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ROLE OF INSECTS AND DISEASES IN A JACK PINE PROVENANCE STUDY[1]

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ABSTRACT

Two jack pine plantations were established at the Cloquet Forestry Center, Cloquet, Minnesota, in 1942 and 1943, using trees originating from 22 sites in the United States and 10 in Canada. From 1945 to 1953 the incidence of attack by insects and diseases was recorded individually for all trees, and in 1980–1981 the diameter and form of both living and dead trees were recorded. There were differences in the incidence of attack by the pests and in tree response to early injury among the various seed sources. In 1980 and in 1981 there were differences in tree form resulting from insect damage and both living and dead pest-free trees had the best form. The diameter increases from 1955 to 1980–1981 were almost identical for all categories with the exception of the dead pest-free trees which had the smallest diameters.

Jack pine (*Pinus banksiana* Lamb.) seeds were collected between 1938 and 1941, through the cooperation of forestry agencies in the United States and Canada, from trees having good or poor form, and trees from Cloquet, Minnesota, with open cones (Schantz-Hansen and Jensen 1954). The seedlings were grown in a nursery at the Cloquet Forestry Center and later transplanted at Cloquet, mostly as 2–0 stock, in plots of 25 trees with a 1.5 by 1.5-m spacing with 3 m between plots. The number of replicates varied from 0–12. Plantation A was planted in 1942 and Plantation B in 1943.

In 1945 trees were identified individually by number and, from 1945 to 1953, the incidence of attacks by the eastern pineshoot borer, *Eucosma gloriola* Heinrich, the northern pitch twig moth, *Petrova albicapitana* (Busck), the white pine weevil, *Pissodes strobi* (Peck), and the pine-oak rust fungus, *Cronartium quercuum* (Berk.) Miyabe were recorded. Tree heights were measured from 1945 to 1955 and diameters in 1955 and 1980–1981. In 1957 tree form was estimated and recorded in six classes based on deflections in the basal 2.4 m of the stem. Thus, for a class 1 tree, the deflection from the vertical was from 0–1/4 of 1/2 the stem diameter; classes 2 to 5 were additional 1/4 increments, with class number 5 having a deflection greater than 1/2 the stem diameter. Class 6 trees were either forked or stag-headed. In 1980–1981 only four form classes (1–4) were recorded: good, fair, poor, and forked or stag-headed.

Shantz-Hansen and Jensen (1954) reported survival, growth, and winter hardiness of the trees in 1950. Schoenike et al. (1962) described the branching characteristics of these trees.

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RESULTS

The percentages of trees in Plantations A and B combined, attacked by the three most common insects or the pine-oak rust fungus, and pest-free trees, along with the percentage of attacked trees that died, are in Table 1. Trees attacked by those species alone and the total number of trees attacked by them plus another are in columns a and b. The results for Plantations A and B were combined in Table 1 primarily for convenience which did not affect the recognition of differences among the seed sources with respect to incidence of attack by the pests observed. It should be noted, however, that in Plantation A the percentage of trees attacked was higher than in Plantation B, while in Plantation B the percentage of trees that died following infestation or infection was higher.

Trees attacked most by the eastern pineshoot borer were grown from seed collected from northern latitudes, including Minnesota, Michigan, and Canadian sources. Trees from Burlington, Vermont; Baldwin, Michigan; and Eau Claire, Wisconsin; representing lower latitudes, had lower amounts of infestation. Trees grown from seed collected at Eau Claire, Wisconsin, also had, by far, the highest percentage of pest-free trees. The sources which had the highest percentage of the trees infested by the pineshoot borer that died were the Miramichi Fire Region, The Pas, St. John, Fort McMurray, and the junction of the Athabasca and Slave rivers, all Canadian sources. Trees from the Fort McMurray District, The Pas, Miramichi Fire Region, Fort Francis, Peterson, Minnesota, and Burlington, Vermont, had the highest mortality among the pest-free trees.

