

COMPARISON OF FALL AND SPRING PLANTING ON STRIP-MINE SPOILS IN THE BITUMINOUS REGION OF PENNSYLVANIA

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To evaluate fall versus spring planting of 10 coniferous tree species and 5 hardwood shrub species, experimental plantings were established over a 2-year period on 7 graded strip-mine spoils. In general, initial tree survival was better with spring planting than with fall planting, especially on the more acid sites. Shrubs survived well with both spring and fall planting on the better sites, but spring planting of shrubs was more successful on the more acid sites. Season of planting had no significant effect on fifth-year height of either trees or shrubs.

INTRODUCTION

The climate of Pennsylvania is such that trees and shrubs are usually planted on soils during two seasons: spring—April, May, and early June; and fall—late September, October, and early November. Most planting on strip-mine spoils is done in spring, but it would be desirable to be able to plant seedlings throughout both planting seasons. This would allow planting contractors to retain their experienced employees and distribute work loads over a longer period. The question arises as to whether both seasons can be utilized on these exposed and often acid sites. A study to determine which species of shrubs and trees perform best during each planting season was proposed by the Research Committee on Coal Mine Spoil Revege-

tation in Pennsylvania. The study was conducted by Forest Service personnel, and member agencies of the Research Committee provided funds, planting stock, field assistance, and guidance.

THE STUDY

In 1961, the study was initiated to evaluate the relative success of fall versus spring planting of 10 tree species and 5 shrub species on strip-mine spoils. Because spoil material is quite variable, experimental plantings were placed on seven graded strip-mine banks formed by stripping the coal seams most common in the Bituminous Region of Pennsylvania. Four sites were very acid, and three were less acid and were considered more favorable for vegetation. In order to assure that planting was done under a variety of weather conditions, the planting covered two years and included three planting dates each season. This paper summarizes the results of 5-year height growth and first-year survival.

Species tested in the study were restricted to those that previous studies had indicated were most likely to perform well on spoils. Tree species included in the test were: white pine (*Pinus strobus* L.), red pine (*P. resinosa* Ait.), jack pine (*P. banksiana* Lamb.), pitch pine (*P. rigida* Mill.), Scotch pine (*P. sylvestris* L.), Austrian pine (*P. nigra* Arnold), Norway spruce (*Picea abies* [L.] Karst.), white spruce (*P. glauca* [Moench] Voss), European larch (*Larix decidua* Mill.), and Japanese larch (*L. leptolepis* Gord.). Shrub species included were: autumn olive (*Elaeagnus umbellata* Thunb.), Asian crabapple (*Crataegus* L. sp.), Tatarian honeysuckle (*Lonicera tatarica* L.), silky dogwood (*Cornus amomum* Mill.), and multiflora rose (*Rosa multiflora* Thunb.).

Coniferous tree species were selected because previous success in establishing satisfactory stands has been inconsistent, especially when planted in the fall. Fall and spring planting of hardwood tree species has been generally reliable; and so they were not included in this experiment. Also, hardwoods represent only a small percentage of trees planted on spoils in Pennsylvania. Hardwood shrubs were included because little was known about the effect of season of planting on their performance on soils.

DESIGN

A modified random block with a split-split plot design was used. Two replicated blocks of trees and shrubs were placed on the graded portion of each of the seven banks. Species were assigned a plot at random within

each block, but the trees were grouped separately from the shrubs. Each plot consisted of 12 rows of 35 trees or shrubs spaced 2 ft apart within the row. Rows were 6 ft apart and ran perpendicular to the highwall and parallel to the slope in order to equalize any effect of slope. The 12 rows were split randomly into 2 years, 2 seasons each year, and 3 planting dates each season. The planting dates were selected to represent early-, middle-, and late-season planting. Planting took place during the weeks beginning 2 October, 23 October, and 13 November 1961 and 9 April, 30 April, and 21 May 1962 and approximately the same dates in fall 1962 and spring 1963. Local contract planters supplied experienced crewmen and mattocks for planting. As far as possible, the same crew planted the same species throughout the experiment.

