 1	Location 2	Location 3
(1) Number per hectare[a]			
Spruce	2403	1030	2787
Fir	1138	540	26
Maple	362	692	303
Birch	44	100	6
Other	139	167	5
Total	4086	2529	3127
(2) Percent Stocking[b]			
Spruce	71	49	73
Fir	56	36	7
Maple	11	40	20
Other	29	32	1
All species	89	79	79
(3) Mean height, m			
Spruce	0.5	0.5	0.6
Fir	0.5	0.4	1.1
Maple	1.1	1.1	1.6
Birch	0.1	0.2	1.3
Other	0.3	0.4	1.3
(4) Seedlings >0.2m height, %[c]			
Spruce	60	67	84
Fir	51	58	100
Maple	74	62	96
Other	48	48	83

[a]Based on 'closest individual' method of Cottam and Curtis (1956);

$$\text{Seedlings/ha} = \frac{10{,}000}{(2\text{x mean distance in m})^2}$$

Includes seedlings and vegetative reproduction.

[b]Milacre basis, i.e. seedlings within 1.14 m of stake.

[c]Percentage of recorded seedlings under (1); predominantly advance growth or vegetative reproduction.

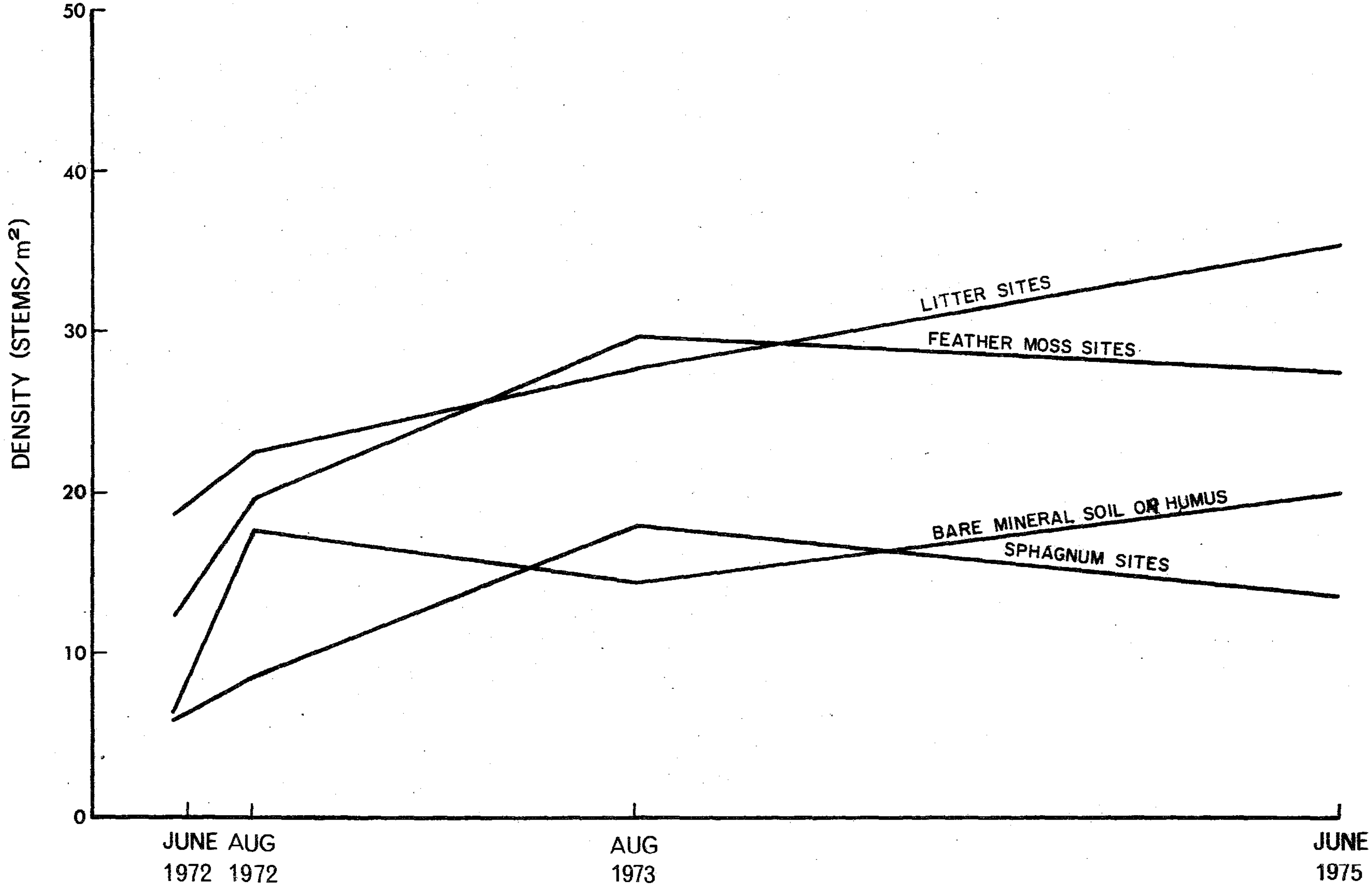

Figure 2. Increase in density of Lambkill on various microsites, classified by surface cover, at the Six Mile Cutover (Location 2), 1972-1975.

