ECOLOGY OF SPECKLED ALDER AT THE DUNBAR FOREST EXPERIMENT STATION, MICHIGAN

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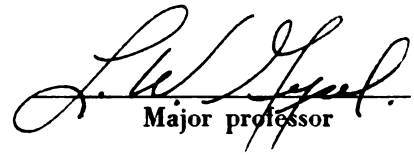

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ECOLOGY OF SPECKLED ALDER AT THE DUNBAR FOREST EXPERIMENT STATION, MICHIGAN

by

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THESIS

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ECOLOGY OF SPECKLED ALDER AT THE DUNBAR FOREST EXPERIMENT STATION, MICHIGAN

by

Thomas Leonard Brickman

INTRODUCTION

With each passing day the pressing need for more timber is becoming more acute. This is especially true in the north eastern and north central sections of the country where vast quantities of structural timber are shipped in from the west and south. But, in these same sections large areas of potential timber land remain unproductive with a high percentage of them now occupied by speckled alder (Alnus incana Moench)[1/], a species which has no commercial value.

While surveying the literature preparatory to the formulation of a problem, there was found to be a dirth of information concerning alder. It is felt that speckled alder presents a sufficiently serious problem to warrent more study than it has been given in the past. For this reason, and also for reasons of convenience, a problem dealing with speckled alder was formulated.

The scope of the inquiry was limited to the ecology of the alder at Dunbar Forest Experiment Station and was further limited by time available to collect data. There

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1/. Henceforth, the scientific name of all species mentioned will be found in the Appendix.

are at least eleven or twelve different alder types[2/] on the Dunbar Station but time permitted the collection of data on only five of these. The study was accomplished by means of establishing sample plots throughout the stands and recording the data concerning density, frequency, vigor, d.b.h., and height on specially prepared field tally sheets together with a detailed soil analysis. Data was also collected concerning the topography, height of the water table, and the past history of the stands.

The purpose of this study was to discover some of the relationships which exist between the alder and such environmental factors as soil, overstory, shrub and herbacious growth, water table, and past history of the stands.

The author is indebted to Mr. Maurice W. Day, director of the Dunbar Forest Experiment Station, for his kind assistance, the use of his personal library, and for making available the station experiment records; Professors P.W. Robbins and Henry Stoehr for their contributions; Professor Earl J. Hodgkins for reviewing the manuscript and his helpful suggestions; and is especially indebted to Dr. Leslie W. Gysel for his guidance, assistance, encouragement, and patience throughout.

2/ A "type" or "stand" is a unit of vegetation which is determined by the past history, overstory, and soil type.

REVIEW OF LITERATURE

Speckled alder, also known as tag alder, and hoary alder belongs to the family Betulaceae, but is readily distinguished from the birches by its stalked, valvate, winter buds and cones (stobiles) with thick woody scales which persist on the branchlets long after their small winged - fruits (nutlets) have been released (4). Speckled alder is usually a large shrub but often may attain a height of twenty-five feet and a diameter of four or five inches (7). Day (3) states that alder propogates itself by seeding and stump sprouts but never by root sprouting. Due to this sprouting habit it occurs in clumps of several stems. He goes on further to say that the stems are relatively short lived, but because new sprouts appear to replace the dead stems the clump remains and the stands of alder do not thin appreciably with age.

McDougall (12) points out that alder is one of several species of plants which have root tubercles. These, together with the root system of alder may be seen in figure 1. The root tubercles differ from those on leguminous plants in that they are produced through the modification of lateral rootlets while in legumes they are produced as out-growths of the cortex. Alder has the same symbiotic relation with nitrogen-fixing bacteria as do the legumes.

The rapid growth and denseness of alder stands prevent the establishment and growth of other more valuable species(3). If such tolerant species as balsam fir, white cedar and red

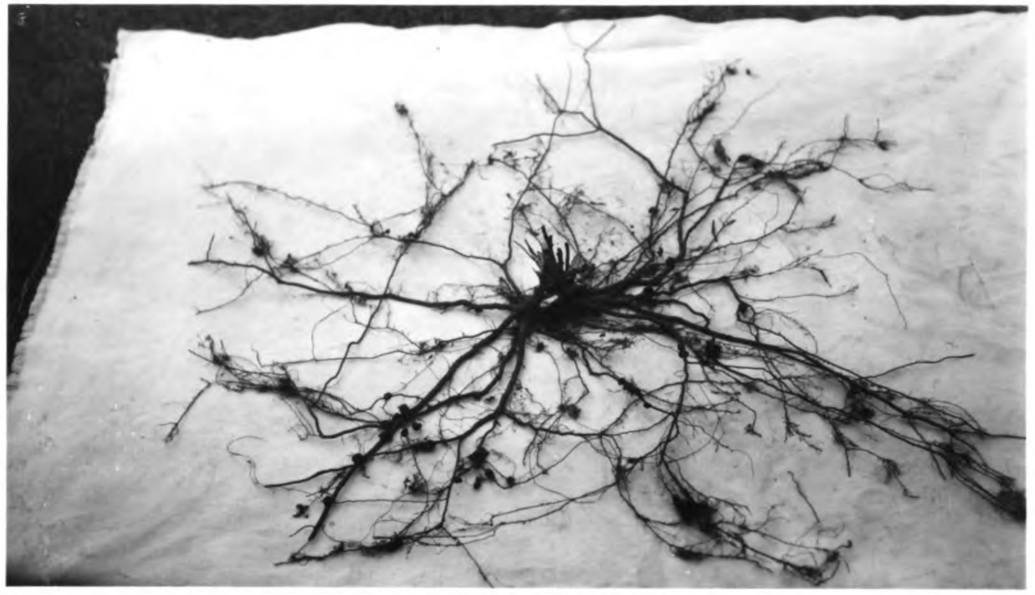

Figure 1. Root system of speckled alder showing root tubercles.

maple are able to become established before the canopy of alder is completely closed, they are gradually able to overtop and replace alder stands. The process is usually very slow (3).

Speckled alder is most common along our northern boundary of the United States, from Newfoundland to Saskatchewan but ranges as far south as Pennsylvania, Iowa, and Nebraska. It is also present, but rare, along the eastern coastal plain where smooth alder is more representative. Speckled alder is distinctly more northern in its range than smooth alder (14).

Alder is most common in swamps and poorly drained areas and along streams, particularly those that are small(14). While alder has been considered intolerant by some workers, a consideration of its growth habits tends to indicate that it is moderately tolerant (3). Day (3) points out that while alder is never found growing under stands of northern white cedar or balsam fir, it is found growing under stands of tamarack, balsam poplar, aspen, and birch. It is also found growing under open stands of red pine and white pine growing in moist sites. Alder is able to withstand flooding and saturated soils, accounting for its presence on stream banks and similar situations (3).

Too little is known about the ecology of alder and its place in succession. McDougall (12) in his discussion on the succession in water divides his discussion into two categories, succession in undrained or poorly drained areas

(typical bogs) and succession in drained areas (swamps). He makes no mention of alder as an invader in the undrained areas. However, while discussing drained areas he states:

> As a depression is filled a stage is reached where the water is at the surface and which is characterized by various species of sedges and grasses. This stage is followed by the shrub stage in which the dominant plants are likely to be willow, alder, and dogwood. The first trees to follow the shrubs are likely to be ashes, soft maple, and elms, which are later replaced, as the substratum becomes drier, by the trees of the climax forest.

Westveld (20) notes that alder occurs on denuded tamarack, northern white cedar, aspen, paper birch, and black spruce sites. Alder was observed on the Dunbar Station invading an old field which had been plowed and which still had the remains of old furrows. The alder was invading only in the furrows where water apparently stands during the season when alder seeds germinate. Alder was also observed at the Dunbar Station to be a primary invader along a receding lake bottom. Le Barron and Neetzel (11) in their studies of clear-cut and drained conifer bog forests, state that the red maple - alder type is an ecologically more advanced stage than the conifer bog forest. It is presumed that the above authors consider a deciduous stand more advanced ecologically than a conifer swamp stand as is exemplified in the plant succession of a bog.

In general then, alder might be considered a primary invader, as far as woody species is concerned, on denuded, undrained sites and in drained swamps.

The utilization of alder in this country is negligible and any silvicultural treatment of alder is directed toward its elimination rather than its increase. Palmer (14), however, does state that alder probably is of considerable importance in anchoring streams to their beds and in providing shelter for trout. He also says that alder is a favored food for beaver which use the bark for nourishment and the sticks for their dams and dwellings. These dams, he goes on further to say, are important in flood control and in building soils. In Europe alder has proven of some value. Steinmeyer (18) reported that a dense cover of grass, which hindered the growth of young spruce and pine, was effectually eradicated within five years by planting white alder. He further states that the alder improves the soil and later serves as a nurse crop for young conifers.