Spoil samples were collected from each plot, sieved, and the soil-size portion (<2 mm) was analyzed for acidity and texture. The results of the spoil analyses of 30 samples from each bank appear in Table 1. Spoils from the Clarion and Kittanning seams were quite acid, and the pH of the Freeport and Pittsburgh seams was considered favorable.

TABLE 1
Spoil characteristics of experimental planting sites

Coal-seam spoil	Spoil texture			Texture class	Spoil acidity
	Sand	Silt	Clay		
	%	%	%		pH
Clarion at Clearfield	59	21	20	Sandy loam	3.6
Clarion at Clarion	61	20	19	Sandy loam	2.9
Lower Kittanning	61	21	18	Sandy loam	3.3
Middle Kittanning	44	27	29	Sandy clay loam	3.6
Lower Freeport	55	21	24	Sandy clay loam	6.4
Upper Freeport	66	18	16	Sandy loam	5.9
Pittsburgh	56	21	23	Sandy clay loam	7.8

Survival was measured after the first, second, third, and fifth growing seasons. Percent survival data for three planting dates were averaged, transformed (arc-sine), and subjected to analysis of variance. All tests were conducted to the 5% level of significance.

Height was measured after the fifth growing season. The tree plots were then thinned to approximately 6- by 6-ft spacing, and height will be measured again at 10 years.

WEATHER

Both fall 1961 and spring 1962 were extremely poor planting seasons. The dry fall 1961 was followed by a cold winter with little snow cover to protect the seedlings. Late spring and early summer 1962 was one of the driest seasons on record. Precipitation deficits started as early as March in some areas. By the end of August, the following accumulated deficits were compiled in the Bituminous Region of Pennsylvania: Central Mountains, 7.1 inches below normal; Northwest Plateau, 5.9 inches below normal; and Southwest Plateau, 6.1 inches below normal. In spite of the generally dry conditions, seedlings were planted in moist spoil, although it was necessary to postpone planting for a few days on several occasions. Rainfall during the second year also was below normal, but not quite as critical as the first year.

RESULTS

First-year survival was used to compare the relative success of fall vs. spring planting. After the first growing season, all trees are subject to the same weather stress regardless of time of planting; and subsequent survival data may reflect the influence of site and competition more than season of planting. Survival data are summarized in Table 2. More detailed data on survival of individual species appear in Tables 3 and 4. Percentages in the tables were computed directly from the untransformed data.

Overall survival was lower than was expected because of unfavorable weather during and after establishment of the study. Shrubs survived better than trees, especially on the three better sites where shrubs averaged over 70% survival.

Spring planting of trees was better in terms of survival than fall planting over all sites and both years. Differences between spring and fall plantings were significant within each site and year except for the second-year planting on the Upper Freeport spoil. The advantage of spring planting was greater on the more acid sites. Fall survival was 30% of spring survival on the two spoils where average pH was below 3.5; 65% of spring survival on the two spoils where pH averaged 3.6; and 73% of the spring survival in the three spoils above pH 6.

Season of planting had a significantly different effect depending on species. It had no detectable effect on the larches. Spring planting was some-

TABLE 2

Average first-year survival of fall- and spring-planted trees and shrubs (in percent)

Coal seam	Test year ^a	Trees			Shrubs		
		Average survival		Average	Average survival		Average
		Fall	Spring		Fall	Spring	
Clarion at Clearfield	I	20	39	30	44	55	50
	II	43	59	51	51	62	57
	Average	32	49	40	48	58	53
Clarion at Clarion	I	1	12	7	>1	1	1
	II	3	11	7	1	3	2
	Average	2	11	7	>1	2	1
Lower Kittanning	I	14	50	32	13	30	22
	II	30	46	38	21	38	30
	Average	22	48	35	17	34	26
Middle Kittanning	I	32	52	42	13	21	17
	II	36	54	45	7	14	10
	Average	34	53	43	10	17	14
Lower Freeport	I	39	52	45	70	80	75
	II	61	73	67	73	88	80
	Average	50	62	56	71	84	77
Upper Freeport	I	31	62	47	75	75	75
	II	51	52	51	70	65	68
	Average	41	57	48	72	70	71
Pittsburgh	I	44	66	55	86	79	83
	II	22	35	29	65	70	68
	Average	33	51	42	76	75	76
Totals	I	26	48	37	43	49	46
	II	35	47	41	41	49	45
	Average	30	47	39	42	49	45