A comparison in 1957 of tree form of pest-free trees and of trees attacked from 1 to 4 years by the eastern pineshoot borer is in Table 2. In the older planting (Plantation A) 50% or more of all the trees were rated in class 5, and there was little difference between pest-free and infested trees. In Plantation B the greatest number of trees were rated in class 2, with again about the same relative number of pest-free and infested trees. In this planting there were about half as many trees rated in class 5 as in the older planting. One explanation for these differences may be that in 1957 the trees in Plantation B were from 15 to 30 cm shorter than those in Plantation A. This difference also is shown in the average figures for heights and percentage infestation by the eastern pineshoot borer from 1945–53 (Table 3). By the time the trees reached heights of 2.4–2.7 m, the percentage of trees with leaders attacked was much less than when the trees were shorter. These data agree with the results of another provenance study (Hodson et al. 1982) where the greatest number of trees were attacked when they were 1–2 m tall, and many fewer trees attacked when they were about 2.7 m tall.

As can be seen in Table 1, the seed sources having 10% or more of the trees infected by the pine-oak rust fungus came from Chisholm, Cloquet, and Hinckley, Minnesota; Manistique, Michigan; Sandiland Forest Reserve, Manitoba; and Fort Francis, Ontario. For these and other sources the number of fungus-infected trees that died was greater than when damage was caused by other pests. The relationship between age and height of trees with both branch and stem infections is presented in Table 4. The infections that were established during the 1944–48 period occurred when the trees were less than 3 m tall. There were very few found between 3 m and 6 m and above when the records were taken in 1980. At this time the majority of the galls were located at heights between 6 and 8 m. There were striking differences among sources with respect to whether the infection occurred early or late, and whether there were more galls on branches than on stems.

In general there were many more galls found high in the trees with the number of branch galls greater than stem galls. Four sources, all from Minnesota, had the most galls established during the 1944–1948 period; in eight cases there were no galls formed during this period, and two of them, St. Croix Recreational Area and Eau Claire, Wisconsin, had no galls at any time. The most striking examples of sources with no galls early and many later were Sandiland Forest Reserve, Manitoba; Fort Francis, Ontario; Chalk River, Ontario; and poor form trees from Manistique, Michigan. Six sources had only branch galls. These were, Peterson, Minnesota; Baldwin, Michigan, Bar Harbor, Maine; and the three Canadian sources: Chalk River, Regina, and junction of Athabasca and Slave rivers.

Table 1. Percentage of trees invaded by insects and the pine-oak rust fungus in plantations A and B combined (1) and the percentage of those trees that died (2). Column (a) includes trees attacked by only one pest and column (b) total-trees attacked by that pest and others.

	SB[a]		P[b]		W[c]		P-O[d]		Pest-free	Total trees
	a	b	a	b	a	b	a	b		
					Chisholm, Minnesota					
1	33	55	20	45	5	7	1	9	16	386
2	40	48	27	29	46	15	75	33	44	
					Grand Marais, Minnesota					
1	28	60	17	33	3	5	3	7	16	480
2	29	33	46	34	2	42	63	44	37	
					Park Rapids, Minnesota					
1	33	64	16	45	5	11	1	6	15	
2	32	33	35	26	34	33	100	33	33	482
					Cloquet, Minnesota—General					
1	34	72	16	46	3	12	1	8	11	408
2	29	33	34	34	1	33	50	42	56	
					Cloquet, Minnesota—Good Form					
1	28	65	18	52	2	9	2	7	16	453
2	42	34	33	34	14	28	67	44	35	
					Cloquet, Minnesota—Poor Form					
1	34	70	15	42	3	8	1	3	20	586
2	34	33	41	35	15	63	40	40	45	
					Cloquet, Minnesota—Open Cones					
1	33	61	14	45	3	9	1	4	19	708
2	42	41	47	34	42	39	75	92	44	
					Jenkins, Minnesota					
1	40	70	14	39	1	12	1	3	16	518
2	29	30	33	33	44	28	100	33	33	
					Wellston, Michigan—Good Form					
1	21	45	19	41	0	4	1	8	43	155
2	25	55	40	33	0	0	100	33	44	
					Wellston, Michigan—Poor Form					
1	36	59	19	34	2	2	3	5	38	176
2	33	33	21	26	0	0	33	13	49	
					Manistique, Michigan—Good Form					
1	29	59	8	28	2	4	3	8	9	298
2	19	24	26	27	50	36	38	33	36	
					Manistique, Michigan—Poor Form					
1	26	49	15	36	3	5	4	7	18	263
2	15	15	25	21	33	35	55	26	15	
					Huron, Michigan—Good Form					
1	34	54	15	33	2	2	1	3	33	232
2	35	26	34	21	20	20	67	75	44	
					Huron, Michigan—Poor Form					
1	33	51	17	35	4	4	1	1	33	231
2	19	17	36	19	13	13	0	0	43	