Schulenburg (16) in 1929 reported that in Germany alder does well on dry, rocky and gravelly soils, provided they are not acid, and quickly builds up a humus that enables better species to grow. Robotnov (15) states that alder enriches the soil with nitrogen. Kalela (9) in Finland pointed out that up to ten years alder has a favorable affect on spruce by serving as a nurse tree; later, it retards their growth probably more as a result of root competition than of shade. Eulefeld (5) and his co-workers

in Germany also found alder to be of value as a nurse crop in preparing the ground for better species, especially on dry limestone soils and to be useful in checking coastal dunes, provided its roots could reach water. It does not do well on dry sandy soils. They also found that alder suffers but little from browsing by game. It is interesting to note that European workers associate alder with dry sites while here in America alder is invariably associated with moist sites. In Europe[3/], Alnus incana is called white alder.

The only cultural method employed for the production of alder which could be found in the literature was that put forth by Kundzina (10) of Latvia, in which he states that alder must have full sunlight for good growth. He goes on further to explain that in the coppice method of reproduction, winter cutting results in more and stronger sprouts than spring cutting. He found that the method of cutting (saw or ax) has little affect on sprouting.

Alder apparently does not present a serious problem in Europe where intensive forest management has been in practice for centuries; however, alder assumes a different role in this country where economic conditions still demand a more extensive management of our forests. The detrimental aspects of alder are well recognized by American investigators as is evidenced by the classification of alder as an undesirable species on forest land and its control by

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3/ All European citations made involve Alnus incana although they may be different varieties.

chemical means (3). No articles have been found dealing specifically with alder and its detrimental affect on forest reproduction, but numerous mention is made of alder in connection with low value and unproductive forest land. Specifically, alder prevents or greatly slows down the establishment of forest reproduction on areas where it has become established (3).

Our knowledge of the control of alder is meager indeed, Day (3) found that the cutting of a species which sprouts as readily as alder cannot be a satisfactory method of control. Spring and winter cutting resulted in the most rapid growth and densest stands; July and August cutting resulted in the thinnest stands and least height growth. Le Barron and Neetzel (11) hint at a way that alder might be prevented from becoming the dominant species in the conifer bog type which is to be logged and drained. They point out that conditions for plant growth are greatly improved by drainage and that to insure the development of commercially valuable trees these should be present before drainage is undertaken or else the site will be taken over by alder and other inferior species. No mention is made of eradicating the alder once it has become established.

Much research is being carried out at the present time in connection with the application of various chemicals for the control of alder and other undesirable species. At present, the results and techniques of application are inconclusive though they are gratifying and much hope is

held for further research. It might be noted here that killing the tops with a chemical accomplishes no more than cutting it. Freely sprouting shrubs can be killed only by destroying the tissues that give rise to the sprouts (3).

DESCRIPTION OF AREAS STUDIED

The areas studied are located on the Dunbar Forest Experiment Station in Chippewa County, Michigan, seventeen miles south, south east of Sault Ste. Marie on the St. Mary's River.

The climate (17) of the general area is characterized by a mean temperature of about 40 degrees F., a mean annual precipitation (including melted snow) of approximately 30 inches, and average snowfall of seventy inches a year, high relative humidity, low percentage of possible sunshine, low wind movement, and low evaporation.

The winters are long and frequently extremely rigorous. The mean temperature averages below freezing from November to March, and a minimum of -37 degrees F. has been recorded. The period of warm weather is short and characterized by moderate temperatures with a seasonal average of about 61 degrees F. from June to August.

The frost-free season is about 136 days although light frosts have been known to occur in June, July and August. Precipitation is fairly evenly distributed throughout the year but is generally somewhat greater in the fall and summer than in the spring and winter. Rains are slow or continuous, rarely destructive downpours. Considerable variations in the annual amounts of rainfall are recorded, and short periods of drought sometimes occur. The snowfall, which generally forms a permanent cover from November to April, prevents freezing of the soil to a great depth.

The soils upon which alder was found varied from muck soils to wet sands. The soils, according to description by the Soil Survey (17), were Carbondale muck on two sites, Bruce fine sandy loam, Munuscong fine sandy loam, and Newton sand. For the most part, these soils are poorly drained or are quite moist in the spring and early summer when reproduction becomes established; the upper layers are slightly acid to rather strongly acid.

The vegetative types found were classified as to the present dominant overstory, the history of the stand which affected the vegetation, and the soil type.

These types are as follows:

Stand I - Swamp conifer, logged, Carbondale muck

Stand II - Swamp conifer, logged and burned, Carbondale muck

Stand III- Red Maple - Ash, logged, Munuscong fine sandy loam

Stand IV - Aspen, logged and burned, Bruce fine sandy loam

Stand V - Aspen - balsam poplar, natural, Newton sand

METHODS OF PROCEDURE

Preparatory to making an analysis of the vegetation in the field, aerial photographs of the Dunbar Station were carefully studied and with the aid of Mr. Maurice W. Day, director of the station, tentative alder stands were chosen for study. These stands were then checked on the ground with the photographs and final selection was made. This final selection was based upon diversity of the various stands, accessibility to the stands, and distance of the stands from the authors place of lodging since transportation and time were factors to be considered.

The following strata were recognized and studied accordingly; overstory, alder stratum, tree reproduction, shrubs, and herbs.

The method of analysis of the vegetation was as follows: The overstory was studied by consulting aerial photographs, and beginning at a position about at the center of a side of the stand, tenth acre plots, 33 feet by 132 feet, were uniformly laid out in a straight line across the stand, using only alternate plots in the field. If the limits of a stand were reached before the desired number of plots was obtained, two chains were off-set to the right or left and a line of plots was run parallel and in the opposite direction to the first line of plots.

The overstory tree species were tallied by d.b.h. class, crown position, and vigor. The number of plots

taken varied in different stands from four to seven. The number of plots needed was checked by calculating the standard deviation (not to exceed 2) of the species present. In only one case, stand II, was it necessary to take an additional number of plots.

These same plots were used to study the alder stratum. Data concerning the alder consisted of the average d.b.h., average number of stems per clump, average height of the stems, and average distance between the clumps. A photographic record was made of what seemed typical for the stand as a whole. In addition, several alder clumps were dug up and notes were made of the expanse, depth, and origin of the root systems. A photographic record was also made of the root systems.

Tree reproduction and shrub composition was studied by establishing three mil-acre quadrats, 6.6 feet by 6.6 feet, in each tenth acre plot. The quadrats were laid out midway between the sides along the long axis of the tenth acre plots with the number of plots checked by the standard deviation and standard error methods. The species of reproduction were tallied by the size classes 0 inches to 6 inches high, 6 inches high to 2 feet high, and 2 feet high to 1 inch in diameter (19). Four different densities were recognized in the shrub strata and were tallied accordingly by species:

Density	Area of plot covered
T	0 sq. ft. to 4 sq. ft.
1	4 sq. ft. to 1/3 of plot
2	1/3 of plot to 2/3 of plot
3	2/3 of plot to 3/3 of plot

Inside each mil-acre quadrat a .0025 acre quadrat (3.3 ft. by 3.3 ft.) was established to study the herb composition. Here again the number of plots was checked by the standard deviation and standard error method of the species present. The species found were tallied by the following densities:

Density	Area of plot covered
T	0 sq. ft. to 1 sq. ft.
1	1 sq. ft. to 1/3 of plot
2	1/3 of plot to 2/3 of plot
3	2/3 of plot to 3/3 of plot

A detailed soil profile analysis was accomplished by drilling auger holes in the first and last mil-acre quadrat of each tenth acre plot. From these borings soil profile descriptions were written, pH values (as determined by the Soiltex method) were recorded at the various horizons, and the height of the water table was noted. In addition, notes were made of the topography and drainage.

ANALYSIS OF DATA AND OBSERVATIONS

Soil and vegetation data was analyzed individually for each stand. The vegetation was further subdivided into the various recognized strata. From this analysis the ecology and trends of succession in each stand was traced. It was felt that such a treatment would lend clarity and continuity to the presentation of the analyses and observations.

STAND I - SWAMP CONIFER, LOGGED, CARBONDALE MUCK

Soil Factors

Though this area was mapped as a Rifle peat (17) the author could find no resemblance to the typical Rifle peat. From the evidence of the data collected it is believed to be a Carbondale muck. It is characterized by its dark brown loamy muck which is high in organic matter and slightly acid in reaction. The organic soil ranges in depth from 18 to 24 inches and is underlain by a coarser brown, less decomposed woody material which increases in acidity with depth. Beneath this muck layer, at about 30 to 36 inches, the area is underlain by a mottled, very plastic, gray and red clay which is slightly alkaline in reaction.

