GENETIC IMPROVEMENT CONVERSION

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Because of the increasing value of forest acreage in the Northeast, I am happy to be able to tell this group how forest land, even a medium site such as this, can pay extremely handsome dividends. The landowner must do three things: practice good silviculture; find a profitable market; and finally--and this is most essential--he must discover uranium on the land.

Genetic Mass Selection

The program described this field session as a "Discussion of a demonstration of the possibilities and limitations of genetic mass selection in the spruce-fir type." Briefly stated, the objective of genetic mass selection is to utilize only the inherently best individuals, the best genotypes, as the progenitors of each succeeding generation. As applied to forest stands managed for natural regeneration, this implies silvicultural measures to limit the regeneration of the stand to the progenies of the genetically best parents. Since our knowledge of inheritance in forest trees, at present, is insufficient for positive recognition of the genetically elite trees in the stand, selection of in dividual trees must be based on their phenotypic qualities. The phenotype is the tree as we see it in the forest; the product of the effect of its individual environment on its inherent potentialities.

Genetic mass selection over several generations will improve the inherent quality of the stand. Perhaps the greatest benefit to be derived from mass selection is the fact that it will prevent genetic retrogression; lowering of the genetic quality from generation to generation.

Mass selection in forest stands managed for natural regeneration is limited by what is on the ground; the extent of improvement depends on the inherent qualities of the trees that occupy the site. A further limitation is the slow rate of improvement. It will normally take many generations of mass selection to achieve really appreciable improvement.

Improvement of the Genetic Stand Potential

This one-acre demonstration plot goes beyond the application of genetic mass selection. It is an attempt to demonstrate an objective that may be called improvement of the "genetic stand potential" by the interplanting of trees with more desirable inherent qualities than these in the present stand. These may be better races of the native species, better exotics such as Norway spruce, and when they become available, elite strains, clones or hybrids.

Genetic Improvement Conversion

Since improvement of the genetic stand potential involves conversion to a different stand composition, it seems appropriate to name this suggested practice "genetic improvement conversion"; in accordance with custom, I will brief this to GIC. (I had thought of "heredity improvement conversion," but gave up this name because it would be abbreviated to HIC!)

There is no a priori biological reason to negate the feasibility of conve sion in forest management. Natural conversion is a continuing, often almost imperceptible process on a local scale in the natural forest. It becomes all too obvious following catastrophe such as fire or heavy logging. I first came to work in western Maine in 1924. During the past ten years I have revisited areas that were in spruce-fir when they were logged in the 1920+s; now they are covered by hardwoods. If we want hardwood, that represents good silviculture; if we want conifers, it represents extremely poor silviculture. Conversion can be an excellent tool, but we have much to learn before we can use it beneficially in this spruce-fir type.

The quickest genetic improvement conversion on this site would be to clear-cut and to replant with the best genotypes available. But experience indicates that in the spruce-fir type, clear-cutting is often an unwarranted economic risk because the hardwoods, shrubs, and weeds, that normally take over are expensive to control.

This demonstration plot is an attempt to use our presently limited genetical and silvicultural knowledge to improve the genetic stand potential. Forest genetics is one of the sciences essential to the art of silviculture (to the geneticist, of course, the most important); and silvicultural methods will seldom be accepted unless they promise an economic return. (Money is not only the root of evil, it is also the root that nourishes research.) But first we must know what is biologically possible. Forest research ideas are too often nipped in the bud--before the possible economic returns have been determined--with the remark that they would not "pay off".

Plot Data

In his brief remarks on the Penobscot Experimental Forest, Frank Longwood mentioned the early history of this forest area, the uneven age of the trees, and that this is a medium site for red spruce. We do not have an evaluation of this site in terms of white spruce or eastern white pine, but the trees of both species on the plot have exceeded red spruce in growth-rate.

Plot Maps

All trees in the original and residual stands, 5-inch d.b.h. class and up, were numbered at approximately breast height and mapped (figs. 1 and 2).

Number of trees 4 inches d.b.h. and up

This 1-acre plot carried a total of 346 trees above 4 inches in d.b.h. (including 53 non-merchantable culls). The number of merchantable stems (including both stems of a forked red spruce) in the original and residual stands are listed by species and diameter classes in tables 1 and 2.