^a Test I planted fall 1961 and spring 1962; Test II planted fall 1962 and spring 1963.

TABLE 3

First-year survival of fall- and spring-planted trees on seven spoils
(in percent)

Coal-seam spoil	Test year ^a	White pine	Red pine	Jack pine	Pitch pine	Scotch pine	Austrian pine	Norway spruce	White spruce	European larch	Japanese larch
Clarion at Clearfield		F S	F S	F S	F S	F S	F S	F S	F S	F S	F S
	I	25 31	26 48	7 30	16 54	9 31	2 50	46 49	30 42	32 22	10 33
	II	41 64	60 78	54 50	36 73	37 76	8 33	63 66	43 36	45 64	46 52
	Average	33 48	43 63	30 40	26 63	23 53	5 41	55 58	37 39	38 42	28 42
Clarion at Clarion	I	2 3	1 22	2 9	1 17	4 17	>1 33	0 10	2 9	0 0	3 3
	II	3 13	2 11	9 19	1 22	3 22	>1 12	1 3	5 5	>1 0	1 0
	Average	3 8	1 17	5 14	1 19	4 20	>1 22	>1 6	3 7	>1 0	>1 1
		I 32 61	5 41	8 57	19 62	9 57	0 47	14 76	5 34	10 25	23 44
Lower Kittanning	II	43 51	44 80	47 67	13 36	15 60	4 28	34 35	29 20	31 32	37 55
	Average	37 56	25 60	28 62	16 49	12 58	2 37	24 56	17 27	20 29	30 50
	I	43 62	64 70	29 56	22 64	10 31	3 68	22 42	39 80	33 14	50 37
	II	71 71	43 74	46 81	15 47	22 55	15 36	20 34	49 45	22 39	61 60
Middle Kittanning	Average	57 66	53 72	38 68	18 56	16 43	9 52	21 38	44 62	28 27	55 48
	I	35 35	72 72	28 50	15 42	14 41	7 53	71 89	43 67	58 38	43 32
	II	71 55	62 74	68 77	46 86	22 78	27 55	70 61	84 88	79 77	81 76
	Average	53 45	67 73	48 63	30 64	18 60	17 54	70 75	64 78	69 58	62 54
Lower Freeport	I	35 35	72 72	28 50	15 42	14 41	7 53	71 89	43 67	58 38	43 32
	II	71 55	62 74	68 77	46 86	22 78	27 55	70 61	84 88	79 77	81 76
	Average	53 45	67 73	48 63	30 64	18 60	17 54	70 75	64 78	69 58	62 54
		I 32 61	5 41	8 57	19 62	9 57	0 47	14 76	5 34	10 25	23 44
	II	43 51	44 80	47 67	13 36	15 60	4 28	34 35	29 20	31 32	37 55
	Average	37 56	25 60	28 62	16 49	12 58	2 37	24 56	17 27	20 29	30 50
Lower Kittanning	I	43 62	64 70	29 56	22 64	10 31	3 68	22 42	39 80	33 14	50 37
	II	71 71	43 74	46 81	15 47	22 55	15 36	20 34	49 45	22 39	61 60
	Average	57 66	53 72	38 68	18 56	16 43	9 52	21 38	44 62	28 27	55 48
	I	35 35	72 72	28 50	15 42	14 41	7 53	71 89	43 67	58 38	43 32
	II	71 55	62 74	68 77	46 86	22 78	27 55	70 61	84 88	79 77	81 76
	Average	53 45	67 73	48 63	30 64	18 60	17 54	70 75	64 78	69 58	62 54

TABLE 3 (cont.)