The topography is level and the drainage very poor due to the impervious heavy glei substratum. In moist seasons the water table is at the surface with much of the area totally flooded. In dry seasons the water table drops as low as the glei substratum.

Vegetation

Overstory

The original dominant overstory in this stand was composed of black spruce, tamarack, balsam fir and white birch as the predominant species with balsam poplar, ash, and aspen the minor species. In the winter of 1937-38 the area was completely logged-off of everything over five inches in diameter at breast height.

The present dominant over-story was composed primarily of the few trees that were left which were less than five inches in diameter and the reproduction which came in at the time of logging and which was able to gain dominance over the shrub stratum. These species, (table 1) are white birch, balsam fir, tamarack, and balsam poplar, the dominant species, with ash, red maple, aspen, black spruce as very minor species. There are 459 trees per acre in this stand with a total basal area of 10.434 sq. ft. per acre. This clearly indicates that the stand is very much understocked and it is doubtful if a closed canopy will be formed for many years. On the other hand, the more valuable species, with the exception of black spruce, are well distributed throughout the stand; their vigor and crown positions indicate that they are well established and may well form a nucleus around which to work to further stock the stand. There are, however, very few trees in this stand capable of producing seed.

Table 1 - Overstory, Analysis for Stand I.

Species	Number Trees	Basal Area	Frequency	Crown Class[1]				Vigor[2]			
				D	C	I	O	A	B	C	D
		sq. ft.	percent	Number of trees				Number of trees			
White birch	110	2.232	100	43	67	-	-	80	28	2	-
Balsam fir	105	4.909	100	53	35	12	5	83	12	8	2
Tamarack	155	2.038	100	115	22	17	2	142	12	2	-
Balsam poplar	52	.750	100	26	27	-	-	50	3	-	-
Ash	22	.339	33	7	15	-	-	10	7	-	5
Red maple	2	.035	17	-	2	-	-	2	-	-	-
Aspen	8	.075	67	5	2	-	-	5	2	-	-
Black spruce	5	.055	33	-	3	2	-	5	-	-	-
Totals	459	10.434		249	173	31	7	377	64	12	7

1. D - Dominant
   C - Codominant
   I - Intermediate
   O - Overtopped

2. See bibliography (6)

Shrub Stratum

Woody shrubs cover 86.6 percent of the total area of this stand (Table 2). Although eleven species are represented, only four, wild raisin, red osier, willow, and

Table 2. Density and Frequency of Shrub Species in Stand I.

Species	Amount of total area covered	Frequency
	percent	percent
Wild raisin	13.61	50.0
Red osier	19.44	94.4
Willow	7.67	44.4
Alder	37.97	100.0
Juneberry	.25	5.5
Black Alder	2.39	11.1
Hazelnut	1.19	5.5
Gooseberry	2.39	11.1
Elderberry	1.19	5.5
Cokecherry	.25	5.5
Honeysuckle	.25	5.5
Total	86.60	

alder appear to be of any significance; they occupy about seven-eighths of the area covered by shrubs. Of these alder is the predominant species, covering a little less than half the area covered by shrubs. It is felt that the great number of shrubs present, besides alder, can be traced to the fact that the stand was only recently denuded and the alder is just now beginning to overtop them. It was observed that the rigorous competition between the alder and the various shrubs appears to have affected the vigor of both the alder and the other shrubs. The semi-tolerance

exhibited by alder and its inherent rate of height growth characteristics are enabling it to overtop its competitors and gain dominance of the shrub strata.

Herb Stratum

The minor vegetation was quite luxuriant and covered 89.13 percent (table 3) of the total area of the floor of the stand (figure 2). No one species seemed to predominate over any other species. The major species, with reference to their frequency and percent of area covered, were grasses, Joe-Pye Weed, bramble, golden-rod, ground mosses, bunchberry and sphagnum moss. These seven species covered more than three-fourths of the total area. It is this vegetation

Table 3. Density and Frequency of Herb Species in Stand I.

Species	Amount of total area covered	Frequency
	percent	percent
Grass	14.23	67
Joe-Pye Weed	7.35	39
Bramble	12.65	94
Shield fern	5.23	33
Golden-rod	8.91	72
Moss	7.16	50
Bunchberry	10.19	56
Violet	4.59	39
Blueberry	4.44	22
Labrador Tea	1.38	11
Horsetail	4.44	28
Sphagnum moss	8.54	44
Lily	1.02	22
Total	89.13	

Figure 2. Stand I showing dense minor vegetation together with small balsam fir (front right) and tamarack which is characteristic of stand as a whole.

which would offer the major resistance to any tree species becoming established. In most respects the above herb community is typical of a recently "logged-off", unburned bog of relatively high site quality (11).

Tree Reproduction

There is only a fair amount of reproduction in this stand with a good share of it inferior species (table 4). The major species are balsam fir, black ash, tamarack, and white birch. The minor species consist of elm, black spruce, aspen, and red maple. The frequency of the species present indicates that they are only fairly well distributed throughout the stand. The greater number of individuals in the larger size classes suggests that most of the reproduction was present or became established at the time of logging. This is particularly true of ash and aspen which are found only in the largest size class; and no ash or aspen, which are intolerant, have become established since the canopy has closed. It is felt that the rather fast growth rate of these species (ash and aspen) has permitted them to stay in a codominant crown position with the shrubs; this is also true of some tamarack. Tamarack, which has been reported (8) to be extremely intolerant, appears to be much more tolerant in the seedling stage than ash because some tamarack seedlings are present in the smaller size classes while no ash are. White birch, another intolerant species, shows some signs of being tolerant in the seedling stage

Table 4. Stand Table of Reproduction in Stand I.

(per acre basis)

Species	Size Classes: 0-6 in. inch	6 in.-2 ft. high	2 ft.-1 in. diam.	Totals	Frequency
					percent
Balsam fir	444.0	55.5	555.0	1054.5	44.4
Black ash	-	-	1619.5	1619.5	38.8
American elm	-	55.5	-	55.5	5.5
Tamarack	111.0	222.0	666.0	999.0	50.0
Black spruce	111.0	333.0	-	444.0	27.7
White birch	555.0	610.5	55.5	1221.0	33.3
Aspen	-	55.5	222.0	277.5	22.2
Red maple	55.5	55.5	277.5	388.5	11.1
Totals	1276.5	1387.5	3395.5	6059.5	

but almost disappears in the size class between the seedling stage and the size where it shows dominance in the stand. This may be interpreted to mean that no more white birch will come into dominance in the stand than is already in the dominant crown class. Balsam fir, black spruce, and red maple, all being tolerant may persist and eventually gain dominant positions. These three species with the possible addition of tamarack, for some may gain dominant positions before the crowns close, and the individuals which now occupy dominant position, appear to be the only species with any significance in the future of the stand.

Discussion

When this stand was logged it would seem that an insufficient number of trees was left to protect the site. This factor, together with a favorable soil condition led to the invasion of the area by alder and various other woody shrubs. It is not believed that alder was present before logging occurred, at least not to any great extent, since alder seldom exists in the understory of a coniferous forest (3). The saplings and seedlings which have gained dominance in the stand seem to be entirely inadequate to form a closed canopy, at least for many years to come. In the meantime, many of these may also drop out of the stand. The reproduction which has become established is fair in number at present, but as the alder stratum is closing much of it is being eliminated. In addition, both

aspen and tamarack seedlings are suffering greatly from deer browse. Many tamarack were observed which were about eight years old and no more than a foot high because of repeated browsing. A few more tolerant species, namely black spruce, balsam fir, and red maple may persist in the alder substratum for many years and may occassionally break through, but for the most part it is felt, these will be stunted and deformed with a majority being eliminated from the stand. The only trees in this stand which might be of any future significance are those which will have expressed dominance before the alder stratum closes.

Essentially then, the stand, which has had eleven years to develop, is composed of alder and the individuals which were left after logging (figure 2). Furthermore, it is probable that the composition will remain more or less stable for many years or until the tree species have attained a size large enough to close their crowns.

It might be stated, in view of the above observations, that a bog forest on a site of relatively high quality should not be logged to the degree where there is insufficient cover to protect the site against invasion of alder and other woody shrubs. Once established, alder prevents the establishment of further tree reproduction.

STAND II - SWAMP CONIFER, LOGGED AND BURNED, CARBONDALE MUCK

Soil Factors

The soil of this stand is essentially the same as that of stand I. The only differences noted were slightly

Figure 3. Stand I is composed essentially of alder and species which were left after logging.

less depth to the organic matter and slightly more mineral material admixed with the organic matter. All other characteristics noted for the soil in stand I are the same for stand II.