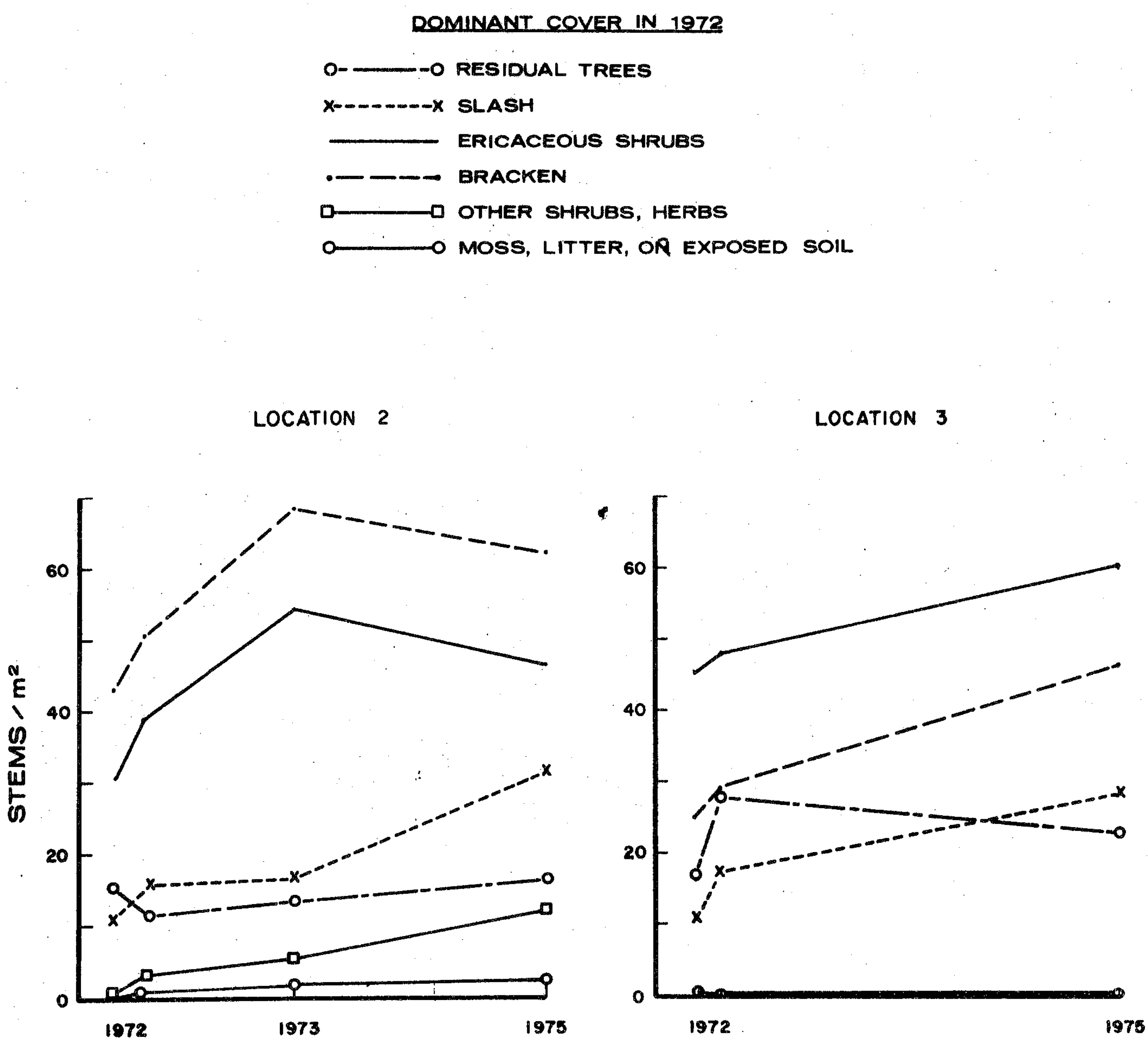

Figure 3. Increase in density of lambkill on different microsites, classified according to dominant cover shortly after cutting.

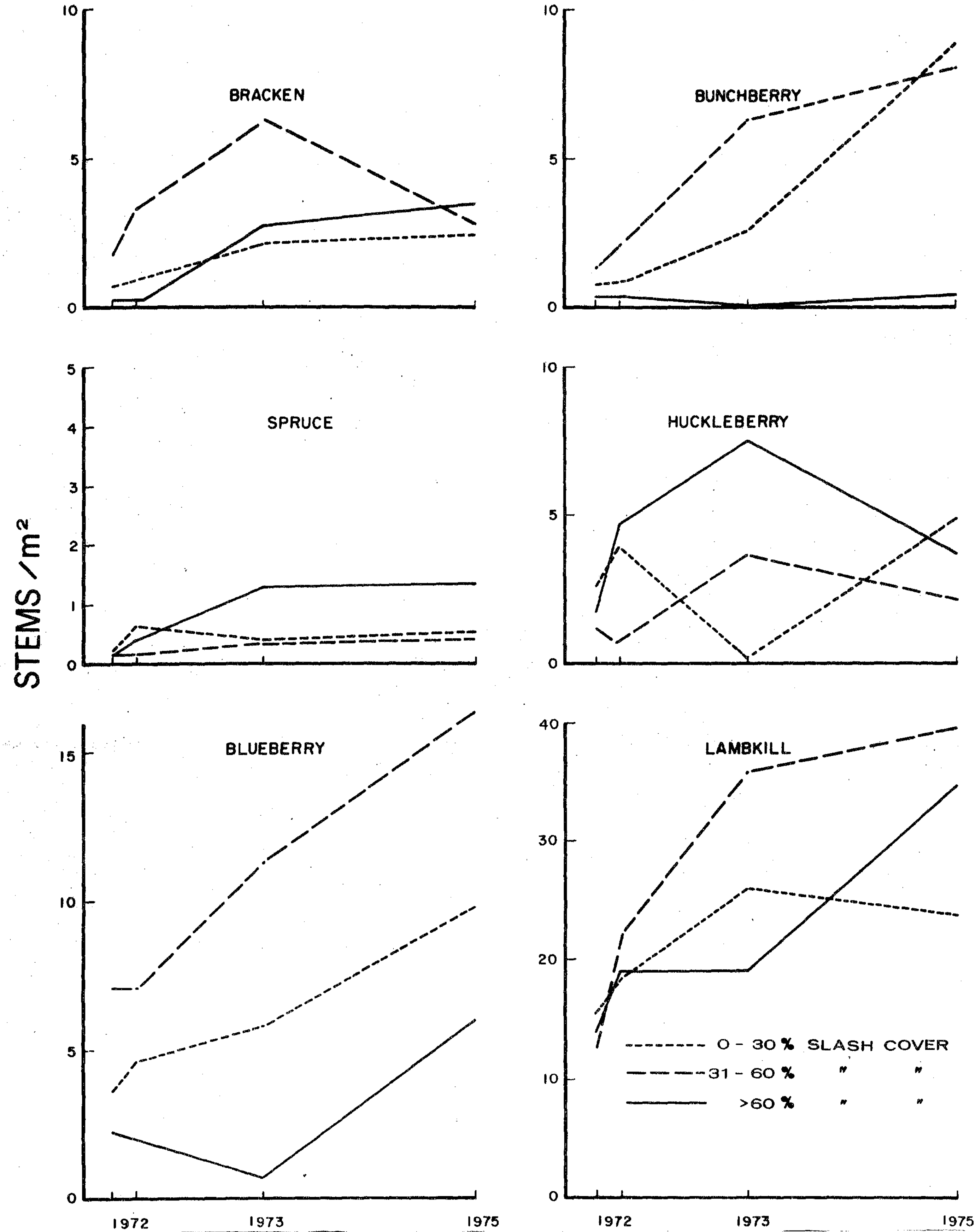

Figure 4. Changes in density of several species of plants under logging slash at location 2.