Upper Freeport	I	32	75	45	72	26	49	6	52	29	72	10	75	63	85	28	68	49	26	27	44
	II	61	50	67	61	70	69	38	60	27	63	24	34	60	51	45	44	54	46	63	43
	Average	47	63	56	66	48	59	22	56	28	67	17	55	61	68	36	56	52	36	45	43
Pittsburgh	I	55	78	69	80	37	61	7	78	65	82	10	64	49	82	32	73	83	35	32	30
	II	19	41	48	34	30	39	19	28	23	44	10	32	13	25	16	31	41	60	5	21
	Average	37	59	59	57	33	50	13	53	44	63	10	48	31	53	24	52	62	47	18	25
Average all seams		38	49	43	58	33	51	18	51	20	52	9	44	37	50	32	46	38	34	34	38

^a Test I planted fall 1961 and spring 1962; Test II planted fall 1962 and spring 1963.

what was better than fall planting for the spruces and red and white pine. Spring planting was much better for jack, Scotch, pitch, and, especially, Austrian pine (Table 3).

Spring-planted shrubs survived better than the average than those planted in the fall. However, there was no significant difference between a fall and

TABLE 4

First-year survival of fall- and spring-planted shrubs on seven spoils (in percent)

Coal-seam spoil	Test year ^a	Test year	Autumn olive	Asian olive	Asian apple	Tatarian honey- suckle	Tatarian honey- suckle	Silky dogwood	Silky dogwood	Multi- flora rose	Multi- flora rose	S
			F	F	SF	SF	SF	SF	SF	SF	SF	S
Clarion at Clearfield	I	I43	543	518	558	571	341	372	632	638	648	67
	II	II51	651	620	760	723	553	508	438	486	756	77
Average	Average		547	579	659	657	447	435	535	552	752	72
Clarion at Clarion	I	I 0	00	01	61	60	00	00	00	00	00	0
	II	II 0	00	02	122	120	00	00	>10	>12	12	1
Average	Average		00	02	92	90	00	00	>10	>11	>11	>1
Lower Kittanning	I	I 9	249	249	219	244	114	116	516	578	318	35
	II	II16	316	355	335	511	311	346	526	524	214	21
Average	Average		213	297	327	377	237	231	521	546	216	28
Middle Kittanning	I	I24	24	414	134	151	71	76	226	287	167	16
	II	II10	110	302	42	44	124	125	215	203	33	3
Average	Average		117	363	163	103	33	90	220	245	105	10
Lower Freeport	I	I67	667	922	872	880	470	434	974	987	767	78
	II	II65	665	945	985	951	661	699	989	975	865	82
Average	Average		666	939	979	926	566	562	982	976	866	80
Upper Freeport	I	I56	666	746	886	879	59	543	873	832	92	79
	II	II36	336	730	890	823	458	457	677	678	688	60
Average	Average		51	733	888	853	58	505	75	750	90	69
Pittsburgh	I	I93	93	808	888	927	67	489	89	916	96	82
	II	II44	44	740	80	952	672	602	42	430	90	78
Average	Average		68	774	84	949	69	545	65	673	93	80
Average all seams			37	37	529	49	566	36	333	43	536	48

^a Test I planted fall 1961 and spring 1962; Test II planted fall 1962 and spring 1963.

spring planting of shrubs on the three sites with pH above 6, as contrasted with the better survival of spring-planted trees. The average fall survival was only 52% of spring survival on the four acid sites.

Season of planting had no detectable effect on survival of Tatarian honeysuckle and multiflora rose; but spring planting was somewhat better for autumn olive, Asian crabapple, and silky dogwood (Table 4). On the three better sites, all shrub species had at least 50% survival for both seasons.