Table 1.--Stand table - Original stand (Exclusive of cull trees)

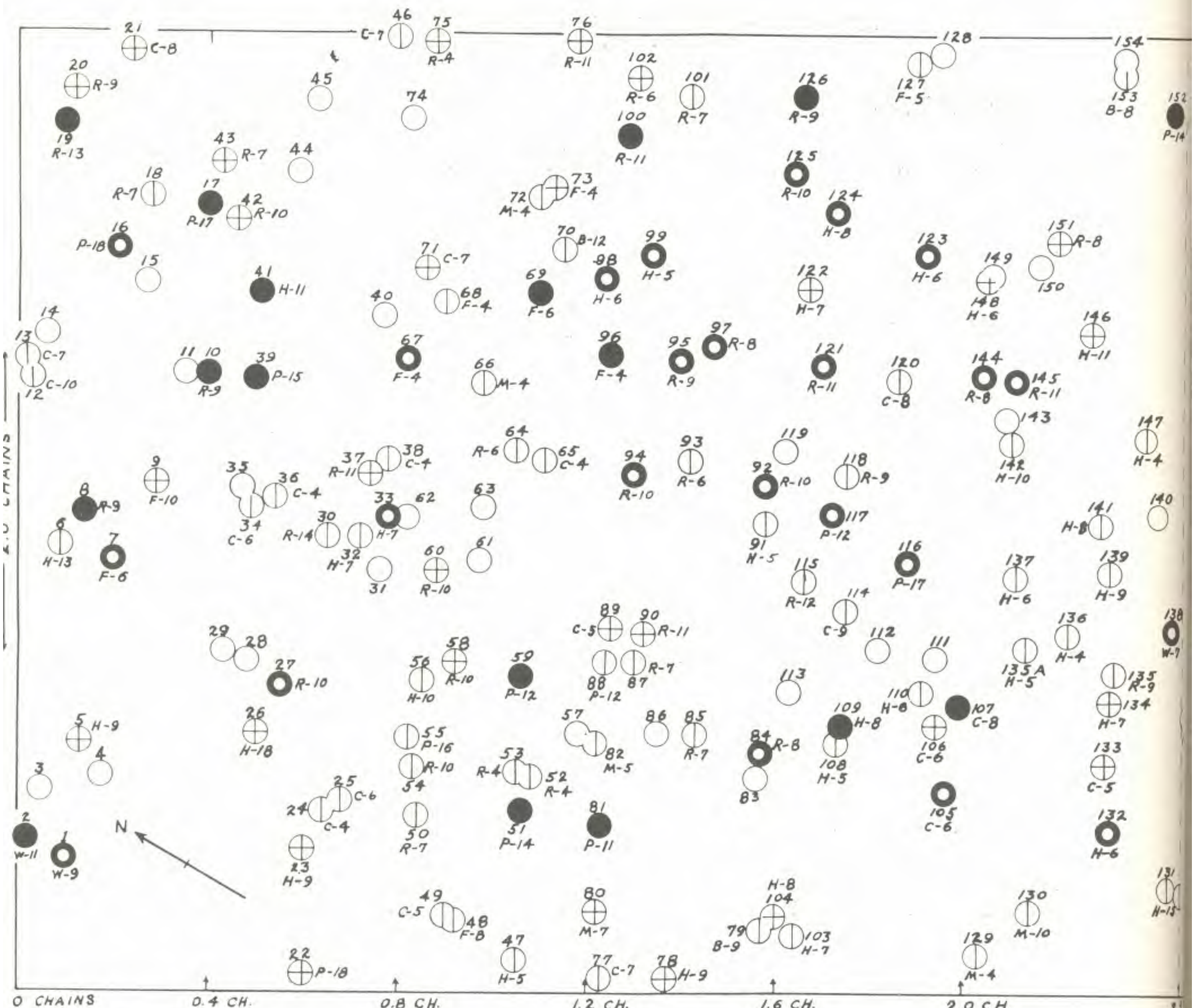
D.B.H. class	Balsam fir	Cedar	Hemlock	Red spruce	White spruce	White pine	Red maple	White birch	Yellow birch	Totals
Inches	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
4-4.5	4	14	6	4			3		2	33
5	2	15	12	1			1		2	33
6	2	20	17	7	2		2			50
7		10	12	11	4		1			38
8	1	8	10	4	2		1	1		27
9		1	9	15	2		1	1		29
10	1	4	8	15	1		1			30
11			5	9	3	1		1		19
12				1		5		1		7
13			1	4	4					9
14				1	1	2				4
15			2	1		2				5
16						4				4
17						2				2
18			1			2				3
19						1				1
Totals	10	72	83	73	19	19	10	4	4	294

Table 2.--Stand table - Residual stand

D.B.H. class	Balsam fir	Cedar	Hemlock	Red spruce	White spruce	White pine	Totals
Inches	No.	No.	No.	No.	No.	No.	No.
4-4.5	4	1		4			9
5	1		1				2
6	2		3	3			8
7			2	7			9
8		1	5	4			10
9			3	11	1		15
10	1	1	3	11			16
11			2	9	2	1	14
12				1		1	2
13				4	3		7
14					1	2	3
15				1		1	2
16						1	1
17						1	1
Totals	8	3	19	55	7	7	99