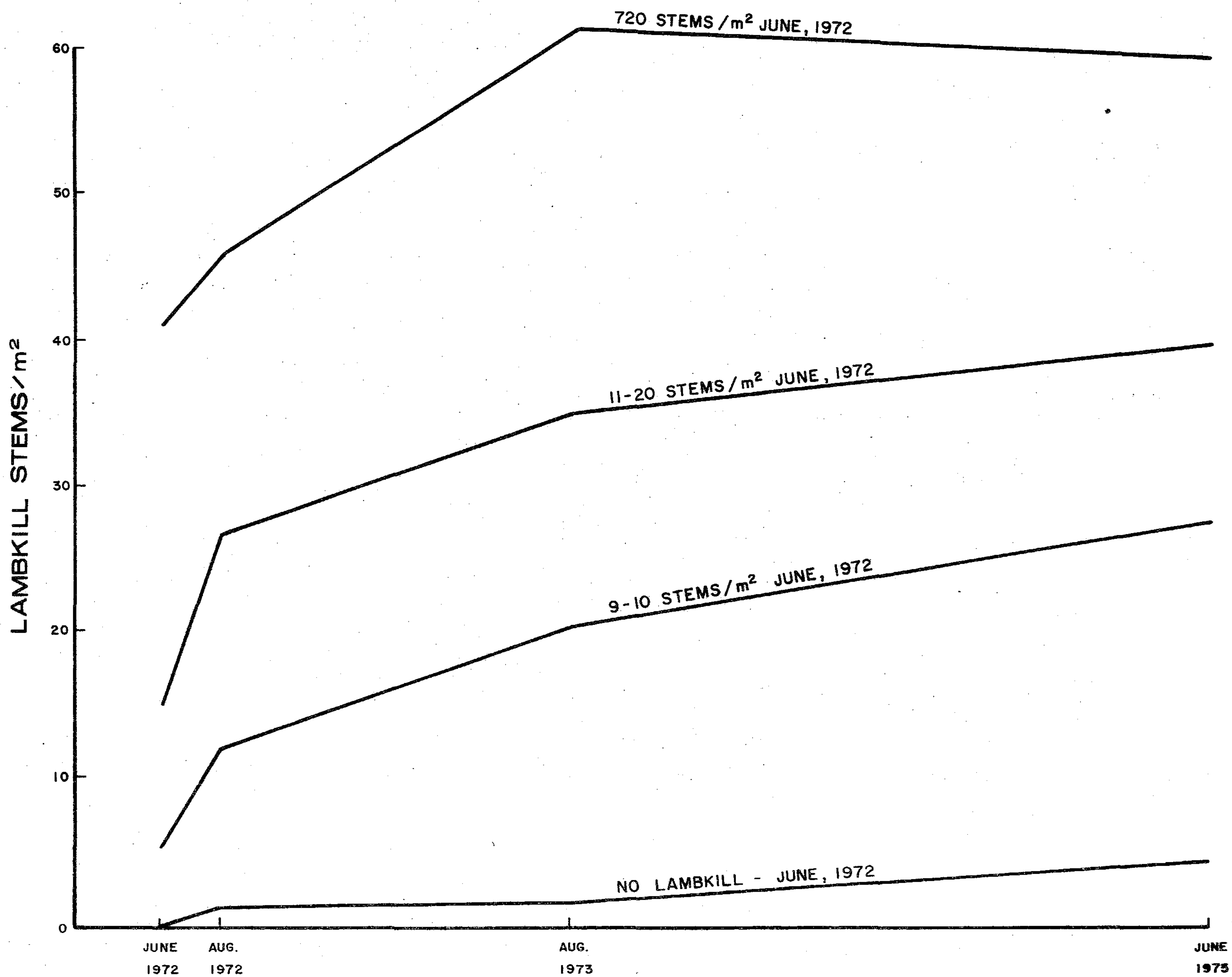

Figure 5. Increase in density of lambkill on various microsites, classified by original density at the Six Mile Cutover (Location 2), 1972-1975.

DISCUSSION

Although it is impossible to foretell the eventual forest cover on the three cutover areas, certain trends appear to be well established. First, the sites are dominated by lambkill and bracken, both of which are considered to be detrimental to tree regeneration (Peterson 1965, Place 1952). Successful regeneration consists largely of advance growth or vegetative reproduction and is thus very uneven in size, distribution, and quality. In a few years, these sites may be partially over-topped by red maple coppice growth, interspersed with spruce-fir thickets and openings with solid lambkill-bracken cover.

Productivity of the next stand is impossible to predict but an optimistic projection is difficult. The previous stands were stocked with about 1200 stems per ha of 15-to 20-cm dbh trees which were 50-100 years of age. These might have yielded a maximum of 30 cords per acre assuming all species had been fully utilized. It is not likely that future productivity will be any higher, and it seems more probable that it will be less.

Not all of the early events in stand reestablishment need be considered detrimental. Although no beneficial effect can be seen from the ingress of lambkill, many of the other ground cover and deciduous tree species may benefit the site in terms of nutrient recycling. McBride[4], working on these same sites, found that the litter of maple, bunchberry, huckleberry, and bracken contained relatively high cation contents compared to that of lambkill and birch. The relatively rapid

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[4] McBride, R.P. Nutrient recycling by major deciduous woody plants in southwestern Nova Scotia. Unpublished report.

decomposition of maple, bunchberry and bracken litter should help maintain the fertility and pH of these sites. Maple, especially, can produce large quantities of litter, and its deep root system could partially offset nutrient losses through leaching.

The increase in lambkill cover was most rapid in the first year after cutting. It did not increase in areas with dense tree cover but was retarded only slightly by heavy slash cover. Since it was present in all parts of the stand prior to logging it is not possible with present data to predict the type of tree cover that would best suppress it. However, it is fairly safe to assume that only an early, dense cover of trees would prevent it from becoming the dominant species on these sites. It is unlikely that such a tree cover will develop for a long time. Black spruce, with its narrow crown is not likely to form a dense cover alone and maple will not form a continuous canopy. Thus, open stands with an almost solid cover of lambkill are a fairly predictable end result.

PART II

PROPAGATION OF ERICACEOUS SHRUBS

Increases in populations of lambkill and huckleberry on cutover areas appeared to be largely by vegetative reproduction. New shoots appearing on previously bare areas arose from horizontal stems lying on or under the duff layer. These rhizomes could be traced back to an older plant which had survived the logging operation. Because of its indeterminate growth habit, it was often difficult to distinguish rhizomes from above-ground stems.

In the autumn of 1971, clones of lambkill and huckleberry were dug and packed in fresh sphagnum moss. They were stored at 4°C until mid-December, when they were separated arbitrarily into rhizome and stem tissue, cut into 5-cm sections, and planted either on the surface of, or embedded in moist peat or moist river sand. Pots were kept in a plastic chamber in the greenhouse (20-25°C, 16 hour daylight) and observed periodically for shoot development. Rhizomes regenerated more readily than above-ground stems, producing shoots in 1-4 months (Table 6). Rooting was slow and the root systems were sparse on all cuttings. Neither the method of planting nor the medium affected the results markedly although lambkill rhizomes did not produce shoots when placed on the surface. Another set of cuttings planted in January, 1972 in moist peat-sand mix gave similar results; 62% of the lambkill and 52% of the huckleberry rhizome cuttings gave rise to shoots whereas only 37% and 25% of the stem cuttings regenerated.