The spoil had a significant effect on overall survival as well as on the results of season of planting. Very few trees and shrubs survived on the most acid site. Initial survival on the other three acid spoils was quite good considering the unfavorable weather and sites, but additional trees and shrubs died throughout the second and third growing seasons.

The second-year planting was a little more successful than the first, especially for tree survival, except on the Pittsburgh spoil where severe competition from heavy herbaceous cover substantially reduced tree survival. After 5 years in this site, only red, Scotch, and Austrian pines had better than 25% survival. Survival of the second-year planting of silky dogwood and autumn olive was reduced some on the Pittsburgh spoil, but the other shrub species showed little effect of herbaceous competition.

Although the study was not specifically designed to determine the effects of planting dates, survival data of the three dates within each season over both years were subjected to Chi-square tests. No significant differences could be detected among planting dates for any species of trees or shrubs. Amount and pattern of rainfall after planting apparently have more effect on survival than early-, middle-, or late-season planting.

Fifth-year height of surviving trees and shrubs was not significantly affected by season of planting (Tables 5 and 6). Chapman (1944) reported that spring-planted shortleaf pines not only survived better, but were 11.0 ft tall compared to 8.6 ft for fall-planted trees after 7 years. Reduced height growth associated with poor survival after fall planting is not an uncommon phenomenon and may be attributed to over-winter damage to roots from frost heaving. Very little frost heaving of fall-planted seedlings was noted on the 7 spoils in this study, which may account for the small differences in height growth.

Fruiting of shrubs was observed during the study. Healthy autumn olive and multiflora rose produced heavy crops during the second growing season, honeysuckle during the third, and silky dogwood during the fourth. A few Asian crabapples produced fruit during the sixth year. No differences in fruiting were detected between fall- and spring-planted shrubs.

TABLE 5
Average five-year heights of fall- and spring-planted trees on spoils
(in ft)

Coal-seam spoil ^a	Test year ^b	White pine		Red pine		Jack pine		Pitch pine		Scotch pine		Austrian pine		Norway spruce		White spruce		European larch		Japanese larch	
		F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S
Lower Kittanning	I	1.4	1.0	1.0	1.1	3.2	2.8	2.8	2.0	2.4	2.2	— ^c	0.8	0.6	0.6	0.8	0.7	2.8	4.2	3.9	
	II	1.0	1.2	1.4	1.7	2.7	3.2	3.0	2.2	2.7	2.8	1.8	1.3	0.9	1.0	1.0	0.6	2.6	3.1	4.6	5.2
	Average	1.2	1.1	1.2	1.4	3.0	3.0	2.9	2.1	2.6	3.0	1.8	1.0	0.8	0.8	0.8	0.7	2.6	3.4	4.4	4.0
Middle Kittanning	I	1.4	1.3	2.1	2.1	3.6	3.0	3.2	2.4	4.3	3.8	1.6	2.0	0.5	0.4	1.1	1.1	2.2	1.5	3.9	3.6
	II	1.6	1.4	2.4	2.0	3.0	2.8	3.4	3.0	4.4	2.6	2.6	1.6	0.9	0.9	1.1	0.9	1.6	2.0	3.8	3.9
	Average	1.5	1.4	2.2	2.0	3.3	2.9	3.3	2.7	4.4	3.2	2.1	1.8	0.7	0.6	1.1	1.0	1.9	1.8	3.8	r3.8
Lower Freeport	I	1.5	1.4	1.6	1.4	3.4	2.9	2.8	2.7	3.0	2.9	1.4	1.6	1.1	1.1	1.6	1.4	2.6	2.4	2.7	2.5
	II	1.4	1.4	1.4	1.2	3.6	2.6	1.6	1.8	2.4	2.4	1.6	1.2	1.0	1.0	1.4	1.4	1.8	2.1	3.0	3.0
	Average	1.4	1.4	1.5	1.3	3.5	2.8	2.2	2.2	2.7	2.6	1.5	1.4	1.0	1.0	1.5	1.4	2.2	2.2	2.8	2.8
Upper Freeport	I	1.5	1.4	2.4	1.8	3.6	3.0	3.0	2.8	3.0	2.9	1.6	1.8	1.2	1.2	1.2	1.0	2.0	2.0	3.1	2.8
	II	0.8	1.0	2.0	1.6	2.2	3.6	2.0	2.4	3.3	2.8	1.6	1.4	1.0	1.0	1.1	1.1	1.8	1.6	2.2	2.2
	Average	1.2	1.2	2.2	1.7	2.9	3.3	2.5	2.6	3.2	2.8	1.6	1.6	1.1	1.1	1.2	1.0	1.9	1.8	2.6	2.5