Figure 1.--Original stand - Before logging

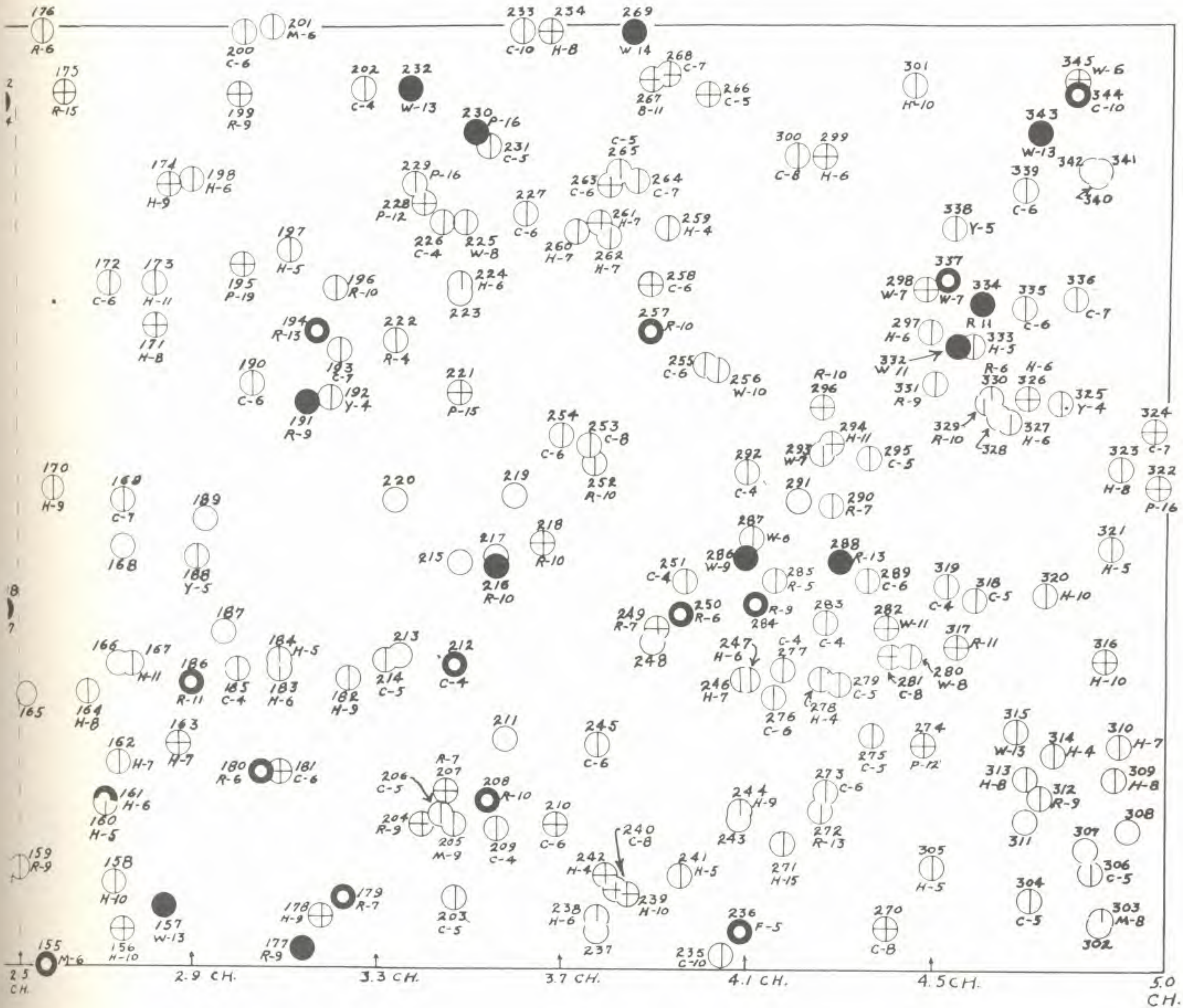
(Trees in the 5-inch d.b.h. class and up)



Legend

B = Paper birch
C = Northern white-cedar
F = Balsam fir
H = Eastern hemlock
M = Red maple
P = Eastern white pine
R = Red spruce
W = White spruce
Y = Yellow birch

Figure 1 (continued)



Legend (continued)