Little experimental work was done on seed propagation of these species. Huckleberries collected from the Yarmouth barrens and Molega Lake in August, 1971 were air-dried and the seeds were extracted by agitation in water in January. Seeds were placed on moist filter paper and incubated at room temperature or stratified for 5 weeks at 4°C. None germinated. Longer periods of stratification and dusting the seeds with captan to suppress moulds did not result in germination. Extraction of seeds from the pulp in 0.01N HCL for 1 h did not affect the results.

Hall, Jackson, and Everett (1973) similarly reported failure in several attempts to germinate seed of lambkill. Although seed propagation of these species undoubtedly occurs in nature and may be a means of long-distance spread, it is thus, secondary to vegetative reproduction as a means of local population increase. Their rapid increase in density by means of rhizomes gives lambkill and huckleberry a distinct competitive advantage over species that are propagated entirely by seed.

Table 6. Propagation of stem cuttings of lambkill and huckleberry under greenhouse conditions

Medium and Planting method	Number of cuttings producing shoots[a]			
	Lambkill		Huckleberry	
	Rhizomes	Above ground stems	Rhizomes	Above ground stems
River sand				
Submerged	2	0	7	2
Surface	0	1	8	2
Peat				
Submerged	6	0	6	1
Surface	0	0	3	1

[a]Based on 15 cuttings collected from 3 locations and incubated for 4 months.

PART III

DISEASES OF ERICACEOUS SHRUBS

Although not well documented, disease plays a role in the distribution and density of all wild plants. Given sufficient understanding of their life-cycles and limiting factors, some diseases could be exploited to control weed species. Fungus diseases should be relatively easy to manipulate for biological control compared to insects. Most fungi can be cultured on relatively simple media and they produce abundant spores which can be handled as suspensions or lyophilized powders. Unfortunately, infection and disease development are more difficult to control. Most fungus diseases require a prolonged period of free moisture for establishment on the host. Usually, the host can be infected only in a certain physiological state or stage of development and there is often a complex interaction between temperature, pathogen, and host prerequisite to disease establishment.

In eastern North America, nine fungus diseases have been reported on lambkill and 10 on huckleberry (USDA 1960). Most are leaf spots which may cause some late season defoliation but cannot be considered good biological herbicides. Root rots and stem cankers also have been reported. Two diseases which appeared in the field to have more impact on these two species were leaf gall of huckleberry caused by *Exobasidiam vaccinii*, and witches' broom of lambkill caused by *Dothidella kalmiae*. *Exobasidium* was associated with hypertrophy of flowers and leaves in late June and a reddish leaf discoloration in July and August. *Dothidella* caused black swellings of the stem tips.

None of the fungus diseases of wild ericaceous shrubs have been studied in detail. Blueberries are the most closely related group where disease control has been investigated; several studies of red leaf disease caused by *Exobasidium vaccinii* and of cankers caused by *Fusicoccum* spp. are reported (Creelman 1958, Hilborn and Hyland 1956, Lockhart 1958, Lockhart and Craig 1967). Graafland (1953) has studied the species of *Exobasidium* in culture and reported successful inoculations of one of the host species.

METHODS

No organized survey was made of diseases in ericaceous shrubs but in the course of other work, diseases were noted, and infected plants were collected and cultured. Tissues of huckleberry infected with *Exobasidium vaccinii* were frozen within a few hours after collection to prevent colonization by secondary organisms. Other disease specimens were stored dry at room temperature. Diseased tissues were examined under dissecting and compound microscopes for spores and other identifying features.

Isolations from diseased tissues were generally made on 2% malt extract agar in petri dishes. Sections of plant tissue were surface sterilized by soaking them for 1-2 min in 1% sodium hypochlorite solution. Fragments from the advancing margin of the disease were then cut from the plant tissue and planted on agar. If spores were present, they were washed off with sterile water and spread on the surface of agar plates. When these had germinated they were transferred to malt agar slants. Cultures of *Exobasidium vaccinii* from huckleberry were obtained by macerating tissues in sterile water in a Waring blender and pipetting 1 ml aliquots onto the surface of malt agar fortified with 500 ppm streptomycin. Colonies of all fungi were transferred to malt agar slants after a few days and stored at 4°C after new colonies were established.

Inoculation Trials With Disease Organisms

Numerous attempts were made from 1971-1974 to reproduce diseases of lambkill and huckleberry by inoculating them with cultures of their associated fungi. Inoculation methods were simple and were not preceded by studies of infection requirements.

Leaf spots of lambkill. Numerous cultures of fungi were isolated from leaf spots during the summer and fall of 1971. Ten representative isolates were cultured on 200 mℓ aliquots of sterile oat-sand medium in April 1972, and in early May these were scattered over 1 m^2 plots of lambkill near the Burnaby Lake Road. Three replicate blocks were inoculated. During the following year, plots were examined for symptoms differing from those on surrounding uninoculated lambkill.

Cytospora canker of huckleberry. In August 1971, a stem canker was observed on huckleberry near Port Joli. Isolations from the margins of cankers consistantly gave rise to a species of Cytospora. Isolates were transferred to moist sterile stem segments of huckleberry in test tubes. Infected segments were fastened with masking tape to the surfaces of fresh wounds on 30 huckleberry plants growing near the Burnaby Lake Road in May, 1972. During the following year, the inoculated shrubs were examined for bark discoloration and mortality of the distal portions of the shoot.

Leaf gall of huckleberry. Inoculation trials with Exobasidium vaccinii are summarized on Table 7. Inoculations were made initially with freshly collected or frozen diseased tissues macerated in a Waring blender and were applied to moist leaves as a dust or as a water or mineral oil suspension. When pure culture techniques had been developed, liquid shake cultures grown on mineral-salts dextrose medium[5] were sprayed onto the foliage, or lyophilized cells in talc were sprayed or dusted onto wet foliage. Wetting agents (Tween 20, Triton X-100, AL1034, AL411F), energy sources (glycerin), antibacterial agents (streptomycin) or antifungal agents (benomyl) were added in low concentrations in some treatments. Through laboratory bioassays, Exobasidium was found to be tolerant to all of these agents.

Inoculations were generally done in the evening, preferably when showers were forecast for the following day. In one trial (Table 7, No. 8), water was sprayed onto the foliage for several hours after inoculation to keep it moist.

The fungus cultures used for inoculation were collected from several locations (disease sources) in southwestern Nova Scotia.

Witches' broom of lambkill. Ascospores washed from diseased stem sections were suspended in distilled water and were sprayed onto quadruplicate 10 m^2 plots on 10 May, and 25 May, 1973. On 25 May, suspensions of liquid cultures of the fungus also were applied to lambkill foliage in four plots each at Moosehorn Lake and Six Mile Road. All of the diseased material had been collected on the Burnaby Lake Road, the only disease source found in Nova Scotia at that time.

