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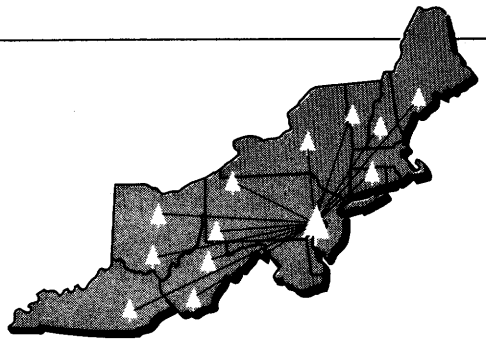

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SPROUTING OF THINNED HYBRID POPLARS ON BITUMINOUS STRIP-MINE SPOILS IN PENNSYLVANIA

Abstract.—Various thinning techniques were applied to 5-year old hybrid poplar stands on bituminous strip-mine spoils. Basal and stump sprays of 2, 4, 5-T in diesel oil were effective for killing the trees. There was no evidence that chemical treatments affected adjacent trees. Where trees were cut and stumps were not chemically treated, all clones sprouted prolifically. Dominance in sprout clumps was asserted soon after thinning. Sprouting vigor was affected more by site quality than clonal parentage. Results indicate that hybrid poplar can be successfully regenerated under coppice management or can be easily removed for stand conversion.

Reclamation practices on strip-mine spoils have centered mainly about establishing a vegetative cover. We have now arrived at the point where it is necessary to consider management of the plantations that have been established.

This is especially true of the hybrid poplar plantings made on the more productive sites. In caring for these plantations, the land manager must decide what the objectives of management are to be. If successive crops of poplars are desired, then coppice management might be practical. If it is desirable to manage for sawlog-size hybrid poplars or to remove the poplars to favor some other tree species on the site, then a thinning or cleaning operation should be considered.

This note deals with the results of an experiment on two aspects of management—thinning techniques and coppice regeneration.

Only a few deciduous tree species have been found that will withstand the rigors of establishment on strip-mine spoil. This meager list is depleted even further by regional variation in spoil types and variation among spoils within a region.

Some hybrid poplar clones have shown promise on bituminous strip-mine spoils in Pennsylvania. The 10-year performance of one hybrid poplar clone reported by Hart and Byrnes *(1960)* prompted further testing of hybrid poplars for strip-mine reforestation. Screening tests of 60 hybrid poplar clones were started in 1961. In 1964 a report summarizing 2-year results of these tests was published *(Davis 1964)*. It indicated that early results were encouraging and that some of the clones showed promise for revegetating all but the most acid spoil banks.

The Experiment

The experimental plots were established in 1961 at six different field locations. At each location, plots were placed on graded and ungraded surfaces of both upper and lower portions of the spoil banks. The plots were replicated three times—a total of 12 plots on

each bank. Sixty different clones were used, but not all clones were represented in each plot. The plots were six rows wide and varied in length according to the number of clones in the plot. Spacing within the plots was 6 x 6 feet, and two cuttings from each clone were planted in adjacent positions.

Soon after test plantings were established, it became obvious that some of the plots would have to be thinned. Rapid development of the hybrids indicated that competition would be detrimental to maximum growth. The objective of thinning was to have a final spacing of approximately 6 x 12 feet or 72 square feet of growing space per tree. Selection of trees to be removed was based on spacing and 5-year survival in each plot.

On two very acid sites (average pH 3.1 and 3.3) survival was so poor that thinning was not required. These sites were on spoils derived from mining the Kittanning coal seams. Two other plots on Clarion coal seam spoils were less acid (average pH 3.6 and 3.7) and had better survival. Thinning was light and was restricted to removing one ramet from a clone where both had survived if the average spacing indicated that thinning was required.

The last two sites were Freeport coal seam spoils (average pH 4.9 and 5.7). Survival on these sites approached 100 percent. The thinning removed one ramet from each clone. This left one ramet of each clone in each plot.

On the two areas having moderate survival, all the thinning was done by cutting the trees.

Three methods of thinning were used on the two areas having the best survival. The first was to cut the trees. The second was to cut the trees and spray the stumps with a mixture of 2,4,5-T in diesel oil. The third was to apply a basal spray of the same 2,4,5-T and diesel oil mixture to the standing trees. In the entire experiment, 256 trees were cut, 176 trees were cut and stump-sprayed, and 108 trees were basal-sprayed.