Vegetation

Overstory

The original dominant overstory in this stand was tamarack, black spruce, balsam fir, white birch, and aspen. The area was heavily logged in about 1930 (the exact date is not known); this was followed by a rather light burn which apparently did not harm the residual stand. The trees left when the stand was logged were black spruce smaller than eight inches d.b.h. and tamarack smaller than ten inches d.b.h. with a very few small white birch, balsam fir, and aspen; so few as to be insignificant.

The present dominant overstory is composed essentially of these same individuals (table 5) with the addition of a few pincherry and a greater number of mountain ash which have become established since fire swept the area. There are 260 trees per acre with a basal area of 26.33 sq. ft. per acre. Exactly half of the trees are composed of pin cherry and mountain ash with a total basal area of 1.629 sq. ft. per acre. This leaves 130 trees per acre with practically all the basal area present and with an average diameter at breast height of 5.9 inches. This indicates that the stand is entirely inadequate to produce a quality

Table 5 - Overstory Analysis for Stand II.

(per acre basis)

Species	Number trees	Basal area	Frequency	Crown Class				Vigor			
				D	C	I	O	A	B	C	D
		sq.ft.	percent	Number of trees				Number of trees			
Black spruce	53	10.257	100	48	-	-	6	38	11	45	-
Tamarack	60	13.719	71	54	3	-	1.5	43	12	3.5	1.5
White birch	7	.328	29	6	-	-	1.5	6	1.5	-	-
Balsam fir	3	.153	14	3	-	-	-	3	-	-	-
Aspen	7	.247	14	7	-	-	-	7	-	-	-
Pin cherry	4	.048	43	4	-	-	-	1	3	-	-
Mountain ash	126	1.581	47	12	11	-	1	125	1	-	-
Totals	261	26.333		134	116	0	10	223	29	8	1.5

crop in the future or to have a closed canopy for many years, if ever. The pin cherry and mountain ash may be discounted as far as the future timber crop is concerned and also as a factor in closing the canopy over the alder for they are little more than shrubs themselves.

The primary species of this stand, black spruce and tamarack, are well distributed throughout the stand (table 5) and for the most part are of good dominance and vigor. They are capable of producing sufficient seed in a good year to adequately supply the stand.

Here, as in the first stand, the logging operation opened the stand to such a degree that the alder readily invaded the area and became established.

Shrub Stratum

Woody shrubs cover 91.7 percent of the total area of this stand (table 6). Of this total, alder covers over half the area with viburnum, red osier, and willow as minor shrubs. Also present, but very sparse, are chokecherry, gooseberry, juneberry, and black alder. It is believed that the preponderance of alder is tracable to its inherent height growth and semi-tolerance. This stand has been cut about 8 years longer than stand I and hence alder has had a longer time to assume dominance over the other shrubs.

The greater basal area of the overstory present on this stand than on stand I apparently does not have any affect on the shrub stratum for its density has increased 5 percent over that of stand I. It was observed that the

Table 6. Density and Frequency of Shrub Species in Stand II.

Species	Amount of total area covered	Frequency
	percent	percent
Wild raisin	16.73	95.2
Red osier	10.42	33.3
Chokecherry	4.31	23.8
Alder	47.08	100.0
Gooseberry	1.03	4.7
Willow	6.57	38.1
Juneberry	1.03	4.7
Black alder	4.09	19.0
Total	91.26	

trees in which the greatest amount of basal area was concentrated had less affect upon the alder than the smaller trees. This appears obvious when one remembers that in the larger trees the crowns are far above the alder with a very open canopy and the smaller trees have their crowns directly in the alder stratum or only slightly above, thus affording greater competition to the alder. Some large individuals which had pruned well appear to offer no resistance to the alder for the alder canopy has closed completely against the trunks of these trees.

From the above observations it can be deducted that a cutting operation which leaves a residual stand which is little more than a clear-cutting with seed trees has no place on this type of site.

Herb Stratum

The minor vegetation forms a complete coverage in this stand (table 7). As in the previous stand, it is well diversified and no one species predominates. The great number of species present and their relatively uniform distribution over the stand would seem to indicate the high site quality of the stand. Such species as blueberry, horsetail, Labrador Tea, bunchberry, and Sphagnum are typical of the bog type forest.

Table 7. Density and Frequency of Herb Species in Stand II.

Species	Amount of total area covered	Frequency
	percent	percent
Blueberry	10.5	57
Horsetail	6.9	48
Labrador Tea	9.0	57
Bunchberry	6.5	52
Sphagnum moss	10.8	52
Violet	6.1	48
Moss	10.8	52
Bramble	8.7	57
Strawberry	2.0	10
Horsehound	1.2	10
Golden-rod	9.0	48
Shield fern	8.3	43
Leather leaf	1.0	5
Star-flower	2.6	24
Grass	5.9	29
Lily	2.0	10
Total	101.3	

In this stand, as in the previous stand, the minor vegetation may be a limiting factor in the establishment

of tree reproduction since it is this vegetation which would offer initial resistance.

Tree Reproduction

Reproduction in this stand is exceedingling sparse, having but 2208 individuals per acre (table 8). Sixty-three percent of the reproduction is composed of black spruce, a very tolerant species. All the species present are apparently found in groups as is indicated by the frequency with which they are found; this was observed to be true.

The lack of reproduction can be accounted for in two ways. Much might have been destroyed when fire swept the area and also the dense growth of shrubs and herbs has offered too great a resistance to their establishment. Reproduction which may have become established after the burn when a suitable seed bed was available has since been eliminated by the heavy shrub and herb cover. Black spruce, a very tolerant species, and one which is typical on old burns, has been able to withstand the rigorous competition afforded by the dense shrub and herb covering to a greater degree than the other species of reproduction.

The greater number of individuals in the larger size classes, excluding black spruce, points to the fact that tree reproduction has ceased to become established since the shrub canopy has closed.

Of the more tolerant species present, namely black spruce, balsam fir, and red maple, only black spruce is likely to be of any significance in the future stand for red

Table 8. Stand Table of Reproduction in Stand II.

(per acre basis)

Species	Size Classes			Totals	Frequency
	0-6 in. high	6 in.-2 ft. high	2 ft.-1 in. diam.		
					percent
Black spruce	464.8	464.8	464.8	1394.4	28.6
Balsam fir	-	58.1	-	58.1	4.7
White birch	58.1	-	58.1	116.2	9.5
Mountain ash	-	-	232.4	232.4	9.5
Red maple	-	58.1	58.1	116.2	9.5
Tamarack	-	58.1	232.4	290.5	32.8
Totals	522.9	639.1		2207.8	

maple and balsam fir are almost insignificant in number. It is also doubtful if the role of black spruce will be any more than very minor unless some cultural methods are applied to release it; the alder overtops the spruce completely, giving it a distinct advantage over the spruce in their fight for survival. This would not be economically feasible at present.

Discussion

This stand is similar to stand number one in soil type and because it was logged to such a degree that insufficient cover was left to protect the site against the invasion of alder. Their differences lie in the fact that in this stand, a few larger black spruce and tamarack were left behind and also the area was swept by a light fire following logging. In addition, this stand was denuded about eight years before stand I, hence it has had eight more years to develop. The fire did no apparent harm to the overstory but seems to have aided the shrub stratum by eliminating some advance reproduction which might otherwise have gained dominant positions. The reproduction which has become established since the burn is largely black spruce with the other species minor in number. It is felt that black spruce is the only species of great enough tolerance or of sufficient number to be of any significance in the future; the other species will more than likely be eliminated because of excess competition from the shrub stratum or are insignificant in number (red maple and balsam fir).

It is possible that this stand will reach a more or less stable condition in that the overstory will be unable to close a canopy over the alder. However, it may be very slightly dynamic because of the black spruce and a very few red maple and balsam fir which may possibly persist in the understory and occassionally break through to a dominant position. This will be an exceedingly slow process however and it will be many years before the alder will be appreciably diminished.

STAND III - RED MAPLE - ASH, LOGGED, MUNUSCONG FINE SANDY LOAM

Soil Factors

The topography of this stand is level and the soil is characterized by a thin covering of black or dark brown organic matter which was slightly acid in reaction. Beneath this covering was found a layer of fine sandy loam underlain by fine sand as far as the auger would reach. Acidity was found to increase with depth.

The soil found on this stand was mapped (17) as Munuscong fine sandy loam, but there is a question in the mind of the author if this was the correct interpretation since no clay layer at 12 to 24 inches was encountered as is found in the typical soil. If a clay layer does exist it is at a greater depth than four and a half feet, the length of the soil auger used.[4/] It is possible however that a clay

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4/ At this point the author showed very poor judgement by not digging a soil pit to obtain a profile at a greater depth.

layer or a hard pan does exist, for the area is poorly drained. All other features found in the profile of this soil are characteristic of Munuscong fine sandy loam.