Table 1. (continued)

	SB[a]		P[b]		W[c]		P-O[d]		Pest-	Total
	a	b	a	b	a	b	a	b	free	trees
					Baldwin, Michigan—Good Form					
1	27	34	33	34	2	2	2	2	35	49
2	8	18	63	21	0	0	0	0	29	
					Baldwin, Michigan—Poor Form					
1	21	47	28	47	1	1	0	21	23	47
2	20	14	33	18	0	0	0	100	46	
					Miramichi, Fire Region, New Brunswick, Canada					
1	28	51	17	34	2	2	0	0	34	47
2	54	63	50	34	0	0	0	0	74	
					Fort Francis, Ontario, Canada					
1	37	71	12	33	0	8	4	8	10	49
2	50	43	33	33	0	50	100	50	60	
					Chalk River, Ontario, Canada					
1	44	70	14	34	2	3	0	8	12	50
2	18	14	43	11	100	100	0	50	33	
					Regina, Saskatchewan, Canada					
1	23	50	26	52	1	1	0	0	33	42
2	56	14	27	34	0	0	0	0	6	
					Jct. Athabasca and Slave Rivers, Alberta, Canada Plantation A only					
1	24	76	0	48	0	4	0	0	20	25
2	17	58	0	40	0	0	0	0	16	
					Fort McMurray District, Alberta, Canada					
1	36	56	18	34	2	4	0	5	18	50
2	67	68	89	61	100	100	0	0	78	
					Sandiland Forest Reserve, Manitoba, Canada					
1	40	72	11	26	0	6	4	11	30	47
2	33	35	33	17	0	33	100	80	38	
					St. John, Quebec, Canada					
1	42	66	12	33	0	4	0	1	16	50
2	71	58	50	34	0	0	0	0	25	
					The Pas, Manitoba, Canada					
1	58	70	8	18	2	2	0	0	20	50
2	86	66	25	89	100	100	0	0	90	
					Iroquois Lake District, Alberta, Canada All Dead 1980—Sweet Fern Rust					
					St. Croix Area, Hinckley, Minnesota					
1	29	59	12	34	0	10	0	3	25	49
2	57	24	50	11	0	20	0	0	58	
					Peterson, Minnesota					
1	29	61	12	45	4	14	0	0	14	49
2	36	33	8	5	50	2	0	0	71	

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Table 1. (continued)

	SB[a]		P[b]		W[c]		P-O[d]		Pest-free	Total trees
	a	b	a	b	a	b	a	b		
					Eau Claire, Wisconsin					
1	13	21	8	16	0	0	0	0	71	24
2	4	4	4	4	0	0	0	0	50	
					Bar Harbor, Maine Only One Tree Left in 1981					
					Burlington, Vermont					
1	22	34	40	50	8	12	6	6	12	50
2	18	22	45	34	25	17	27	27	67	
					Bass River State Forest, New Jersey					
1	34	62	6	28	8	12	0	4	30	50
2	41	26	0	1	0	0	0	50	40	
					Percentage Averages—All Plots					
1	32	58	16	37	2	6	1	5	24	
2	35	33	34	28	23	27	36	30	45	

[a]Eastern pineshoot borer
[b]Northern pitch twig moth
[c]White pine weevil
[d]Pine-oak rust fungus

Table 2. Percentage of trees in each of six form classes for pest-free trees and for trees attacked from 1 to 4 times by the eastern pineshoot moth.