In 1974, a high incidence of this disease was found at the Acadia Forest Experiment Station in New Brunswick. Diseased tissues were collected from Acadia and from the Burnaby Lake site and suspended with fine thread at 10-50-cm intervals over 10 m^2 disease-free plots of

[5] Monopotassium phosphate - 0.25g, calcium chloride - 0.25g, magnesium sulfate - 0.07, ammonium nitrate - 0.1g, asparagine - 0.1g, dextrose - 1.0g, thiemine - 0.001g, distilled water - 1000 ml.

lambkill at Moosehorn Lake, Ten Mile Lake, and Six Mile Road. These areas have since been visited yearly in search of new disease incidence.

RESULTS AND DISCUSSION

Cultures of *Exobasidium vaccinii* were successfully recovered from dilutions of macerated diseased tissue plated on malt agar. Recovery was enhanced by amending the agar with 500 ppm streptomycin. Cultures were cream colored, waxy, slow growing, and macroscopically resembled bacterial or yeast colonies. Frozen tissues of diseased huckleberry gave rise to cultures after storage for as long as one year.

In liquid cultures containing mineral salts and dextrose, *E. vaccinii* grew in a yeast-like fashion, growth being noticeably enhanced by the addition of 1 ppm thiamine. Addition of up to 2% glycerin, 100 ppm streptomycin, 1 ppm benomyl, or 0.01% of any of the wetting agents did not noticeably affect growth in liquid shake culture. Fungal material lyophilized on talc remained viable for several weeks.

Lambkill stem fragments infected with *Dothidella kalmiae* surface sterilized in dilute javex and plated on malt agar gave rise to very slow growing, hard, black cultures. In the spring months, moistened tissues produced ascospores which germinated and grew into cultures on malt agar.

To date, none of the inoculation trials with disease organisms have resulted in infections which could be attributed to inoculation. Plots of lambkill treated with cultures of leaf spot fungi showed no increase in disease over surrounding uninoculated areas. No cankers developed on huckleberry stems inoculated with *Cytospora*. Huckleberry plots sprayed with suspensions of *Exobasidium* showed no increase in incidence of leaf gall over surrounding uninoculated shrubs and in 1973, when no leaf gall could be found in the region, the inoculated plots were likewise disease free. No witches' broom of lambkill has yet been found in plots inoculated either by spore suspension or by suspending diseased tissues over them.

It is impossible to explain any of these numerous failures in the absence of at least one successful inoculation. Nevertheless, the results are not atypical of artificial inoculation attempts with disease organisms under uncontrolled conditions. Certainly weather, competing fungi and bacteria, and host resistance play a role. More needs to be known about the requirements of individual pathogens before they can be manipulated for specific purposes. It is possible that more virulent strains of these pathogens could be brought in from outside regions but this practice could pose a threat to the blueberry industry. It is also conceivable that most clones of huckleberry are already infected by *Exobasidium* and that further infection is in some way prevented by acquired immunity. One disease which does not seem to be fully distributed throughout the range of its host is witches' broom of lambkill caused by *Dothidella kalmiae*. Studies of its impact and requirements might be rewarding.

Table 7. Inoculation trials on huckleberry with *Exobasidium vaccinii*

Number, location and date	Stage of host development	Weather: During	Weather: Next day	Inoculum	Additives	Variables	Treatments x Replicates
1. Six Mile Road 28-6-72	Full leaf	Warm, dry	Warm, dry	Wet tissue macerate	Mineral oil	Water vs oil	3 x 1
2. Moosehorn Lake 12-7-72	Full leaf	Warm, dry	Warm, dry	Wet tissue macerate	Mineral oil	--	2 x 4
3. Moosehorn Lake 13-7-72	Full leaf	Warm, dry	Rain	Wet tissue macerate	Mineral oil	Disease source	3 x 4
4. Moosehorn Lake 14-7-72	Full leaf	Overcast showers	Overcast	Dry tissue macerate	Nil	Disease source	2 x 4
5. Moosehorn Lake 17-7-72	Full leaf	Overcast	?	Wet tissue macerate	Nil	--	1 x 4
6. Moosehorn Lake 18-7-72	Full leaf	Warm, sunny	Rain	Wet tissue macerate	Mineral oil	Disease source	3 x 4
7. Moosehorn Lake							
18-4-73	Dormant	Cloudy	?	Liquid cultures, oat-sand cultures, and lyophilized	Tween 20, Triton X-100, and glycerin	Cultures, adjuvants, and disease sources	20 x 1
9-5-73	Bud swell	Cloudy	Rain				
23-5-73	Bud swell	Cloudy	Rain				
8. Moosehorn Lake							
18-4-73	Dormant	Cloudy	?	Liquid cultures sprayed onto foliage in large quantity of water. Spraying continued until sundown.		Dates of inoculation	3 x 1
9-5-73	Bud swell	Cloudy	Rain				
23-5-73	Bud swell	Cloudy	Rain				

Table 7. Continued.

Number, location and date	Stage of host development	Weather		Inoculum	Additives	Variables	Treatment x Replicates
		During	Next day				
9. Moosehorn Lake Burnaby Lake Six Mile Road 6-5-76	Bud swell	Cloudy, showers	Cloudy, showers	Lyophilized cells	Triton X-100 Streptomycin	Additives Locations	15 x 1
10. Moosehorn Lake 23-5-76	Bud break	Rainy	Clearing	Lyophilized cells	Tween 20 AL1034 AL411F Triton X-100 Streptomycin Benomyl	Additives	15 x 1
11. Moosehorn Lake Burnaby Lake Six Mile Road 11-6-76	Pre-bloom	Cool, cloudy	Rain	Lyophilized cells	Tween 20 AL1034 Streptomycin Benomyl	Additives Locations	15 x 1
12. Moosehorn Lake Burnaby Lake Six Mile Road 6-5-76 to 11-6-76	Bud swell to pre-bloom	As in 9, 10, & 11		Lyophilized cells on stringsuspended over plots		Locations Dates	9 x 1

PART IV

SPECIES DIVERSIFICATION

Because of the tendency for ericaceous shrubs to dominate the cutover sites, a need to diversify ground cover was evident. The ideal ground cover should: 1) provide some competition for ericaceous vegetation without taking over the site; 2) recycle nutrients bound within the organic horizons but retain them for a sufficient time to prevent leaching; 3) provide a light cover for conifer seedlings, modifying the harsh microclimate of the cutover; 4) not be a fire hazard; and 5) contain some nitrogen-fixing species. For practical reasons, only species which were grown commercially or otherwise had a readily available seed supply were considered. The most obvious choices were the forage grasses and legumes sown on nearby farms and roadsides, and the lupine which had escaped from abandoned farmyards and was found along roadsides. Grasses and legumes were noticeably absent from any of the cutover areas observed in the district, except in those areas immediately adjacent to seeded roadsides. A few other cut-or burned-over sites in the district had been invaded by pilewort or sweet fern and attempts were made to establish these in the study areas. Application of limestone was also tried with the objective of altering plant succession on the study areas.

Peterson[6] attempted to establish two legumes, lupine and scotch broom, on the Yarmouth barrens by spot planting in prepared soil. Early survival was promising but his trials did not demonstrate establishment by the more practical method of broadcast seeding.