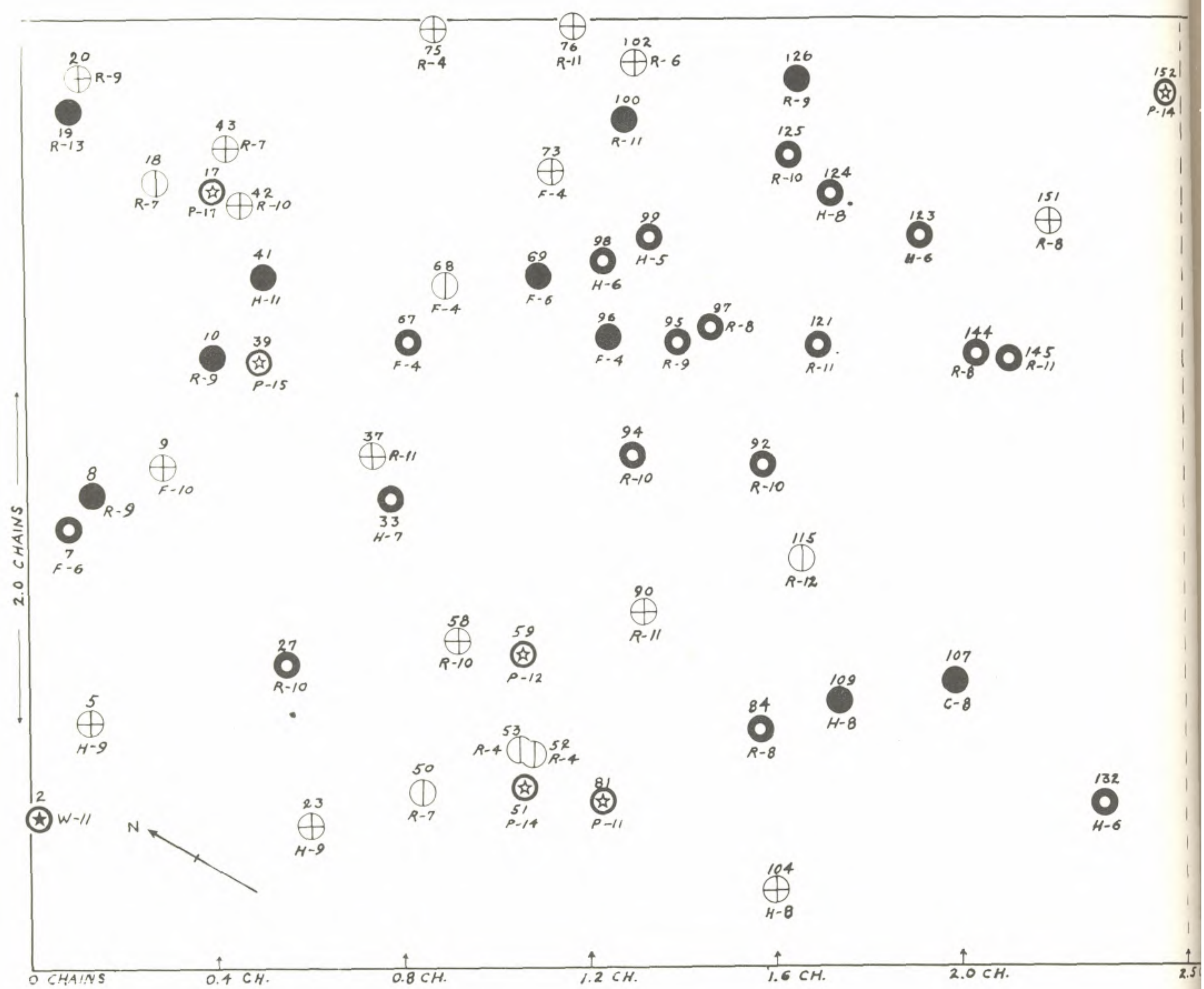
1, 2, 3, etc. = Tree numbers

Tree Ratings ● = 1 ◉ = 2 ⊕ = 3 ⦶ = 4 ○ = 5

Letters indicate species; number following letter (W-9) is the d.b.h. class in inches. Species and diameter class designations are omitted for cull trees.