	Tree Form Classes						Total Trees	
	1	2	3	4	5	6	No.	%
				Plantation A				
Pest-free	7.4	21.8	11.0	8.2	50.0	1.6	620	25.5
Attacked								
1 time	5.2	19.2	9.7	9.5	53.5	2.9	1136	46.7
2 times	3.2	17.5	9.6	11.9	55.0	2.8	502	20.7
3 times	4.6	19.2	3.3	12.6	57.6	2.7	151	6.2
4 times	4.5	13.6	9.1	18.2	54.6	0	22	0.9
				Plantation B				
Pest-free	28.1	40.5	3.9	3.2	21.5	2.7	846	36.2
Attacked								
1 time	17.7	40.4	6.1	8.0	25.0	2.8	1055	45.2
2 times	11.8	42.1	4.6	9.0	30.3	2.3	390	16.7
3 times	14.0	30.2	4.7	20.9	27.9	2.3	430	1.8
4 times	0	0	33.3	0	66.7	0	60	0.2

Table 3. Percentage of trees attacked by the eastern pineshoot borer from 1945–1953 and corresponding tree heights (m), in plantations A and B.

	1945	1946	1947	1948	1949	1950	1951	1952	1953
				Plantation A					
% trees	19.1	30.4	38.8	29.9	9.5	6.3	5.9	6.9	6.6
Tree hts.	1.0	1.5	1.9	2.2	2.7	3.3	—	—	—
				Plantation B					
% trees	4.1	27.0	40.8	24.2	9.9	7.5	5.7	6.4	8.9
Tree hts.	0.9	1.3	1.7	2.0	2.5	3.0	—	—	—

The northern pitch twig moth attacks were not related to the latitude of the seed sources. There was no evidence to suggest that attacks by this species could account for the quite high mortality among the infested trees. In fact, with a few exceptions, the mortality of trees infested by this pest were about the same as that of the pest-free trees. These sources were trees of good form from Baldwin, Michigan, and from the junction of Athabasca and Slave rivers, Alberta, Canada. The mortality was much higher among trees from Wellston, Michigan; The Pas, Manitoba; Peterson, Minnesota; Eau Claire, Wisconsin; and Bass River State Forest, New Jersey. The incidence of white pine weevil damage was much lower than for the other principal pests. The greatest amount of injury occurred on trees from Cloquet, Jenkins, and Peterson, Minnesota; Manistique, Michigan; and Sandiland Forest Reserve, Manitoba.

The average diameters of pest-free and infested trees in 1955 and in 1980–1981 are in Table 5. Only sources with five or more replicated plots are included in the table. There was little difference in diameter increase for the living trees. For dead trees, the smallest increase was recorded for those damaged by the white pine weevil and the pest-free trees. With the exception of trees infected by pine-oak rust, dead trees, including pest-free ones, had the poorest form. With respect to tree form there was no difference between sources originating from trees of good or poor form. Dead trees infected with pine-oak rust had the greatest diameter increase, probably because most of them became infected when they were 20 or more years old. These results agree with the findings of Westing (1965) who stated that in many tree species displacement deformities are corrected by adjustments in radial growth, and with those of Miller et al. (1978) who found that pole-sized trees had sufficient time to overgrow early injury by the European pine shoot moth.

CONCLUSION

There were marked differences in the incidence of attack by pests and in tree response to early injury. Trees grown from seed collected in the more northern latitudes suffered the greatest amount of injury, particularly those attacked by the eastern pineshoot moth and the pine-oak rust fungus. Damage from the tree insect species occurred during the first 10–12 years, while the greatest amount of infection by the pine-oak rust fungus occurred when the trees were much older. Shantz-Hansen and Jensen (1954) reported that there also were differences among the same sources with respect to winter injury and in tree form when rated in 1950, and that the form at that time was affected most by leader killing by the eastern pineshoot borer.