In early summer when the data on this stand was collected the water table was at the surface of the ground, About one month later it had dropped to two feet below the surface. During this period no rain fell. If this soil is a Munuscong fine sandy loam, it is believed that this phase is slightly better drained than the typical soil.

Vegetation

Overstory

The original overstory in this stand is not definitely known for the records of the Dunbar Station do not go back that far and no one could be found who knew of the original cover or subsequent treatment, but it is believed to have been composed of swamp conifers and swamp hardwoods, namely tamarack, balsam fir, red maple, black ash and elm. This is supported by the fact that several, large, old tamarack are scattered throughout the area, that the red maple present appear to have originated from stump sprouts, and that ash is well represented in the stand, as well as elm. The area probably was "logged-off" about forty years ago for red maple sprouts were found which were about forty years old. For matters of convenience, and since no evidence exists to the contrary, it will be taken for granted that the stand was logged-off.

Table 9 - Overstory Analysis for Stand III.

(per acre basis)

Species	Number trees	Basal area	Frequency	Crown Class				Vigor			
				D	C	I	O	A	B	C	D
		sq. ft.	percent	Number of trees				Number of trees			
Ash	123	10.778	83	29	62	23	10	50	48	21	5
Red maple	168	11.033	100	14	88	28	37	34	58	60	15
Elm	10	2.106	33	6	2	2	-	2	6	2	-
Tamarack	15	6.536	33	16	-	-	-	8	6	2	-
Aspen	2	.427	17	-	2	-	-	2	-	-	-
Totals	316	30.809		65	152	63	38	96	118	85	20

The present dominant overstory (table 9) is composed primarily of red maple and ash with a very small smattering of aspen, elm, and the residual tamarack. There is a total of 315 trees per acre with a basal area of 30.809 sq. ft.; the average diameter is 4.2 inches at breast height. This stocking is not sufficient to produce quality timber in the future as is evident by the poor form of the stand. Ash, an intolerant species, shows much better form than the red maple where it has reached a dominant position in the stand. The stocking however will be sufficient, to eventually close a canopy over the alder which became established at the time of logging. Here again it is felt that alder was not present to any great degree before denudation, because of the composition of the original overstory. The poor vigor of many of the overstory trees (table 9) is even now showing the affects of the competition which is going on in the stand and much of the alder has already been overtopped and eliminated.

Succession in this stand, from an alder type, appears to have been carried farther than in any previous stand studied. It seems probably that the future stand will be composed almost exclusively of red maple and ash, with red maple the predominant species.

Shrub Stratum

The shrub stratum of this stand covers only 36.8 percent (table 10) of the total area with alder composing nearly 100 percent of this total. Very minor shrubs are willow and spiraea.

Table 10. Density and Frequency of Shrub Species in Stand III.

Species	Amount of total area covered	Frequency
	percent	percent
Spiraea	1.19	5.5
Alder	34.16	100.0
Willow	1.45	11.1
Total	36.80	

There is evidence in the stand that at one time alder covered a much greater area than it does at present for there are many dead clumps, partially dead, and little mounds of refuse which are all that remain of old clumps. The clumps which now remain are tall and spindly with few stems per clump (table 21) and very sparse crowns. The red maple and ash, which apparently came from stump sprouts, showed more vigor than would have been shown by seedlings and were able to compete successfully with the alder for dominance in the stand. For this reason it seems that alder is definitely on its way out and the stand is composed of more favorable species, though still not of great economic value.

Herb Stratum

The herbs present on this stand cover about 80 percent of the total area and though the vegetation is rather diversified, grass is by far the most common species found (table 11). Others which appear of some importance are shield fern, violet, horehound, and rubus.

Table 11. Density and Frequency of Herb Species in Stand III.

Species	Amount of total area covered	Frequency
	percent	percent
Shield fern	7.35	38.8
Violet	13.59	72.2
Horehound	8.54	44.4
Grass	27.91	88.8
Bramble	8.81	50.0
Golden-rod	3.48	16.6
Strawberry	1.19	5.5
Iris	3.67	38.8
Jewel-weed	1.93	22.2
Parsnip	1.19	5.5
Star-flower	1.65	16.6
Horsetail	.26	5.5
Total	79.57	

Grass appears to be the most significant species found in that it is the most widely scattered over the stand and has the greatest density. Where it is found in heavy densities it offers maximum resistance to the establishment of tree reproduction. It is believed that the other species present, with the possible exception of bramble and the shield ferns, offer little resistance to the establishment of reproduction.

Tree Reproduction

This stand is adequately stocked with reproduction as far as the number of individuals is concerned, having 10,156 seedlings per acre (table 12). The most abundant species is red maple with nearly four-fifths of the total present. This great predominance of red maple is due to the great

Table 12. Stand Table of Reproduction in Stand III.

(per acre basis)

Species	Size Classes			Totals	Frequency
	0-6 in. high	6 in.-2 ft. high	2 ft.-1 in. diam.		
					percent
Red maple	4440.0	1554.0	1554.0	7659.0	88.8
Ash	166.5	388.5	1110.0	1665.0	66.6
Elm	-	-	55.5	55.5	5.5
Sugar maple	555.0	222.0	111.0	888.0	22.2
Totals	5161.5	2164.5	2830.5	10,156.5	

number of seed trees present and the tolerant nature of the species. Ash will be of little importance in the stand in the future for as the crowns close the individuals which are not in a dominant position will be eliminated. Even now, few new individuals are becoming established. The number of elms is insignificant. It is quite probable that the sugar maple which is present will not survive to become a component of the future stand. This is indicated by the decrease in the number of seedlings in each successively larger size class. It is quite possible that they are "off-site" with excess moisture the limiting factor.

Though the tamaracks present are capable of producing abundant seed, no tamarack reproduction is present. This being accounted for by the intolerant nature of the species.

Discussion

Stand III differed from the two previous stands in that at the time it was logged it contained a good share of swamp hardwoods, which sprout vigorously when they are cut, in addition to the swamp conifers which do not sprout. This stand apparently was cut equally as heavy as either stand I or II and alder apparently invaded just as readily, but the marked difference in the results would appear to be that the vigorously sprouting red maple and ash were able to compete successfully with the alder and eventually will eliminate it. It has taken about 40 years for the stand to develop to the point where alder no longer appears to be the controling influence on the stand and is effectually being eliminated.

The red maple in turn having a characteristic greater height growth than the ash might quite possibly eliminate this species from the stand (figure 4).

Reproduction appears to be very adequate in this stand with red maple overwhelmingly in the majority. Perhaps much of this reproduction may take the place of the alder and ash as they are eliminated since red maple is a very tolerant species. Along with the red maple reproduction, some sugar maple reproduction is appearing. The future of this species in the stand is not known but it appears to be "off-site" because there are no seed trees of this species in the stand and no individuals greater than about four feet high. It seems that the trend in this stand is away from an alder type toward a swamp hardwood type in contrast to the original mixed swamp conifer-swamp hardwood type.

From all evidence it would seem to be much safer to clear cut a stand of the above original composition than to apply the same treatment to a pure swamp conifer type, for in the former, vigorous sprouts readily appear and eventually eliminate shrubs which become established at the time of denudation, while in the latter, no sprout growth appears.

STAND IV. ASPEN, LOGGED AND BURNED, BRUCE FINE SANDY LOAM.

Soil Factors

The soil on this stand is a typical Bruce fine sandy loam. The first two to four inches is composed of dark brown, decomposed organic matter with a pH of 6.0 underlain with fine gray sand which shows slight streaks of yellow

Figure 4. Stand III. Red maple and ash are overtopping the alder and will soon eliminate it. The above photograph shows the red maple to have better form than is characteristic for the stand as a whole. The alder clump is also larger than is characteristic of the stand.

due to the high water table. The poor drainage is due to its low-lying position in the general relief. At greater depths the soil becomes more acid.

The topography is level and the area has a high water table, as mentioned above, which is at the surface during the moist seasons and which may drop as low as three and half feet during the dry seasons.

Vegetation

Overstory

The original overstory of this stand was composed primarily of swamp conifers, namely tamarack, black spruce, balsam fir, white birch and aspen. In 1934 or 1935 the area was completely "logged-off" except for a very light scattering of birch and balsam fir. In 1935 the area was swept by fire, though it was not of great intensity since a few residual trees were left unharmed.

The present stand is composed of the original individuals which survived the fire and aspen. There are 4535[5/] trees per acre present with a total basal area of 40.2325 sq. ft. (table 13). This indicates that the stand is fairly well stocked and of sufficient density to insure good natural pruning. The stand as a whole is very uniform in its composition and character, the aspen and alder being even aged. This is characteristic of old burns where aspen has invaded.

5/ The number of trees in each size class was estimated with no exact count being made.