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[6] Peterson, E.B. 1964. Some land-vegetation relationships on non-forested crown lands in southwestern Nova Scotia. Can. Dept. For. For. Res. Br. Rept. 64-M-17. 56p.

Allen and Peterson[7] applied limestone and three herbicides to ericaceous sites but could not significantly alter the dominant cover. However, since their trials were conducted on barren sites where ericaceous vegetation was firmly established, it was thought that their approach might be more successful on cutover forest sites.

METHODS

Species establishment trials were conducted from 1971 to 1973 using grass and clover seeds from local retail outlets, sweet fern seed collected from a former burned over area, pilewort seed from a nearby cutover and lupine seed from a roadside in Annapolis County. Seeds were stored at room temperature and their viability was periodically checked by germination tests on moist filter paper.

Trials were established near locations 1 and 2 either by spot seeding in evenly spaced grids or rows or by broadcast seeding over larger plots at predetermined densities. No tillage or other disturbance preceded seed placement. The various trials are listed in Table 8.

Dolomitic limestone, purchased at local retail outlets, was broadcast over 0.1 ha plots at location 3 and a point 2 miles northeast of location 3. In addition, limestone was applied prior to seeding in some of the species establishment trials.

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[7] Allen, R.K. and E.B. Peterson. 1964. An assessment of shrub cover four years after chemical treatment in Yarmouth County, Nova Scotia. Can. Dept. For., For. Res. Br. Rept. 64-M-2. 9p.

Table 8. Species establishment trials by spot - or broadcast - seeding on cutover sites at the Herring Cove Lake Experimental Forest, Nova Scotia

Date	Location	Method	Plot Size	Reps	Variables	Species
26-7-71 and 2-5-72	1	Broadcast	10 m^2	4	Season	Timothy, creeping red fescue, Kentucky bluegrass, red top, alsike, white sweet clover, birdsfoot trefoil.
7-6-72 and 15-9-72	1	Seedspot (50 seeds/grid)	-	4	Season	Timothy, Japanese millet, alsike, red clover, white sweet clover, birdsfoot trefoil, lupine, siberian pea, lilac, bayberry.
20-9-72	2	Seedspot (50 seeds/row)	-	4	Limestone at 2000 kg/ha vs unlimed	Red spruce, timothy, Japanese millet, alsike, red clover, white sweet clover, birdsfoot trefoil, lupine, siberian pea, lilac, sweet fern, bayberry, pilewort.
18-5-72 and 24-5-73[a]	2	Broadcast	0.1 ha	3	Microsite	Timothy, Kentucky bluegrass, creeping red fescue, red top, Japanese millet, alsike, birdsfoot trefoil, sweet clover, red clover, vetch, crown-vetch, lupine, sweet fern, pilewort.

[a]Repeated on same plots in 1973 using lime pelletted and Rhizobium inoculated clover seed according to Cass-Smith and Goss (1964).

RESULTS AND DISCUSSION

Broadcast and seed spot trials at the Burnaby Lake site (Location 1) resulted in no species establishment. Seed germination in the laboratory was high (timothy-96%, Japanese millet-62%, alsike-66%, red clover-87%, sweet clover-40%, trefoil-38%, lupine-29%, siberian pea-81%, lilac-60%) for all but bayberry which probably required stratification. In the broadcast seeded plots, some grasses germinated on moist mineral soil but they did not survive the following year. In the seed spot trials, which were all located on exposed duff or feather moss, there was a 1.5% emergence of lupine, 1.0% of siberian pea, and 3.8% of Japanese millet in the spring planting but none survived into the following year.

Seeding trials at location 2 where soil moisture was somewhat higher, were more promising. A year after placement of seed spot trials, a 25, 8, 7, 6, and 0.5% establishment was found on limed plots for timothy, birdsfoot trefoil, red spruce, pilewort, and red clover, respectively, while on unlimed plots there was a 10, 9, 1, and 0.5% establishment of red spruce, Japanese millet, pilewort and birdsfoot trefoil, respectively. No other species were found and establishment was usually restricted to one or two replicates out of four, indicating strong site effects.

The effects of microsite were strikingly evident on the large broadcast seeded plots in location 2. Grasses and clovers became established in only one replicate where the soils were generally very moist. Japanese millet developed to the flowering stage on moist exposed mineral soil during the first and second years after the initial seeding. Thereafter, it disappeared. Red top, timothy, fescue, alsike, and white clover were found in moist spots, often growing directly on sphagnum, but only on two 50 m^2 limed areas did the clovers show much vigor. In any case, the seeded species showed no likelihood of taking over the site and did not affect the density of natural ground cover (Fig. 6). No instance of establishment in lambkill thickets was observed.

The application of limestone at 2000 kg/ha raised the pH of the upper soil horizons slightly but did not measurably affect the natural vegetation. Intensive species counts three years after liming showed negligible effects on conifers, ericaceous shrubs, and other species present (Table 9).

It is apparent that alteration of the pattern of revegetation will not be feasible on these sites without drastic treatments. It is not likely that legumes could be established without intensive scarification, liming, and inoculation with Rhizobium bacteria. Grasses might be established more easily but their effects on the fire hazard make their presence less desirable. Certainly any forage species would attract deer and other herbivores and result in damage to tree regeneration. Thus, the desirability of drastic site change must be thoroughly considered before it is applied beyond the experimental stage.

The establishment of species by broadcast seedling is especially difficult in southwestern Nova Scotia because of the rapid evaporation rate. In spite of fairly frequent rainfall, as exemplified in the data from 1972 (Fig. 7), soil surfaces and other exposed materials were usually found to be very dry to the touch. With such dry surface conditions it is not surprising that seed propagated species are poorly represented on these sites.

The absence of legumes is immediately noticeable in this part of southwestern Nova Scotia and on the study areas there were virtually no species with known nitrogen-fixing capability. Sweet fern and alders could be found nearby but some factors prevented their establishment on the sites under study. Undoubtedly, soil acidity and possibly low soil fertility are major determining factors but further studies should attempt to pin point the factors required for establishment of nitrogen-fixing species. While it might not be desirable to completely change the ground cover, diversification should be beneficial, especially if nitrogen-fixing species are included.