Figure 2.--Residual stand - After logging

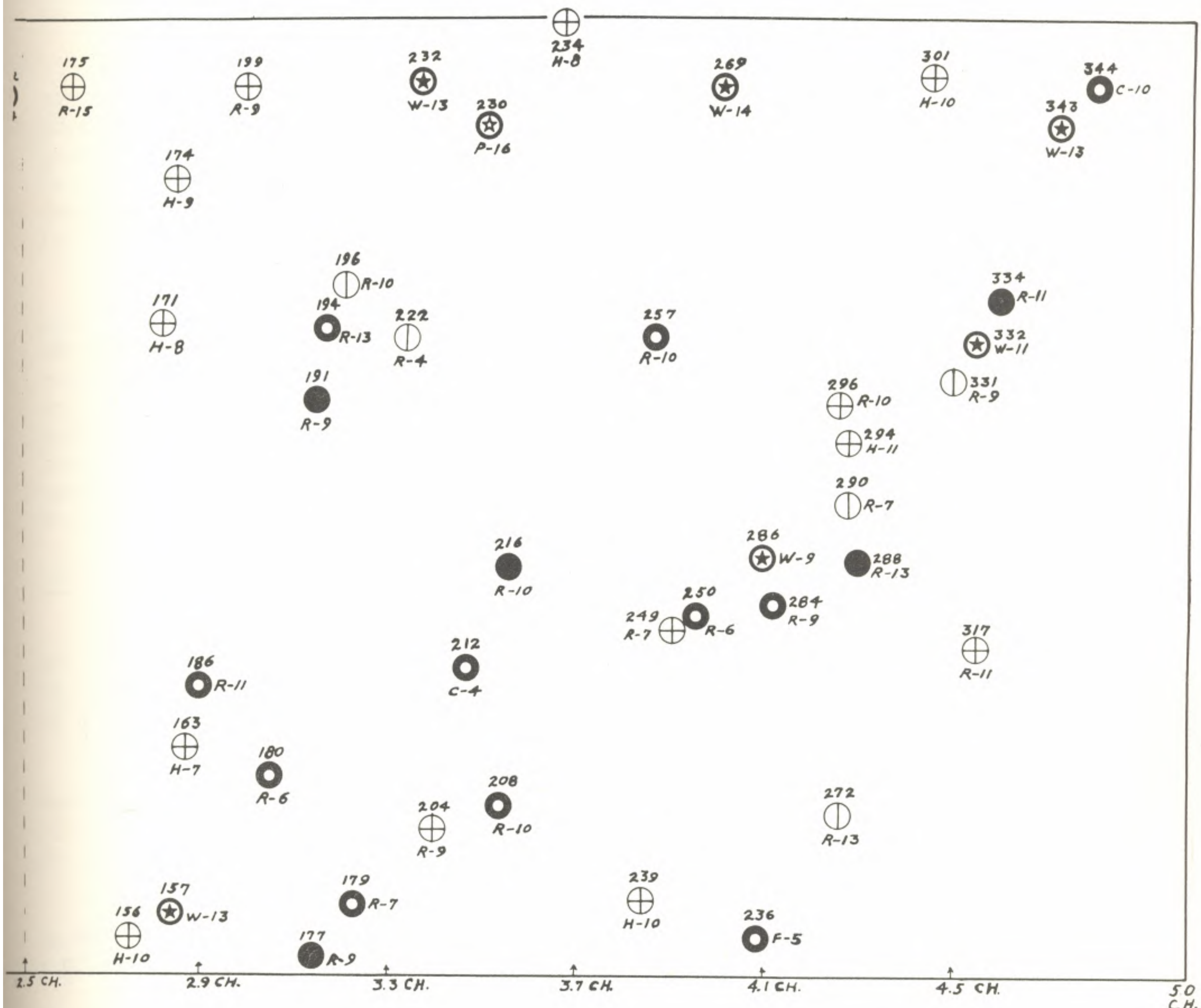
(Trees in the 5-inch d.b.h. class and up)



Legend

C = Northern white-cedar
F = Balsam fir
H = Eastern hemlock
P = Eastern white pine
R = Red spruce
W = White spruce

Figure 2 (continued)



Legend (continued)

1, 2, 3, etc. = Tree numbers

Tree Ratings ⊛ = 1 W ⊛ = 1 P ● = 1 ◉ = 2 ⊕ = 3 ⦶ = 4

Letters indicate species; number following letter (w-9) is the d.b.h. class in inches.

Advance Reproduction

The potential future increase in the proportion of balsam fir is obvious from the following tabulation of the number of trees 1 to 4 inches d.b.h., and of trees less than 1 inch d.b.h. but over 12 inches in height:

	1 to 4 inches d.b.h.	Less than 1 inch d.b.h. More than 12 inches in height
Balsam fir	995	1362
Red spruce	12	0
Cedar	138	0
Hemlock	26	16
Red maple	86	5
Yellow birch	19	0
White birch	28	1
Totals	1304	1384

Tree Quality

Mr. Hart has explained the quality ratings. The following is a summary of the ratings of the 346 trees on the plot:

Species	Quality Rating 1 Best	2 Good	3 Fair	4 Marginal	5 Cull
			Number		
Balsam fir	2	3	2	3	0
Cedar	1	3	15	53	40
Hemlock	2	7	23	50	5
Red spruce	10	18	19	26	1
White spruce	7	3	3	6	0
White pine	7	3	6	3	0
Red maple	0	1	1	8	7
White birch	0	0	1	3	0
Yellow birch	0	0	0	4	0
Totals	29	38	70	156	53

Basal Area and Volume

The basal areas and volumes by species (trees 6 inches and up, exclusive of culls) in the original stand, the cut, and the residual stand are listed in the following tabulation:

Species	Basal area Original stand	Cut	Residual stand	Volume Original stand	Cut	Residual stand
		Square feet			Cubic feet	
Balsam fir	1.29	0.35	0.94	27.2	7.2	20.0
Cedar	12.02	11.12	0.89	125.8	115.3	10.5
Hemlock	26.69	17.22	9.47	439.1	324.4	114.7
Red spruce	33.87	7.48	26.39	709.3	159.9	549.4
White spruce	10.33	4.73	5.60	252.8	104.8	148.0
White pine	23.42	15.64	7.78	535.1	361.1	174.0
Red maple	2.00	2.00	0.00	32.3	32.3	0.0
White birch	2.24	2.24	0.00	40.4	40.4	0.0
Total	111.86	60.78	51.07	2162.0	1145.4	1016.6
			Cords	24.0	12.7	11.3

Application of Genetic Improvement Conversion on the Demonstration Plot

This is an attempt to fit the concept of genetic improvement conversion to the silvicultural, genetical, and present economic limitations of the spruce-fir type in New England. I underline resent economic limitations because I am certain that eventually large-scale planting of genetically superior conifers will be an accepted practice on the best sites.

There is nothing original in the details of the genetic improvement conversion I have attempted to demonstrate here. It is essentially a combination of ideas garnered from the inspection of many silvicultural systems and "on the ground" discussions with foresters in the United States and Europe. The method is simply mass selection, selection of the best phenotypes of the best species for immediate natural regeneration, and interplanting of better or more promising genotypes.

Only white spruce and white pine have been selected and favored for regeneration: in my opinion red spruce and fir are less desirable species from the standpoint of growth-rate or ultimate market value. Also, red spruce is far too numerous on this site to permit genetical mass selection. In order to leave only the very best trees of red spruce for restocking this area, it would be necessary to make practically a clear-cutting with only seed trees left. Such large openings would bring in a large amount of fir, hardwoods, and undesirable undergrowth, such as bracken and brambles, and would make regeneration of the desired species much more difficult.

Procedure

1. Summer logging was employed in an attempt to get seedbed preparation; spruce seedlings are reported to be limited by 2 inches of un-decomposed litter. It is questionable whether there has been sufficient seedbed preparation. The 53 cull trees listed on page 36 were poisoned.

2. Patch or group cutting was used to obtain natural reproduction of white spruce and eastern white pine without exposing the forest floor to the inroads of weed and brush species. Some of these openings are difficult to visualize at present because the recently poisoned cull trees are still green.

A total of 195 merchantable trees were removed (66 percent of the merchantable stand), leaving a residual stand of 99 stems per acre (table 2 and fig. 2).

3. For genetic mass selection of white spruce and eastern white pine, seven of the very best phenotypes of each of these species present in the orig inal stand (table 1 and fig. 1) spaced to provide for adequate cross-pollination and restocking of the openings were left in the residual stand (table 2 and fig. 2). The location of excellent white pine and white spruce phenotypes outside the plot boundaries was considered in selecting some of the seed trees. (For example, tree number 2, figs. 1 and 2).

4. Sufficient residual basal area (51.07 square feet) and volume (1,016.6 cubic feet) was left to make at least one, and possibly two commercial cuts in the next 10 to 15 years (see tabulation on page 36). The next cutting will be timed to release the natural white spruce and white pine regeneration and the interplanted trees of genetically better stocks.

The basal area removed was 60.78 square feet, 5i percent of the total merchantable basal area (111.86 square feet). The volume cut was 1,145.4 cubic feet, 54 percent of the total merchantable volume (2,162.0 cubic feet). Converted on the basis of 90 cubic feet per stacked cord, this cut represents a standing volume of 12.7 cords per acre (tabulation on page 36).