Table 13 - Overstory Analysis for Stand IV.

(per acre basis)

Species	Number trees	Basal area	Frequency	Crown Class				Vigor			
				D	C	I	O	A	B	C	D
		sq. ft.	percent	Number of trees				Number of trees			
White birch	2.5	.340	25	2.5	-	-	-	2.5	-	-	-
Balsam fir	15.0	2.204	25	12.5	-	-	2.5	2.5	-	5	7.5
Aspen	4517.0	37.688	100	377.0	2240	950	955	-	-	-	-
Totals	4535	40.232		392	2240	950	957	5.0	-	5	7.5

After the area was burned alder invaded and became established. This together with a vigorous stand of root sprouts of aspen took over the site. The vigorous nature of the aspen sprouts probably enabled them to remain in a codominant position with the alder until the alder had reached its maximum height growth. At present, the aspen is just beginning to over top the alder but as yet is not closing its crowns. It is doubtful if the aspen even with a closed canopy, will ever entirely eliminate the alder since aspen has a very sparse canopy, and, as was pointed out by Day (3), alder is often found growing under stands of aspen. A closed aspen canopy probably would materially reduce the quantity and quality of alder and permit other more tolerant and valuable species to become established. In this case, it would probably be the original swamp conifer type, black spruce and balsam fir.

The smaller trees (one inch d.b.h.) for the most part are codominant (table 13)[6/], intermediate or overtopped with none in the dominant crown class. The smaller individuals are suffering greatly because of the intense competition and many will soon be eliminated. It is felt however, that a sufficient number will remain to insure a closed canopy of aspen.

6/ No data was taken on the vigor of individual trees but in general it was noted that overtopped and intermediate trees were of rather poor vigor while codominant and dominant trees were of good vigor. In addition, the number of trees in each crown class was estimated with no actual count being made.

Another factor at work in this stand is the Hypoxylon canker of aspen. At present the stand is fairly heavily infected and unless some control methods are applied the disease may be a limiting factor in the succession of the stand for it can account for the killing of many trees in a relatively short time.

Shrub Stratum

The shrub stratum covers 54 percent of the total area of the stand with alder accounting for 40 percent of this total (table 14), wild raisin and gooseberry being fairly minor. There is evidence in the stand that the shrub cover at one time was much greater but the intense competition which has taken place has eliminated much of it. The vigorous aspen sprouts were able to compete successfully with the shrubs and are now beginning to dominate the stand.

Table 14. Density and Frequency of Shrub Species in Stand IV.

Species	Amount of total area covered	Frequency
	percent	percent
Wild raisin	10.47	80.0
Alder	40.49	100.0
Gooseberry	3.05	30.0
Total	54.01	

Herb Stratum

The herb stratum covers 92 percent of total area of the floor of the stand (table 15). Grass is the dominant species

Table 15. Density and Frequency of Herb Species in Stand IV.

Species	Amount of total Area covered	Frequency
	percent	percent
Horsetail	9.90	70
Moss	12.76	60
Bramble	19.56	100
Golden-rod	10.65	50
Grass	22.31	100
Aster	6.88	40
Violet	2.11	10
Lily	2.57	20
Forehound	2.11	10
Star-flower	.46	10
Shield fern	1.38	30
Sarsparilla	.46	10
Purchberry	.46	10
Dandelion	.46	10
Iris	.46	10
Total	92.54	

closely followed by several bramble species with moss, golden-rod, and horsetail fairly prominent species and well distributed throughout the stand. The remainder of the species present are very minor. Such species as grass and rubus point to the fact that the overstory crown is not exceedingly dense for these are fairly intolerant species. The dense herb covering in this stand will offer resistance to the establishment of tree reproduction. However, it is possible that as the stand matures the herb stratum will be reduced

and if an adequate seed supply were available a suitable stand of reproduction might be established.

Tree Reproduction

Reproduction in this stand is practically nil (table 16). Only two individuals were found in the plots tabulated; these were one tamarack about ten inches high and a balsam fir of the same size. There are exceedingly few trees present which are capable of producing seed. It is felt that if there were seed trees present that in time a good stand of reproduction could be established. The author was informed by Mr. Day that during the winter months when snow covers the area and a crust forms on top, several conifer seeds were observed in this area which had been blown from a nearby stand. It is extremely doubtful if sufficient seed could be obtained in this manner to supply the area. It would however establish a few conifers which in time could supply more seed. This would of course be a very slow process.

Discussion

Stand IV is similar to stand III in that a species was present at the time of denudation that was able to propogate vegetatively immediately after denudation occured. Aspen is especially notable in this respect since the suckers which appear are not restricted to the old stump but will appear wherever the spreading root system of the original tree extends. The moist nature of the soil in this area provided an excellent seed bed for alder, thus permitting it to invade

Table 16. Stand Table of Reproduction in Stand IV.

(per acre basis)

Species	Size Classes			Totals	Frequency
	0-6 in. high	6 in.-2 ft. high	2 ft.-1 in. diam.		
					percent
Tamarack	-	100	-	100	10.0
Balsam fir	-	100	-	100	10.0
Totals		200		200	

and become established. However, the vigor of the aspen suckers which appeared about the same time, has enabled them to compete successfully with the alder (figure 5). The greater inherent height growth of aspen is apparently enabling it to overtop the alder and eventually close its canopy. It is felt however, that the canopy of aspen will not entirely eliminate the alder but it will reduce it appreciably and permit more tolerant and valuable species to become established in the understory.

It is not known to what extent the fire which swept the area affected the residual overstory. It is believed however that it was not of great intensity since some trees do remain from the original stand. Most probably the greatest significance of the fire lies in the extent that it affected tree reproduction, though it more than likely also killed some trees capable of producing seed. Stands of tolerant species, which have aspen in mixture, characteristically have some reproduction present in the understory. For this reason it is felt that reproduction was present after the area was logged and this reproduction was destroyed by the fire. If the fire had not occured there probably would now be a much greater amount of reproduction present to form an understory as the aspen overstory reduces the alder. As it is, the process of obtaining natural reproduction in this stand will be exceedingly slow since no seed trees are available in the immediate vicinity.

If the Hypoxylon canker on the aspen is not checked in

Figure 5. Stand IV. Aspen beginning to overtop the alder. Grass and herbaceous growth are a hinderance to tree reproduction establishment.

its spread and if sufficient reproduction does not become established there is a chance that the stand will open sufficiently to once again permit the alder to become the dominant species in the stand. It might be pointed out that aspen is a pioneer species which depends upon cutting and fire for its perpetuation. The complex factors working make it difficult to predict the ultimate succession in this stand if it is left untreated by man. At present though, it is felt that the trend is toward a pure, even aged aspen type with a thin swamp conifer understory.

STAND V. ASPEN - BALSAM POPLAR, NATURAL, NEWTON SAND.

Soil Factors

The soil found on this stand is a Newton sand and is different than any soils found previously in that the surface layers are strongly acid. The surface is covered with one to two inches of decomposed organic matter and is underlain with a gray-brown to gray, medium textured sand, highly leached, with smoke-colored stains as evidence of standing water. The surface layers have a pH of 5.5 and the acidity increases with depth to a pH of 4.5 at three feet.

The topography is level with poor drainage; the water table being generally at about 15 inches though during wet seasons it is at the surface and during dry seasons it is found as low as three and a half feet. When this particular stand was examined in late summer no rain had fallen for about a month and a half; the water table was three and a half feet below the surface and the surface layers were extremely dry.

Vegetation

Overstory

From all information the author was able to obtain and from all appearances, this is a natural stand with no treatment in the past such as logging or fire. It is quite possible that many years ago this stand originated in a manner similar to stand IV but there is no evidence remaining that it did. For the most part, it is old and decadent; the overstory being composed of balsam poplar, willow, and aspen. There are 130 trees per acre with a total basal area of 21.209 sq. ft. (table 17). The site is quite poor; hence the overstory trees are of rather poor vigor, and do not attain a very great size. The aspen in particular is of poor vigor due to the prevalence of Hypoxylon canker.

The stand has been opened excessively by the death of many of the dominant trees. When an opening is created both aspen and balsam poplar root suckers appear along with alder and other shrubs. It is felt that at one time this stand was an evenaged stand composed entirely of aspen and balsam poplar, but with decadence it has changed to an uneven aged, poorly stocked stand with a large percentage of alder in the understory. It is extremely doubtful that the young aspen and balsam poplar will ever succeed in closing their crowns to form a canopy over the alder. For this reason it is felt that the stand will continue in the direction it is headed, i.e., toward a pure alder type.

Table 17 - Overstory Analysis for Stand V.