In the present study the highest mortality occurred in trees infected by the pine-oak rust fungus and among many groups of pest-free trees, probably due to suppression. The poorest form was exhibited by trees attacked by the white pine weevil, while the living

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Table 4. Percentages of trees with pine-oak rust, branch and stem infections.

Plantation A

1944–1948		Above Six Meters—1980		Total
Branch	Stem	Branch	Stem	trees
		Chisholm, Minnesota		
19	5	23	9	197
		Grand Marais, Minnesota		
22	9	21	2	245
		Park Rapids, Minnesota		
11	2	8	3	247
		Cloquet, Minnesota—General		
10	4	10	4	173
		Cloquet, Minnesota—Good Form		
13	4	12	6	286
		Cloquet, Minnesota—Poor Form		
9	3	8	1	305
		Cloquet, Minnesota—Open Cones		
11	5	7	0.2	408
		Jenkins, Minnesota		
8	1	4	1	272
		Manistique, Michigan—Good Form		
7	5	14	11	123
		Manistique, Michigan—Poor Form		
6	4	23	8	120
		Wellston, Michigan—Good Form		
1	1	4	0	81
		Wellston, Michigan—Poor Form		
4	4	12	1	113
		Huron, Michigan—Good Form		
5	2	11	1	120
		Huron, Michigan—Poor Form		
3	1	13	1	117
		Baldwin, Michigan—Good Form		
0	4	8	4	25
		Baldwin, Michigan—Poor Form		
0	0	8	0	24
		Miramichi, Fire Region—New Brunswick		
4	4	29	5	24
		Regina, Saskatchewan		
0	0	9	0	22
		Jct. Athabasca and Slave Rivers, Alberta		
0	0	12	0	25
		Fort McMurray District, Alberta		
4	4	8	4	25
		Lake St. John, Quebec		
0	4	16	4	25
		The Pas, Manitoba		
0	0	4	4	25

Table 4. (continued)

1944–1948		Above Six Meters—1980		Total
Branch	Stem	Branch	Stem	trees
		Sandiland Forest Preserve, Manitoba		
9	0	22	4	23
		Fort Francis, Ontario		
4	0	44	20	25
		Chalk River, Ontario		
4	0	44	0	25
		Bar Harbor, Maine		
0	0	17	0	24
		Bass River State Forest, New Gretna, New Jersey		
4	4	8	0	25
		Burlington, Vermont		
0	0	8	8	25
		Peterson, Minnesota		
13	0	4	0	24
		St. Croix Recreational Area, Hinckley, Minnesota		
0	0	0	0	24
		Eau Claire, Wisconsin		
0	0	0	0	24

Table 5. Average diameters (cm) in 1955, 1980 (or 1981), increase in diameter between 1955 and 1980, and form class in 1980 (1981) for trees attacked by the three major pests in plantations A and B.

	Eastern pine shoot borer				White pine weevil			
	Diameter		Increase in		Diameter		Increase in	
	1955	1980	diameter	Form	1955	1980	diameter	Form
				Plantation A (1980)				
Living	8.3	15.7	7.3	2.4	8.8	16.5	7.6	2.3
Dead	7.1	10.2	3.1	2.6	7.6	10.2	2.5	2.8
				Plantation B (1981)				
Living	8.3	16.3	7.9	2.2	8.8	16.0	7.1	2.1
Dead	6.6	9.4	2.8	2.7	7.4	9.7	2.3	2.7
	Pine-oak rust				Pest-free			
				Plantation A (1980)				
Living	7.9	15.2	7.3	2.3	9.1	16.5	7.3	1.9
Dead	7.6	11.7	4.1	2.4	7.1	9.7	2.5	2.3
				Plantation B (1981)				
Living	9.1	16.0	6.9	2.3	8.3	15.7	7.9	2.1
Dead	7.6	11.2	3.6	2.2	9.1	9.9	0.8	2.5

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pest-free trees had the best form. Otherwise there was little difference in tree form in 1980–1981. With the exception of the dead pest-free trees the diameter increases from 1955 to 1980–1981 were almost identical.

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