Table 9. Features of two 0.1 ha plots treated with 2000 kg/ha limestone in 1972. Data collected in August, 1976 for plot 4-5 and July 1975 for plot 4-3

	Limed plot	Surrounding unlimed areas
Plot 4-5		
Percent cover (point sampling method)		
Spruce	4	10
White pine	3	8
Bracken	42	33
Sweet fern	1	0
Sarsaparilla	0	1
Red maple	4	5
Lambkill	24	19
Huckleberry	7	10
Blueberry	10	14
Stems/m^2 (closest individual method)		
Spruce	0.4	0.4 NS
Lambkill	2.7	2.2 NS
Soil pH - range of 4 composite samples	3.7-4.2	3.3-4.0
Plot 4-3		
Stems/m^2 (random plot method)		
Bracken	1.2	1.6 NS
Lambkill	12.4	7.8 NS
Huckleberry	0.8	0.6 NS

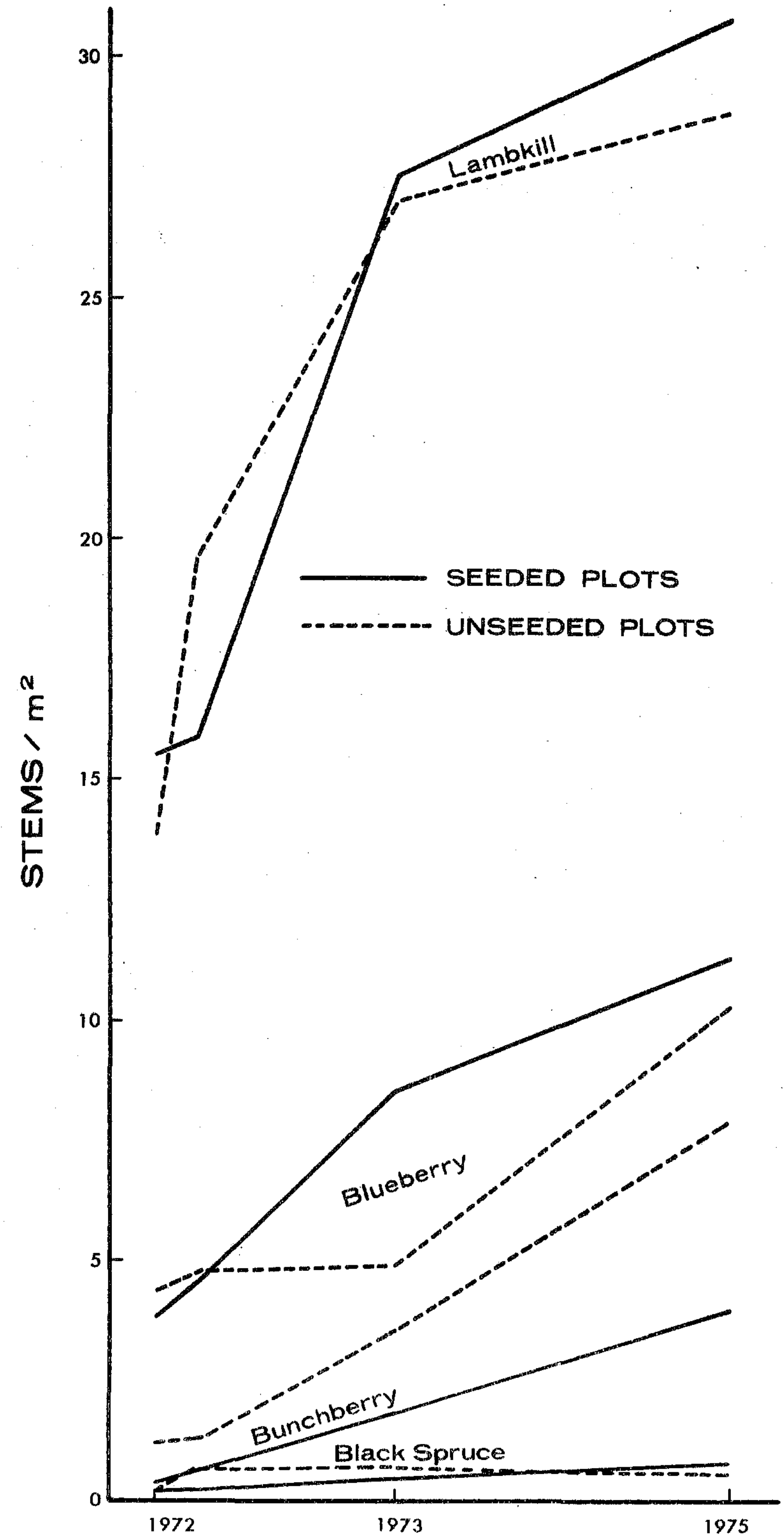

Figure 6. Changes in density of ground cover species on plots seeded with grass-legume mixtures in 1972 and 1973 and on unseeded plots.

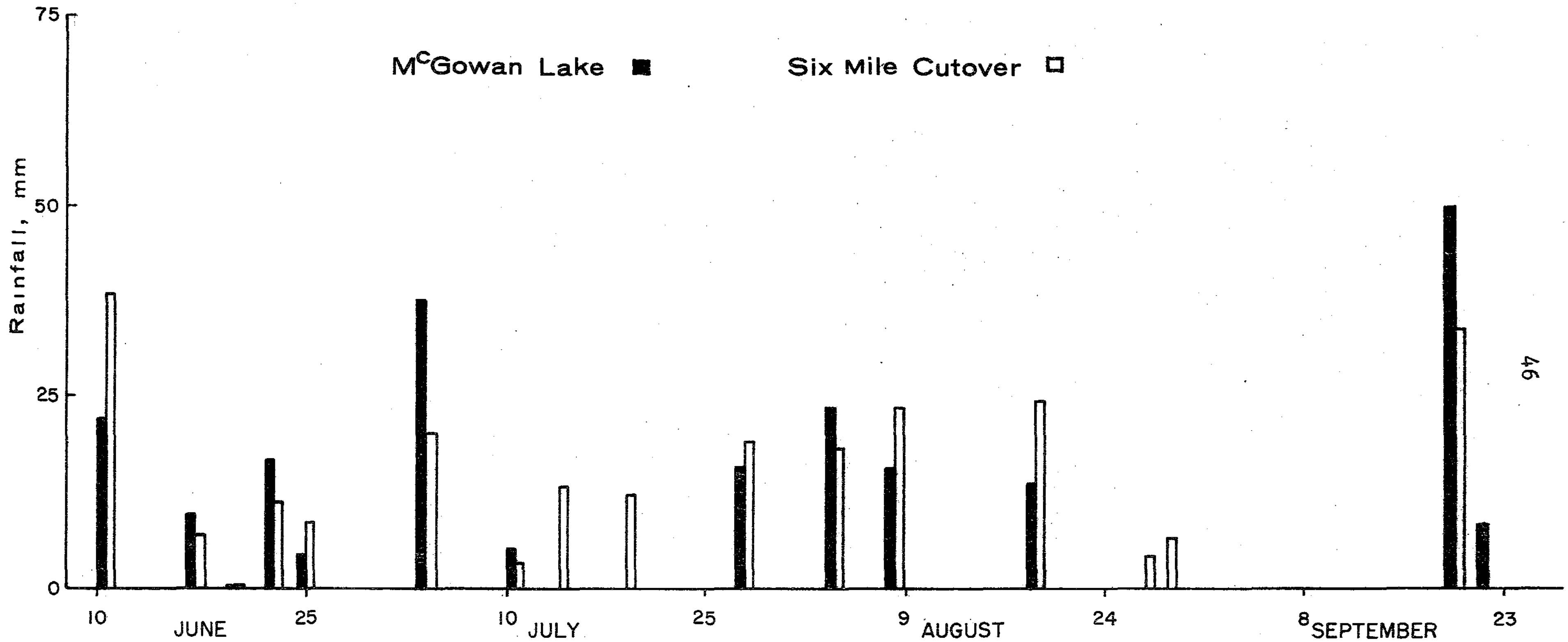

Figure 7. Rainfall measurements at two locations near the study areas in the summer of 1972.