(per acre basis)

Species	Number trees	Basal area	Frequency	Crown Class				Vigor			
				D	C	I	O	A	B	C	D
		sq. ft.	percent	Number of trees				Number of trees			
Balsam poplar	47.5	7.907	75	25	10	10	2.5	10	22	13	2.5
Willow	12.5	.925	50	2.5	7.5	-	2.5	-	-	-	12.5
Aspen	70.0	12.377	75	45	20	-	5.0	17	20	17	15
Totals	130.0	21.209		72.5	37.5	10	10.0	27	42	30	30

Shrub Stratum

The shrub stratum of this stand covers 87 percent of the total area with alder, comprising about three-fourths of the area covered, the dominant species; the other species present are quite minor, both in their occurance and in percent of area covered (table 18).

Table 18. Density and Frequency of Shrub Species in Stand V.

Species	Amount of total area covered	Frequency
	percent	percent
Sweet Gale	8.12	33.3
Wild Rose	1.79	8.3
Willow	5.37	25.0
Red osier	3.58	16.6
Alder	61.11	100.0
Spiraea	7.57	8.3
Total	87.54	

No doubt alder existed in the understory of this stand prior to the time extreme decadence set in, since, as was pointed out elsewhere in this paper, alder is often found in the understory of open crowned species. It is presumed that as more overstory trees passed out of the stand more space became available for alder to become established along with suckers of aspen and balsam poplar. Since alder is slightly more tolerant than aspen or balsam poplar, it has an advantage over these species in the present environment of partial shade.

It is felt that as more of the overstory trees drop out of the stand that the alder stratum will become more dense making it even more difficult for tree reproduction to become established. Also as the alder becomes more dense the other shrubs present will be eliminated since they are rather intolerant species.

Herb Stratum

The minor vegetation covers about 92 percent (table 19) of the total area of the stand; grass being the dominant species, occupying 43 percent of the total area, with sedges, golden-rod, and bramble of some importance. The remainder of the species are quite minor both in area covered and in occurance.

Table 19. Density and Frequency of Herb Species in Stand V.

Species	Amount of total area covered	Frequency
	percent	percent
Grass	43.25	83.3
Golden-rod	7.53	41.7
Parsnip	3.95	25.0
Sedge	11.87	33.3
Jewel weed	2.20	16.6
Horehound	5.88	33.3
Iris	.37	8.3
Moss	3.03	25.0
Bramble	11.43	50.0
Joe Pye Weed	.37	8.3
Wild rose	1.74	8.3
Total	91.62	

The character of the minor vegetation, as in Stand IV, points to a rather open condition of the overstory canopy. The density of the herb covering indicates that much resistance would be offered to the establishment of tree reproduction. This is especially true since a high percentage of the herbaceous vegetation is composed of grasses and sedges; these forming a cover on which it is exceedingly difficult for reproduction to become established.

Tree Reproduction

The tree reproduction on this stand is little better than the reproduction found on the previous stand (table 20). It is composed entirely of balsam poplar. There are about 750 individuals per acre and their frequency of occurance indicates that they are found in clumps, possibly in openings created by the death of overstory trees.

Since balsam poplar is an intolerant species it is doubtful if very much of the reproduction present will be able to survive the competition of the increasingly dense alder, and since no other reproduction is present it is believed that in time both aspen and balsam poplar will be eliminated from the stand.

Discussion

This stand is similar to stand IV in that it is deficient in tree reproduction capable of existing in the understory of the present stand. They are disimilar in their soil types, though not extremely so, and in their respective stages of development. Stand IV is young with the aspen

Table 20. Stand Table of Reproduction in Stand V.

(per acre basis)

Species	Size Classes			Totals	Frequency
	0-6 in. high	6 in.-2 ft. high	2 ft.-1 in. diam.		
					percent
Balsam poplar	249.9	166.6	333.2	749.7	25

just beginning to overtop the alder while stand V is old and decadent.

The overstory of this stand is of quite poor vigor. This is believed traceable to the rather infertile soil and the prevalence of Hypoxylon canker of aspen. As dominant trees drop out of the stand space is made available for the establishment of alder, aspen and balsam poplar. It is felt that the greater tolerance of alder will permit it to eliminate most of these sprouts since it will be better able to compete in the present environment of partial shade.

It is very possible, since no other reproduction is present besides balsam poplar, that as the overstory becomes more and more decadent and fewer dominant trees are left standing that the alder will completely take over the site. It is felt that this is the present trend in succession. It might be pointed out here again that balsam poplar, as well as aspen, is a species which depends upon cutting and fire for its perpetuation.

MISCELLANEOUS OBSERVATIONS

Requirement for Germination of Alder Seed

No extensive study was made of the requirements for the germination of alder seed but several observations were made in the field which the author believes to be significant. The first of these is that alder was observed invading an old field which had at one time been under cultivation and in which the old furrows still remained. Alder was becoming established in these furrows and in these furrows only. The furrows, where alder had not as yet become established, appeared to have the same ground cover, namely grass and weeds as the higher ground between the furrows. The only difference in the two sites, as was pointed out by Mr. Day, is that water stands in the furrows during the spring and early summer while it does not on the higher ground.

The second observation is that at no time was alder observed on sites which do not have standing water or a saturated soil at least during the spring months.

From these observations it is felt that alder requires at least a saturated soil on which to germinate and to become established.

Changes in Moisture Requirement of Established Alder

While alder was never found on sites which do not have a saturated soil during the spring months it was observed on sites which become extremely dry during the late part of the summer. Several alder were dug up on one of these sites and the soil was found to be powdery dry and dusty to a depth of

two feet below the deepest roots. (Most of the root system was in the first four inches of the soil with none below six inches (figure 6). Yet the alder appeared to have suffered no ill affects.

From the above observations it could be deduced that once alder is established its moisture requirements change and that the height of the water table is significant to the existance of alder only during the spring of the year when the alder seeds germinate and the seedlings become established.

Optimum Conditions for Alder Development

It is felt that none of the stands investigated present optimum conditions for the growth and development of alder, for alder was observed on one site (figure 7) where it attained an average d.b.h. of about five and a half inches and an average height of about twenty-five feet. In addition, the alder on this site attained a greater age than any other site investigated. Here ring counts were made on several stems and the stems were found to be about twenty-six years old; the oldest stems found elsewhere were about eighteen years old. These older stems appeared to be of very good vigor with no signs of decadence.

This site which appeared to be optimum for alder was artificially created when clay was pumped on Sand Island while the channel of the St. Mary's River was being dredged. The clay forms a four to five inch layer over what was mapped as Shelldrake sand, a well drained soil. The clay

Figure 6. Root systems of alder are shallow and spreading. Majority of roots are in first four inches of soil with few below six inches.

Figure 7. Artificial site created by dumping clay over Shelldrake sand. (See text.)

is only slightly acid.

It is not known if the alder was present when the clay was pumped onto the island, however, it is felt that it was not; Shelldrake sand is a well drained soil and it is doubtful if the alder could have survived the covering clay.

It appears from the above conditions that alder makes optimum growth on a clay soil which is well drained, however, it is only an indication since no exhaustive study was made but only the above observations noted.

Alder Establishment

Data was collected concerning the average number of clumps per acre, average number of stems per clump, average height of the stems and average diameter of the stems. This data is summarized in table 21 together with the density of the alder taken from tables 2, 6, 10, 14, and 18 and appears to indicate some rather definite characteristics of alder.

Table 21. Summary of Data from Alder Strata of all Stands.
(per acre basis)

Stand	Density	Average number clumps	Average number stems	Average height of alder	Average diam.	Average number stems per clump
	percent					
I	37.97	333	1805	7.5	.66	5.4
II	47.08	362	1977	9.6	1.00	5.5
III	34.16	243	1146	17.1	1.6	4.8
IV	40.49	266	1654	13.3	1.1	6.2
V	61.11	175	2268	17.6	1.9	12.4

Stand V indicates that once alder has become established the number of clumps present does not increase as the stand becomes more open but that the clumps merely increase in size, i.e., the number of stems per clump becomes greater and the crown of each clump occupies more space. This may also indicate that perhaps alder sprouts are more tolerant than alder seedlings, in opposition to Baker who states that sprouts are more intolerant than seedlings. He further states that sprouts must have full sunlight for best development. This does not appear to be true for alder since it was observed to be sprouting vigorously in very dense shade, yet there were no seedlings present. This is probably due to the fact that alder sprouts obtain food for growth from the rest of the plant and need not make their own food. Seedlings of alder, on the other hand, must manufacture their own food as soon as the endosperm of the seed is gone. This is difficult for them to do since they are a semi-tolerant to intolerant species. These observations are further supported by the facts that stand V has the fewest number of alder clumps per acre of all the stands investigated, yet it has the greatest number of stems per acre and the greatest density (area occupied by alder).