TABLE 5 (cont.)

Pittsburgh	I	1.6	0.8	1.5	1.2	1.8	2.2	1.3	1.5	2.4	2.2	1.4	1.2	0.8	1.0	1.1	1.0	1.5	1.6	1.6	3.4
	II	1.0	1.0	0.9	1.2	1.4	1.6	1.4	1.6	2.3	1.8	1.0	1.0	0.6	—	1.2	1.4	1.3	1.2	—	4.0
Average		1.3	0.9	1.2	1.2	1.6	1.9	1.4	1.6	2.4	2.0	1.2	1.1	0.7	1.0	1.2	1.2	1.4	1.4	1.6	3.7
Average all seams		1.3	1.2	1.7	1.5	2.9	2.8	2.5	2.2	3.0	2.7	1.6	1.4	0.9	0.9	1.1	1.1	2.0	2.0	3.0	3.5

^a There are no height data available for the Clarion at Clearfield seam. Planting has been destroyed by re-stripping. Data from Clarion at Clarion was omitted because of insufficient survival.

^b Test I planted fall 1961 and spring 1962; Test II planted fall 1962 and spring 1963.

^c Indicates zero survival, thus no height measurements.

TABLE 6

Average five-year heights of fall- and spring-planted shrubs on spoils (in ft)

Coal-seam spoil ^a	Test year ^b	Autumn olive		Asian crabapple		Tatarian honey- suckle		Silky dogwood		Multi- flora rose	
		F	S	F	S	F	S	F	S	F	S
Lower Kittanning	I	7.0	5.2	2.0	2.1	2.0	1.6	3.0	2.2	2.0	1.2
	II	3.7	4.3	1.8	1.2	2.0	2.3	1.8	1.8	1.9	1.5
	Average	5.4	4.8	1.9	1.6	2.0	2.0	2.4	2.0	2.0	1.4
Middle Kittanning	I	3.0	3.4	2.6	2.6	1.0	2.6	2.5	3.0	3.0	2.7
	II	3.2	4.2	2.1	1.4	1.4	2.2	2.2	1.8	2.8	3.0
	Average	3.1	3.8	2.4	2.0	1.2	2.4	2.4	2.4	2.9	2.8
Lower Freeport	I	7.1	5.5	1.9	1.9	1.5	1.8	2.2	2.0	3.0	2.3
	II	5.1	5.6	1.6	1.6	1.6	1.6	1.6	1.6	2.3	2.0
	Average	6.1	5.6	1.8	1.8	1.6	1.7	1.9	1.8	2.6	2.2
Upper Freeport	I	7.6	7.3	3.6	3.2	2.7	2.6	2.6	2.4	3.9	3.8
	II	7.2	6.8	2.7	2.5	2.4	1.8	2.0	2.1	3.0	2.5
	Average	7.4	7.0	3.2	2.8	2.6	2.2	2.3	2.2	3.4	3.2
Pittsburgh	I	4.4	4.0	2.2	2.3	2.8	2.6	1.1	1.4	N ^c	N
	II	2.4	2.7	1.8	2.0	2.0	2.0	1.4	1.6	N	N
	Average	3.4	3.4	2.0	2.2	2.4	2.3	1.2	1.5	N	N
Average all seams		5.1	4.9	2.2	2.1	1.9	2.1	2.0	2.0	2.7	2.4

^a No data collected for the Clarion at Clearfield seam. Data from Clarion at Clarion were omitted because of insufficient survival.