Data Collection

Two years after thinning, the study plots were examined and data were collected for evaluating the sprouting capacity of the hybrids and the effectiveness of the thinning methods. The following information was recorded for each treated tree: (1) total number of sprouts; (2) height of dominant sprout; (3) d.b.h. of dominant sprout; (4) form of dominant sprout; (5) number of stump sprouts strong enough to attain tree size; (6) number of root suckers; and (7) effectiveness of kill.

Number, height, and diameter of sprouts were measured directly. Form of dominant sprout was coded: 1 = straight; 2 = slight sweep; and 3 = severe sweep or crook. The number of stump sprouts strong enough to attain tree size was predetermined to include the dominant sprout plus all aggressive sprouts at least ¾ the height of the dominant.

All the aforementioned measurements and evaluations were made primarily for determining sprouting capacity of stems thinned by cutting. *No kill* was used to indicate stems that showed no effects of the treatment applied. *Partial kill* was used to indicate an injured main stem or a dead main stem with stump sprouts. *Complete* kill was recorded if the main stem was dead and no stump sprouts were present.

In many instances root suckers were present. The presence or absence of root suckers was not used as a criterion to determine effectiveness of kill because it was not always possible to ascertain the origin of the sprout.

Thinning Techniques

Chemical treatments. — Both treatments gave high percentages of complete kill. Cutting and stump-spraying resulted in a complete kill on 174 of the 176 treated stems (98.9 percent). In the basal spray treatment, 96 of the 108 treated stems (88.9 percent) were killed. In both treatments 14 stems were tallied as either *partial* or *no kill.* These were probably the result of insufficient chemical or misses in application of chemical at the time of treatment. Bridging was noted on some trees, and on others no effect of chemical treatment could be seen.

Root-suckering appeared to be more prevalent in the cutting and stump-spray treatment. Root suckers appeared to be associated with 68 percent of the 174 killed stumps. In contrast, only 40 percent of the 96 dead basal-sprayed trees appeared to have root suckers. It may be too soon to evaluate the root suckers because chemicals used in the thinning procedure may still have some effect on the vitality of the root suckers. There was no evidence that either of the chemical treatments affected adjacent trees.

Cutting.—526 trees on four different areas were treated by cutting the stems. Of these, 517 (98.3 percent) sprouted. One of the other 9 stumps had a single root sucker associated with it. All others showed no sign of life whatever.

Conclusions.—Hybrid poplars can be thinned effectively during the dormant season by using herbicides and standard thinning techniques. Our data show that over 95 percent of the stems basal-treated with herbicide or cut and stump-treated were killed. Cutting the stems, without herbicide application, was not an effective thinning technique. Less than 2 percent of the stumps were completely killed. Prolific sprouting followed this treatment.

If thinning is the management objective, and herbicides are not used, then better results could be obtained by doing the work during the summer. Although this experiment was conducted during the dormant season, past research has shown that sprouting is less vigorous from stems cut during the active growing season *(Ford and Snow 1954)*. Winter-cut stumps produce more sprouts per stump, and nearly all the stumps produce sprouts, while fewer than 60 percent of the summer-cut stumps produce sprouts.

Sprouting Capacity

Data on the sprouting capacity of the various clones does not lend itself to rigorous statistical analyses. However, by combining some statistical analyses with apparent trends in the data, conclusions can be drawn that provide the basis for both future experimental plantings and larger-scale field trials.

A vigor rating was assigned to each sprout clump to prepare the field data for analysis. These ratings were based on an evaluation of the measurements of height of dominant sprout, form of dominant sprout, and number

Table 1.—*Clones used in the study and analysis of vigor ratings, by parentage groups*