There seems to be a slight tendency for alder to become established at a greater density (number of clumps per acre) in stands which have been burned over. This may be observed by comparing stands I and II and stands III

and IV. Stands I and II are both on Carbondale muck but stand I was not burned. In like manner, stand III and IV are on very similar sandy soils but stand IV was burned and has the greater number of clumps per acre while stand III was not burned. It is not known whether this increase in density on the burned stands is significant or not since insufficient data was taken to be analyzed statistically; it is merely an indication. It is believed that in the burned stands alder occupies space which would have been occupied by some advanced reproduction if fire had not swept the area.

From the above data (table 21) stand I, II, III and IV)[7/] it appears that alder invades with a greater density (number of clumps per acre) in the organic soils than in the sandy soils but there is little or no difference in the number of stems per clump on these two different types of soil. However, here again, it is felt that insufficient study has been made to come to any definite conclusions in this matter; many other factors may be concerned here and the author merely wishes to call attention to certain indications which were observed.

7/ It is felt that stands I, II, III, and IV can be compared because they have had similar treatment while stand V appears to be a natural stand.

SUMMARY

This study was undertaken to discover some of the relationships which exist between speckled alder and such environmental factors as soil, overstory, shrub and herbaceous growth, water table, and past history of the stand. The scope of the inquiry was limited to the relationships which exist at the Dunbar Forest Experiment Station.

A summary of findings follows:

1. Speckled alder appears to be a semi-tolerant shrub which requires a moisture saturated seed bed for germination and establishment. Once alder is established it is felt that its moisture requirements change for alder does not appear to suffer any ill affects during periods of drought.

2. Alder was observed to be a primary invader following denudation on all sites investigated. All sites had a moisture saturated surface soil during the germination period of alder seed.

3. There seems to be a tendency , on sandy sites, for mixed swamp conifer-swamp hardwood stands, which have been denuded, to revert to an alder-swamp hardwood phase and eventually to a swamp hardwood type.

4. It appears that swamp conifers will ultimately succeed the alder phase on organic sites which have been denuded.

5. On aspen - alder and aspen - balsam poplar - alder sites where no tolerant tree reproduction is becoming

established, it appears that alder will succeed these species.

6. Shrub and herbaceous growth (particularly alder) appear to be limiting factors to the establishment of tree reproduction on most alder sites.

7. Fire, because it destroys advanced tree reproduction, thus providing more space for alder development, appears to have a greater detrimental affect on swamp conifer stands than on stands which are capable of reproducing by means of root suckers.

8. Once alder has become established as the dominant species of a stand, it requires many years for tolerant tree species to appreciably diminish the alder.

9. Hypoxylon canker of aspen appears to be a definite threat to aspen stands, particularly in stands where no tolerant species of tree reproduction are present, since it hastens decadence which in turn provides more space for alder.

BIBLIOGRAPHY

1. Barick, F.B. 1945. Environmental analysis of forest edges in relation to wildlife. Tran. of 10th North Am. Wildlife Conference.

2. Cain, S.A. 1943. Sample plot technique applied to alpine vegetation in Wyoming. Am. Jour. Bot. 30:240-247.

3. Day, M.W. 1947. The control of certain shrubs in the Lake States. Master of Science thesis. Original filed at Univ. of Calif. Library, Berkeley.

4. Encyclopedia Americana. 1947 Edition. American Book - Stratford Press, Inc. New York.

5. Eulefeld, et al. 1929. Die Weisserle. Deutsche Forstzeitg. 44(21):538-541

6. Goetzen, C.B. et al. 1943. Suggested hardwood tree classification for farm foresters. U.S.D.A. Forest Service. Region 9. Milwaukee, Wisconsin.

7. Harlow, W.M. 1942. Trees of the eastern United States and Canada. McGraw-Hill Book Company, Inc. New York.

8. Harlow, W.M. and E.S. Harrar. 1941. Textbook of dendrology. McGraw-Hill Book Company, Inc. New York.

9. Kalela, E.K. 1936. The development of white-spruce-white alder mixed stands in eastern Finland, Acta Forest. Fennica. 44(2):1-198.

10. Kundzina, A. 1937. The influence of certain factors on the vegetative reproduction of white alder, Reports. Latvian Forest Res. Sta. 8:3-45.

11. Le Barron, F.K. and J.R. Neetzel. 1942. Drainage of forested swamps. Ecology. 23(4):457-465.

12. McDougall, W.B. 1949. Plant Ecology. Fourth edition. Lea and Febiger. Philadelphia.

13. Oosting, H.J. 1948. The study of plant communities. W.H. Freeman and Company. San Francisco, Calif.

14. Palmer, E.L. 1949. Fieldbook of natural history. McGraw-Hill Book Company, Inc. New York.

15. Robotnov, T.A. 1939. Types of Alnus incana stands in the northwestern part of Moscow Province. Botanicheskii Jhurnal S.S.S.R. (Jour. Bot. U.S.S.R.) 24(1):15-29.

16. Schulenburg, von D. 1929. Erfahrungen mit der Weisserle als Vorfrucht fur verwilderte Waldboden. Deutsche Forstztg. 44(37):952-955.

17. Soil Survey of Chippewa County, Mich. U.S.D.A. Series 1927. Number 36. J.O. Veatch, in charge.

18. Steinmeyer, W. 1932. Praktische Erfahrungen mit dem Anbau der Weisserle. Deutsche Forst-Ztg. 47(51):1069-1071.

19. Webb, W.L. 1942. A method of wildlife management mapping in forested areas. Jour. Wildlife Mgt. 6(1):38-43.

20. Westveld, R.H. 1948. Applied Silviculture in the United States. John Wiley and Sons, Inc. New York.

21. Baker, F.S. 1934. Theory and Practice of Silviculture. Mc Graw - Hill Book Co., Inc. New York.

APPENDIX

CONIFEROUS TREES

Common Name	Scientific Name
Balsam fir	*Abies balsamea* L. Mill.
Black spruce	*Picea mariana* Mill.
Northern white cedar	*Thuja occidentalis* L.
Red pine	*Pinus resinosa* Ait.
Tamarack	*Larix laricina* Kock.
White pine	*Pinus strobus* L.

HARDWOODS

Common Name	Scientific Name
American elm	*Ulmus americana* L.
Aspen	*Populus tremuloides* Michx.
Balsam poplar	*Populus tacamahaca* Mill.
Black ash	*Fraxinus nigra* Marsh.
Chokecherry	*Prunus virginiana* L.
Juneberry	*Amelanchier* spp. Medic.
Mountain ash	*Sorbus americana* Marsh.
Pincherry	*Prunus pennsylvanica* L.
Red Maple	*Acer rubrum* L.
Sugar Maple	*Acer saccharum* Marsh.

SHRUB SPECIES

Common Name	Scientific Name
Black alder	*Ilex verticillata* L. Gray
Elderberry	*Sambucus racemosa* L.
Hazelnut	*Corylus americana* Walt.
Honeysuckle	*Lonicera* spp.
Red Osier	*Cornus stolonifera* Michx.
Ribes	*Ribes* spp.
Smooth alder	*Alnus rugosa* Spreng.
Speckled alder (White alder)	*Alnus incana* Moench.
Spiraea	*Spiraea* sp. L.
Sweet Gale	*Myrica Gale* L.
Wild raisin	*Viburnum cassanoides* L.

HERB SPECIES

Common Name	Scientific Name
Aster	*Aster* spp. L.
Blueberry	*Vaccinium* spp. L.
Bunchberry	*Cornus canadensis* L.
Dandelion	*Taraxacum officinale* Weber
Golden-rod	*Solidago* spp.
Grasses	(not identified)
Horehound	*Marrubium vulgare* L.
Horsetail	*Equisitum* spp. L.
Iris	*Iris* spp. L.
Jewel weed	*Impatiens pallida* Nutt.
Joe-Pye Weed	*Eupatorium purpureum* L.
Labrador Tea	*Ledum* spp. L.
Leatherleaf	*Chamaedaphne calyculata* Moench
Lily	*Lilium* spp. L.
Mosses	(not identified)
Parsnip	*Thaspium* spp. Nutt.
Bramble	*Rubus* spp.
Sarsaparilla	*Aralia nudicaulis* L.
Sedges	*Carex* spp.
Shield fern	*Aspidium* spp. Sw.
Sphagnum moss	*Sphagnum* spp.
Star flower	*Trientalis americana* Pursh.
Strawberry	*Fragaria virginiana* Duchesne
Twisted Stalk	*Streptopus* spp. Michx.
Violet	*Viola* spp. L.
Wild rose	*Rosa* spp. L.

FUNGUS

Common Name	Scientific Name
Hypoxylon canker	*Hypoxylon pruinatum* Klotsche

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Mar 12 61

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