The scaled volume of the cut was as follows:

Sawlogs (Bangor rule)		
Eastern white pine	2,482	board feet
Hemlock	611	" "
Spruce	327	" "
Total	3,420	board feet
Cordwood		
Rough hardwood (4 ft.)	0.79	cords
" hemlock (4 ft.)	0.29	"
" spruce and fir (4 ft.)	1.30	"
Peeled hemlock (4 ft.)	0.90	"
" spruce and fir (4 ft.)	0.55	"
Cedar (5 ft.)	0.81	"
Total	4.64	cords

Using a conversion factor of 2 cords per 1,000 board feet, the total cut scaled 11.48 cords per acre.

5. From 50 to 100 trees per acre of species, races, or hybrids, considered or known to be adapted to the site and to be better than the local white spruce or white pine, should be planted in the openings and brush piles within 1 or 2 years after logging.

6. Timber stand improvement work should be applied as needed. There are two choices for handling the dense patches of young balsam fir: they can be eliminated now or in the next cuttings, or they can be thinned and held until merchantable. My inclination would be to release the larger stems and hold them for a future cut.

Discussion of the improvement measures described and demonstrated here was delayed for about an hour to give everyone an opportunity to examine the sample plot.

DISCUSSION

GABRIEL. This morning we had a talk by Prof. Ashman on the performance of Norway spruce; I would like to ask his opinion on how Norway spruce as an exotic would compare with native white spruce and red spruce in this area?

ASHMAN. I told you this morning my experience has been somewhat limited but Norway spruce will do better than white spruce in the area near Patten, Me., and, I believe, on good soils elsewhere. Joe Lupsha said there were two different lAnds of white spruce in that area--good and not too good. I would think that the whole thing would have to be attacked somewhat experimentally, but I do feel that Norway spruce has a definite place in this sort of thing.

LUPSHA. The plantings that Dr. Ashman mentioned were made about 1919 by the Orono Pulp and Paper Co. At one time there were obviously records on these different plantings but the records are gone. There are 10 rows of white spruce averaging 50 feet in height and 38 years old. The trees look very good. They more or less follow the same drainage pattern. On the whole the Norway spruce are better in volume except for some rows planted on shallow rocky soil.

The Norway is the better tree if you consider all the wood volume. The wood volume on the Norway spruce is much higher per tree than on white spruce, except for the solid block of 10 rows of white spruce that I mentioned. No one knows where the Norway spruce came from.

GABRIEL. What I had reference to is the point of view of the forester. Do you feel that Norway spruce is out-performing the white and red spruce.

LUPSHA. From the 1934. Harvard bulletin on planting Norway spruce in the Northeast. I do not think that Norway spruce would do well on this site.

KLAEHN. I have seen quite a lot of Norway spruce; I think this is a good site for it.

LUPSHA. Do you recommend this type of soil?

KLAEHN. Yes.

DINNEEN. The Harvard bulletin on Norway spruce in Northeast United States, page 17, says Norway spruce can do little more than exist where a high water table or poor drainage caused by an impervious layer close to the surface makes the soil wet.

MORROW. Cornell studies have shown that we often have difficulty getting good plantations on old fields formerly in forest. Farming leads to leveling the micro-typography, to erosion, and sometimes to loss of soil fertility. We should remember that the natural stand is a product of mass selection of many thousands of plants per acre and also a product of mass selection of the best micro sites within the acre. Here we have in general poor drainage, but there are islands of deeper soil where the larger pine and spruce were cut. Rather than plant in a conventional "square" spacing or block, I would plant Norway spruce on the deeper soil near the old stumps of some of the pine and spruce. I would also take advantage, where possible, of brush piles for early protection and to reduce competition.

SCHREINER. For some forest species there are indications that planting too near old stumps reduces survival.

ASHMAN. I imagine the drainage here may be fairly good.

BALDWIN.What about introducing Douglas fir?

ASHMAN. We haven't given much thought to Douglas fir in Maine but we have planted Norway spruce successfully on many areas.

BALDWIN. I think Douglas fir might be a good species for Christmas trees; I think it might succeed. I don't think it worth planting for pulpwood or lumber.

LITTLEFIELD. We have had quite a lot of experience with Douglas fir in New York. You have to plant it on very well drained, upland sites. It will stand severe exposure, but it has to have excellent water drainage and excellent air drainage. In that sense you can not compare it to Norway spruce.

ASHMAN. I don't think the conditions here are so different from those in southern Germany.

LITTLEFIELD. One more comment while we are on the subject of climate. This morning Dr. Ashman was bragging about all the cold weather they have up in Maine. In defense of New York, I would like to say we had a white frost at Newcomb on August 13th.

BESLEY. I would like to ask a question. You were spearing about putting in genetically better trees. Do you have genotypes that have proven they apply to your site?

SCHREINER. In my opinion Norway spruce would be superior to white spruce on this site. We must, of course, use the proper race.