Clone number[1]	Parentage	Site[2]			
		C11	C12	LF	UF
NE-32 (A)	*P.* cv. Angulata X *P.* cv. Berolinensis	—	—	—	—
NE-245, -246, -247, -258 (B)	*P.* cv. Angulata X *P. deltoides*	—	—	x	x
NE-35 (C)	*P.* cv. Angulata X *P.* cv. Plantierensis	—	—	—	—
NE-249, -251, -252, -253, -254, -374 (D)	*P.* cv. Angulata X *P. trichocarpa*	x	x	x	x
NE-12, -302 (E)	*P.* cv. Betulifolia X *P. trichocarpa*	—	—	x	x
NE-327 (F)	*P.* cv. Candicans X *P.* cv. Berolinensis	x	—	—	x
NE-17, -313, -314 (G)	*P.* cv. Charkoviensis X *P.* cv. Caudina	x	—	x	x
NE-28, -29 (H)	*P.* cv. Charkoviensis X *P. trichocarpa*	—	—	x	x
NE-221, -223, -224, -228, -353, -359 (I)	*P. deltoides* X *P.* cv. Caudina	x	—	x	x
NE-241, -242 (J)	*P. deltoides* X *P.* cv. Plantierensis	—	—	x	x
NE-206, -207, -208, -211, -213, -214 -215, -216, -346, -350 (K)	*P. deltoides* X *P. trichocarpa*	x	x	x	x
NE-43, -44, -47, -48, -49, -50 (L)	*P. maximowiczii* X *P.* cv. Berolinensis	x	x	x	x
NE-53 (M)	*P. maximowiczii* X *P.* cv. Caudina	—	—	x	—
NE-52 (N)	*P. maximowiczii* X *P.* cv. Plantierensis	x	—	—	—
NE-41, -42, -388 (O)	*P. maximowiczii* X *P. trichocarpa*	x	—	x	x
NE-277 (P)	*P. nigra* X *P.* cv. Italica	—	—	—	—
NE-4, -5, -8, -279 (Q)	*P. nigra* X *P. laurifolia*	x	—	x	x
NE-11 (R)	*P. nigra* X *P. trichocarpa*	—	—	—	x
NE-40 (S)	*P.* cv. Petrovskiana X *P.* cv. Caudina	x	—	x	—
X (parentage uncertain) (X)	Either *P. maximowiczii* X *P. trichocarpa* or *P. maximowiczii* X *P.* cv. Berolinensis	x	—	—	—
	PLANTED AS 1-YEAR CUTTINGS				
M-86 or NY-3139 (86)	Populus robusta (robusta poplar)	x	—	—	—
M-87 or NY-3140 (87)	Populus species (Siouxland poplar)	x	—	—	—
M-88 or NY-3141 (88)	Populus species (Norway poplar)	x	—	—	—
NY-2555 (2555)	Populus canescens (Curly poplar)	—	—	—	—

[1]NE = Northeastern Forest Experiment Station; M = Michigan; NY = New York; Letter or number in parentheses refers to clone group designation as used in anaylsis.

[2]Site designations: C11 = Clarion, Clarion Co.; C12 = Clarion, Clearfield Co.; LF = Lower Freeport; UF = Upper Feeport. x indicates clone groups used in vigor analysis.

of sprouts strong enough to attain tree size. These broad ratings were assigned values of 1 for high vigor; 2 for moderate vigor; 3 for low vigor; and 4 for poor vigor. After the vigor ratings were assigned, the data were grouped for each planting site by clonal parentage. That is, all clones from parents of the same species or varieties were grouped together (table 1).

A contingency table was set up for each site for analyzing the vigor ratings. This type of analysis compares homogeneity within a group of data to homogeneity among all groups of data in the contingency table, using an approximation of the chi-square distribution. Only clonal groups represented by four or more sprout clumps were used in the analysis. A smaller number of representatives would have weakened the analysis. On the basis of this limitation, 13 groups each from the Upper and Lower Freeport sites, 14 groups from the Clarion (Clarion County) site, and 3 groups from the Clarion (Clearfield County) site were used in the analysis (table 2.).

The computed chi-square values were significant at the 5-percent level for the Lower Freeport site and at the 10-percent level for the Upper Freeport site. Chi-square for the Clarion (Clarion County) site was nearly significant at the 10-percent level and not significant for the Clarion (Clearfield County) site (table 3.). These low values of significance suggest that homogeneity within clone groups is nearly the same as homogeneity among groups.

This lack of homogeneity may be due to site characteristics rather than to clonal variation. This is illustrated by the fact that 46 percent of the sprout clumps on the Upper Freeport site were rated vigor class 1 or 2. On the Lower Freeport site 37 percent were 1 or 2; and on the Clarion (Clearfield County) and Clarion (Clarion County) sites 33 and 30 percent were rated 1 or 2. Unfortunately, the available data are not suitable for statistical analysis of site versus clonal variation.