CONCLUSIONS

It is evident that further deterioration of black spruce stands can be expected after logging in the south shore region of southwestern Nova Scotia. Regeneration from natural seedfall is poor in the first few years after clearcutting. Seedling establishment is so precarious that vegetatively propagated species have a distinct competitive advantage. Therefore, one can expect an increased ground cover of ericaceous shrubs partially overtopped with red maple coppice growth and scattered thickets of fir and spruce. With increasing cover, establishment of seedling spruce should be enhanced but growth will then be retarded by the ericaceous shrubs and the hardwood canopy.

Establishment of alternate ground cover species on cutover forest land is not feasible without considerable site preparation and heavy liming. This would not only be expensive but would attract deer and other browsers with resulting ill-effects on tree regeneration. However, inexpensive methods of diversifying ground cover through light scarification and broadcast seeding might be feasible. Perhaps with this amount of input, artificial regeneration of desirable tree species also should be considered, but this leads again to the question of species selection. The sites in question are too poorly drained for the pines or red spruce. Black spruce might not provide a sufficiently dense canopy to shade out the ericaceous ground vegetation. White spruce is not found on these sites, but in nearby coastal areas it forms a dominant part of the forest cover. Local plantations of red pine, larch, and Norway spruce show good early growth[8] but their performance should be evaluated over a full rotation before large-scale planting is undertaken.

Observations in the present study indicate that slight modifications in cutting practices or a few minor postcutting operations would assist regeneration from natural seedfall. Slash dispersal would remove large slash piles under which little except ericaceous vegetation appears to develop. A light disturbance of the soil surface would incorporate some of the surface litter and feather mosses with the mineral soil and thereby create more favorable conditions for seedling establishment. Scarification would also disrupt the large clones of lambkill and huckleberry, possibly providing niches for competing species to become established, but also aiding in their dispersal.

The possibility of controlling the ericaceous shrubs by mass inoculations with disease organisms has not been ruled out by this study. In spite of the large number of trials, only a small percentage of the possibilities have been tried. Failure of any of the inoculations to increase disease severity indicates vital gaps in our knowledge of the disease cycles and of the requirements for successful infection by the organisms that were used in inoculations.

The avenues for control of ericaceous vegetation remain limited. The herbicide trials of Allen and Peterson[7] were not promising. Hall, Jackson, and Everett (1973) have considered the problem of control of

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8 Roller, K.S. and S.E. Hunter. 1972. Field survey of plantations in Queens and Lunenburg counties, Nova Scotia. Dept. Envir., Can. For. Serv. Int. Rept. M-74. 37p.

lambkill in blueberry fields. Herbicides reduced the relative amounts of lambkill and this could be further reduced by burning the treated areas but burning alone or ploughing tended only to increase the number of adventitious shoots.

In spite of the discouraging lack of new methods for site manipulation, there is no reason to abandon these sites to chance after harvesting. To do so would allow them to approach in quality the much less productive sites surrounding the Yarmouth barrens, where reforestation efforts will be much less rewarding (Strang 1972) and where large areas are virtually lost to forestry.

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APPENDIX

Common and scientific names of species used in the text

Alder	*Alnus rugosa* (Du Roi) Spreng.
Aspen - largetooth	*Populus grandidentata* Michx.
- trembling	*Populus tremuloides* Michx.
Bayberry	*Myrica pennsylvanica* Loisel
Birch, gray	*Betula populifolia* Michx.
- paper	*Betual papyrifera* Marsh.
- yellow	*Betula lutea* Michx.
Birdsfoot trefoil	*Lotus corniculatus* L.
Blackberry	*Rubus hispidus* L.
Blueberry	*Vaccinium angustifolium* Ait
Bluegrass, Kentucky	*Poa pratensis* L.
Bracken	*Pteridium aquilinum* (L.) Kuhn
Bunchberry	*Cornus canadensis* L.
Cinnamon fern	*Osmunda cinnamomea* L.
Clintonia	*Clintonia borealis* (Ait) Raf.
Clover - alsike	*Trifolium hybridum* L.
- red	*Trifolium pratense* L.
- white	*Trifolium repens* L.
- white sweet	*Melilotus alba* Desr.
Creeping snowberry	*Gaultheria hispidula* (L.) Bigel.
Crown-vetch	*Cornilla varia* L.
Fescue - creeping red	*Festuca rubra* L.
Fir, balsam	*Abies balsamea* (L.) Mill
Gold-thread	*Coptis groenlandica* (Oeder) Fern
Hair-cap moss	*Polytrichum commune* Hedw

Hay-scented fern	*Dennstaedtia punctilobula* (Michx.) Moore
Hemlock	*Tsuga canadensis* (L.) Carr
Honeysuckle	*Lonicera* sp.
Huckleberry	*Gaylussacia baccata* (Warg.) K. Koch
Japanese millet	*Echinochloa frumentacea* (Roxb.) Link
Lambkill	*Kalmia angustifolia* L.
Lilac	*Syringa* sp.
Liverwort	*Bazzania trilobata* (L.) S.F. Gray
Lupine	*Lupinus* sp.
Maple, red	*Acer rubrum* L.
Oak, red	*Quercus borealis* Michx.
Partridge berry	*Mitchella repens* L.
Pilewort	*Erectites hieracifolia* (L.) Rof.
Pine, white	*Pinus strobus* L.
Raspberry	*Rubus strigosus* Michx
Red top	*Agrostis alba* L.
Rhodora	*Rhodendron canadense* (L.) BSP
Sarsaparilla	*Aralia mudicaulis* L.
Schreber's moss	*Calliergonella schreberi* (Brid.) Grout
Serviceberry	*Amelanchier* spp.
Siberian pea	*Caragana* sp.
Spruce, black	*Picea mariana* (Mill.) BSP
Spruce, red	*Picea rubens* Sarg.
Spruce, white	*Picea glauca* (Moench) Voss
Star-flower	*Trientalis borealis* Raf.

Sweet-fern	*Comptonia peregrina* (L.) Coalt.
Timothy	*Phelum pratense* L.
Trailing arbutus	*Epigaea repens* L.
Vetch	*Vicia sativa* L.
Wild lily-of-the-valley	*Maianthemum canadense* Desf.
Wintergreen	*Gaultheria procumbens* L.
Witch hazel	*Hamamelis virginiana* L.
Witherod	*Viburnum cassinoides* L.