CHILDS. Although I don't know all the factors related to this site, I would say that Norway spruce is the only one to introduce with success. Except for Douglas fir and white pine, I would not go much further. Norway spruce will do here, and there is evidence that we can grow very good Norway spruce here.

SCHREINER. There is a fellow here from a place called Cooxrox" in Mew York State, I would like to hear from him. He should have some remarks on the possibilities of larch on this site.

COOK. For successful growth, European and Japanese larch require at least 16 inches of free-rooting material, and I would not think there is that depth on this plot. I also think the size of the openings would be too small. This site appeals to me as both too wet and too frosty.

SCHREINER. Are you considering the increased size of the openings that will result from the poisoning of the many cull trees?

COOK. Yes.

KLAEHN. I don't see any reason why you should not try European Larch. I woul plant six or seven larch trees.

SCHREINER. Why not Japanese larch or the Dunkeld hybrids? And how about seedbed preparation?

COOK. Japanese larch, if anything, planted on mounds.

GABRIEL Are you poisoning hardwood stumps to prevent sprouting?

SCHREINER. If there were enough we probably would; I don't think there are enough here to worry about.

RUDOLF. I don't think you have enough ground preparation.

SCHREINER. I agree with you; we thought suner logging would give us more extensive seedbed preparation.

WAKELEY. Could you aim the logging damage at your clumps of fir? I don't know how applicable it would be in here, but where intensive logging is the rule, one operator in the South gets good ground preparation by simply training the logging crew. They have a lot of understory hardwoods down there, largely in clumps. By felling the pines so that the tops fall on the denser clumps of hardwoods, they break down the taller hardwoods and to a certain extent smother the resulting sprouts. The result is a reduced and lowered hardwood understory and correspondingly more room for pine reproduction. When you are logging yourself you can do this, though it is not always possible on sales or in contract logging.

You spoke about Genetic Improvement Conversion to improve the genetic potential of the stand. How far would you limi t yourself to the seed source you have on this acre?

SCHREINER. Only to the white pine and white spruce on this area. in addition, better genotypes of these or other species would be introduced by planting.

WAKELEY. In other words--it was said that you had old growth to start with-- you are trying to do the best you can with that, not necessarily trying to find the best white spruce in Maine or in NEFTIC territory.

SCHREINER. Essentially, the objective is to convert the stand (without a clear cut) to the best genotypes adaptable to the site. They may be from plus trees on the area, better races of the native species, better exotics, or tested superior clones or hybrids of any species that are adapted here.

LUPSHA Why wouldn't fir be a good tree to select?

SCHREINER. If you want fir, it would be: if you can keep it from becoming too great a budworm hazard.

COWAN. You were speaking in terms of repeated cuts; in a great deal of the region balsam fir is the one you can count on.

SCHREINER. True, but is it now, or will it in the future be your most profitable tree?

COWAN. I am not in agreement that the young fir should be torn up. Fir grows fast and is a suitable pulpwood species.

DINNEEN. This is an overall picture of what you are doing. You have favored white pine and white spruce. What is your basic reason, the value of the species as a product?

SCHREINER. In my opinion white spruce is the better and more valuable species. And as I mentioned in my paper there is too much red spruce to apply effective mass selection; it would require practically a clear cutting with seed trees. This would leave the site open to invasion by presently less desirable tree species and brush.

DINNEEN. What I was getting at is how come that you cut 40 percent of the white pine and white spruce and 27 percent of your red spruce when you would have been better off to keep 100 percent of the white pine and white spruce? We don't always have a picture of overall quality trees. Wouldn't it have been better to leave all of the trees of these two species?

SCHREINER. We have left enough seed trees for natural regeneration, so why not take out the poorer trees as a matter of insurance against poor genotypes?

DINNEEN. Why didn't you take out all of your red spruce?

SCHREINER. To leave cover to hold the ground against unwanted reproduction until we make the regeneration cut. We also need sufficient growing stock for one, and possibly two more cuts.

JONES. On the way to this sample plot we looked over two or three other compart ments. Which one of these other stops most nearly approaches the type of cutting needed to obtain the best reproduction from the genetical standpoint? Would it be on the farm forestry compartment where you cut the poor quality and leave the best? Would you get it there or in your 5- or 10-year cutting cycle plots; Was there any thought given to that?

SCHREINER. A cutting practice based on individual tree selection would hardly permit the application of mass selection because this necessitates elimination of all but the best trees as parents, and openings big enough to get regeneration started. Genetic improvement conversion could be applied, without mass selection, to any cutting method (such as group or strip cutting) that permits the introduction of better genotypes by planting, provided the cutting cycles are scheduled to release the interplanted trees.