Evaluation of the other measured variables also indicates that site plays an important role in the sprouting characteristics of the hybrid poplars. This is most evident in the height of the dominant sprouts. The average heights of the dominant sprouts on the four areas were 6.1 feet on the Clarion (Clearfield County) site, 7.0 feet on the Clarion (Clarion

Table 2.—Distribution of sprout clumps in each vigor class, by planting site and clone grouping

Clone group	Vigor class				Total
	I	II	III	IV	
LOWER FREEPORT SITE					
B	2	2	4	1	9
D	2	5	7	7	21
E	0	3	2	1	6
G	0	7	2	1	10
H	1	2	1	4	8
I	3	4	4	5	16
J	0	0	1	4	5
K	6	8	12	6	32
L	0	1	11	2	14
M	0	0	0	4	4
O	1	1	3	3	8
Q	3	6	5	1	15
S	1	1	1	1	4
Total	19	40	53	40	152
UPPER FREEPORT SITE					
B	0	1	3	2	6
D	1	7	9	4	21
E	0	1	4	1	6
F	1	2	1	0	4
G	1	2	4	1	8
H	0	2	3	1	6
I	2	7	2	5	16
J	0	0	6	0	6
K	5	14	7	3	29
L	0	5	10	4	19
O	4	3	3	0	10
Q	2	8	6	1	17
R	2	1	1	0	4
Total	18	53	59	22	152
CLARION (CLARION CO.) SITE					
D	4	6	4	5	19
F	0	1	1	2	4
G	0	1	2	1	4
I	0	0	3	1	4
K	4	4	11	5	24
L	0	2	6	13	21
N	0	1	3	1	5
O	1	3	9	2	15
Q	0	5	2	1	8
X	0	1	2	2	5
S	0	0	2	3	5
86	0	2	2	1	5
87	1	0	2	1	4
88	0	4	3	0	7
Total	10	30	52	38	130
CLARION (CLEARFIELD CO.) SITE					
D	0	1	3	2	6
K	1	1	4	3	9
L	0	1	3	2	6
Total	1	3	10	7	21

County) site, 7.3 feet on the Lower Freeport site, and 10.8 feet on the Upper Freeport site.

Average numbers of sprouts per clump increased as the height of the dominants increased. However, the average number of aggressive sprouts per clump was fairly constant; and the median number of aggressive sprouts per clump was the same for all sites. Table 4 lists these sprouting characteristics.

Conclusions

This study has shown that 5-year-old hybrid poplars will sprout prolifically when thinned by cutting during the dormant season. Analysis of sprouting vigor indicated that homogeneity among clonal groups was nearly the same as homogeneity between groups. However, there appeared to be a decrease in

Table 3.—*Chi-square values obtained from contingency tables of vigor ratings*

Planting site	Number of clone groups	df	x^2	Values of x^2 at 0.10 probability level
Clarion (Clarion Co.)	14	39	50.5	50.6
Clarion (Clearfield Co.)	3	6	1.5	10.6
Lower Freeport	13	36	[1]57.1	47.2
Upper Freeport	13	36	[2]49.8	47.2

[1]Significant at the 5-percent level.
[2]Significant at the 10-percent level.

Table 4.—*Sprouting characteristics of hybrid poplars on bituminous strip-mine spoils*

Planting site	Number of observations	Average	Range	Median
NUMBER OF SPROUTS PER CLUMP				
Clarion (Clarion Co.)	141	9.1	2-21	9
Clarion (Clearfield Co.)	33	9.3	3-25	8
Lower Freeport	175	11.1	1-32	11
Upper Freeport	177	13.7	1-35	13
NUMBER OF AGGRESSIVE SPROUTS PER CLUMP				
Clarion (Clarion Co.)	141	2.7	1-8	2
Clarion (Clearfield Co.)	33	3.2	1-10	2
Lower Freeport	175	2.3	1-7	2
Upper Freeport	177	2.4	1-7	2
HEIGHT OF DOMINANT SPROUT IN FEET				
Clarion (Clarion Co.)	141	7.0	0.9-13.6	7.4
Clarion (Clearfield Co.)	33	6.1	1.4-14.3	6.1
Lower Freeport	175	7.3	1.5-18.5	7.3
Upper Freeport	177	10.8	2.3-19.5	10.8

homogeneity between groups as site quality increased.

Although there was a great deal of variation in numbers of sprouts per clump, the number of aggressive sprouts per clump was relatively small and consistent, even between sites. The number of sprouts should not cause concern. Dominance seems to be asserted fairly soon, and reduction in growth rate due to competition from other sprouts in a clump seems to be minimal.

Thus, in managing hybrid poplars for successive crops on spoil banks, the best clones for the site can be selected with some assurance that they can be regenerated by the coppice method.

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