^b Test I planted fall 1961 and spring 1962; Test II planted fall 1962 and spring 1963.

^c N indicates heights not measured on this planting.

RECOMMENDATIONS

The results of this study indicate that spring planting is better than fall planting, especially on acid spoils. Fall planting of trees and shrubs is generally unsatisfactory on highly acid spoils. However, on favorable spoils, some fall-planted conifers—such as the larches, spruces, red and white pines—and some hardwood trees and shrubs may survive adequately.

On exceptionally good sites, competition to trees and some shrubs from herbaceous vegetation may be severe. If tree cover is desired on such sites, seedlings should be established as soon as possible after mining; and the slower growing conifers should be avoided.

The good performance of shrubs indicates that their wider use is warranted, especially on good sites where wildlife food and cover are desired. Autumn olive produced the best cover and yielded heavy crops of berries, but the other four shrub species also grew well enough to be considered for multiple-use plantings.

LITERATURE CITED

- Chapman, A. G. 1944. Forest planting on strip-mined coal lands with special reference to Ohio. U. S. Dep. Agr., Forest Service, Central States Forest Exp. Sta. Tech. Paper 104. 25 p.

DISCUSSION

SHEETS: Have you done any work with grasses and legumes?

VOGEL: We made some comparisons of fall vs. spring seeding in 1963 and 64. Those early seedings, in general, were failures which we learned later were due more to infertility of spoil than time of seeding.

DAVIS: Many operators are trying to regrade all the operations close behind the actual removal of coal. It works much better to seed the spoils immediately after grading, before they get several rains on them and get crusted over. We would like to determine what seed mixtures can be seeded throughout the spring, summer, and fall.

RUFFNER: Seedling survival on spoils of low pH's seemed high. Did this continue throughout the growing season or did mortality set in?

DAVIS: You remember that this test was followed by several dry years. Except for one of the acid areas where almost everything died by the end of 5 years, survival stayed just about the same. The one exception was the Pittsburgh seam which has such heavy vegetation, and anything that didn't get growing fast in the beginning passed out of the picture due to competition. The same thing was true on two of the other sites where the spruces suffered from competition.

PRETO: Was the planting and the seed source the same for spring and fall?

DAVIS: The trees and shrubs were from the same seed sources both years and grown in the same nursery.

MEDVICK: A friend of mine in Indiana has actually planted trees in every month of the year. Although it was not a research study, he points out that his best success for fall work was where there was very little clay. Would you comment on that?

DAVIS: It may be possible to plant some species all through the summer, but you run into supply problems; the nurseries can keep the material only so long because of limited cold storage space. On the heavier spoils frost heaving may be an important factor in fall plantings. We didn't get any damage from frost heaving, probably because our Pennsylvania spoils are quite porous.

BENGTON: Were your seedlings that were planted in the spring lifted in the fall and stored over winter, or were they lifted in the spring just prior to planting?

DAVIS: They were lifted in the spring and those that were planted in the fall were lifted in the fall. In the spring they were all lifted at the same time and stored to be planted on the three dates.

KRAUSE: Did you experience any difficulty with hardening of the plants before fall planting; and second, did you experience any heating in the bundles?

DAVIS: We didn't experience much trouble with this in the fall planting because we used mostly conifers which had already finished growing. We did have trouble with larch heating in the spring, and we lost the late planting in the first year because of heating. The next year the nursery had a cold storage building, so we didn't have that problem. However, you might have difficulty using alder for fall planting. Pennsylvania nurseries report that sometimes alders grow too late into the fall for fall lifting.

DARMER: Do you mean that testing the plants over a 2-year-period is good enough to characterized the growing of the plants?

DAVIS: No, I don't think it is long enough, but we had to set some sort of limit on this study. We hoped to get good weather conditions through at least one of the years or at least get about the same relative conditions in the fall and spring planting. As it turned out, we had four poor seasons, but the relative success should be fairly indicative.