United States
Department of
Agriculture

Forest Service

Pacific Northwest
Forest and Range
Experiment Station

Research Note
PNW-387
May 1981

Development of *Sirococcus* Shoot Blight Following Thinning in Western Hemlock Regeneration

Charles G. Shaw III, Thomas H. Laurent, and Spencer Israelson

Abstract

Shoot mortality from *Sirococcus strobilinus* Preuss. and other causes was recorded by crown position from April 1978 through October 1979 in young-growth western hemlock *[Tsuga heterophylla* (Raf.) Sarg.] crop trees released in a 1977 thinning at Thomas Bay, Alaska. All study trees contained some infected shoots, but no terminal leaders were killed by shoot blight. On individual trees, the number of shoots killed by S. *strobilinus* between April 1978 and October 1979 was significantly correlated with the level of shoot blight mortality present in April 1978. Disease occurrence was highest in the lower crown, but differences in the level of shoot mortality between lower, middle, and upper crown locations were not significant. Disease occurrence during 1978 and 1979 was markedly lower than that in 1976 and 1977. After thinning, shoot blight appears to be causing little damage to hemlock crop trees; suggesting that thinning operations can proceed at Thomas Bay with confidence that the selected crop trees will suffer little, if any, damage from the disease.

Keywords: Shoot blight, diseases (plant), western hemlock, *Tsuga heterophylla* Alaska (Thomas Bay).

Introduction

Western hemlock *[Tsuga heterophylla* (Raf.) Sarg.] regeneration in southeast Alaska is commonly attacked by the shoot blight fungus, *Sirococcus strobilinus* Preuss. (USDA 1979). Wicker et al. (1978) surveyed damage caused by *Sirococcus* shoot blight in western hemlock regeneration at Thomas Bay, where the highest incidence of the disease in Alaska has been detected. All western hemlock regeneration they examined was affected, frequently at rather high intensities. Nevertheless, they concluded that shoot blight had not caused appreciable damage as the densely stocked stands contained enough lightly affected trees to serve as potential crop trees.

Since 1976, when field data were collected by Wicker et al. (1978), several pre-commercial thinnings have been completed at Thomas Bay. Frequently these stands contained over 12,000 stems per hectare, which thinning reduced to around 1,400 stems per hectare. Crop trees selected in these thinned stands are thus growing in an environment vastly different from the densely stocked conditions prior to thinning.

CHARLES G SHAW III is research plant pathologist, Pacific Northwest Forest and Range Experiment Station, Forestry Sciences Laboratory, Juneau, Alaska; THOMAS H LAURENT is plant pathologist, State and Private Forestry, Forest Pest Management, R-10, Juneau, Alaska, and SPENCER ISRAELSON is forestry technician, Timber Management, Stikine Area, Tongass National Forest, Petersburg, Alaska.

The one thinned stand examined by Wicker et al (1978) had the lowest "disease index" they recorded, however, because any current or future damage will occur on selected crop trees in which a direct financial investment has been made, further information concerning disease development was required

Objectives of this study were to examine the amount and causes of shoot mortality, and to evaluate the resulting damage on western hemlock selected as crop trees in a prior thinning of mixed western hemlock and Sitka spruce *[Picea stichensis* (Bong) Carr] regeneration at Thomas Bay Initial levels of shoot mortality from S *strobilinus* and other causes and the development of new mortality were recorded by crown position from April 1978 through October 1979—two full growing seasons

Methods

Two stands were studied Old growth was harvested from the first stand in 1968 and in 1958 from the second stand In both stands, subsequent natural regeneration of mixed western hemlock and Sitka spruce was thinned in 1977 to approximately 1,384 stems per hectare The largest and best formed young-growth trees that met the spacing requirements became the selected crop trees These criteria removed hemlock most severely affected by *Sirococcus* shoot blight If both a spruce and a hemlock met the spacing needs, the'n the spruce was selected as it is less affected by shoot blight at Thomas Bay (Wicker et al 1978)

In the first stand, 10 western hemlock crop trees were randomly selected and three primary branches identified in the lower, middle and upper crown (nine total branches) Each branch was divided into portions growing in interior and exterior crown In April 1978, the terminal shoot of each live secondary branch greater than 15-cm total length was examined and recorded as healthy, killed by *Sirococcus* shoot blight as determined from the characteristic signs and symptoms (Funk 1972, Smith 1973), or dead from other causes Dead shoots were likely killed within the last 2 years as earlier death would have precluded determining that they had once been the terminal shoot If the terminal was recorded as dead at the first examination, then the new dominant terminal was identified and subsequently examined All branches were examined similarly in July and October 1978 and April, July, and October 1979 In all, 1,133 shoots on 90 primary branches in 10 trees were examined six times Mortality data were summarized by cause and crown location

A major concern for potential damage from *Sirococcus* shoot blight is malformation resulting from death of the tree's terminal leader. Terminal leaders in the above 10 trees, and 25 additional ones, were examined for mortality at each assessment

In the second stand, 10 trees, all of which were infected with *Sirococcus* shoot blight, were randomly selected Healthy terminal shoots of 24 primary branches, scattered in the lower, middle, and upper crown and the terminal of each tree were examined as in stand one

In stand two, all 10 study trees had some new shoot mortality from S. *strobilinus* between April 1978 and October 1979. However, only 5 of the 250 study shoots, 1 lateral shoot on each of five trees, were killed by shoot blight between April 1978 and October 1979. Since shoot mortality was extremely low, no analysis of disease occurrence by crown position was conducted. Mortality by causes other than shoot blight was relatively high with 87 shoots scattered among the 10 trees dying over the two growing seasons.

Discussion

Sirococcus shoot blight is still common at Thomas Bay. The disease was observed on nearly all hemlock crop trees remaining in thinned stands. It appears, however, to be causing little damage after thinning. This conclusion substantiates the earlier suggestion of Wicker et al. (1978) that potential crop trees are in little danger from the disease.

Crop tree selection at Thomas Bay presently favors selection of spruce and discriminates against hemlock severely affected by shoot blight. If this level of quality control in crop tree selection is maintained, then foresters can proceed with thinning operations at Thomas Bay confident that selected crop trees should show little subsequent effect from *Sirococcus* shoot blight. In addition, environmental changes associated with thinning the nearly impenetrable, densely stocked stands to a more open-grown condition suitable for development of individual trees will likely be less favorable for disease development (Wall and Magasi 1976). The reduction in shoot blight in 1978 and 1979, when compared to 1976 and 1977, supports the suggestion that this change is occurring.

Current shoot mortality is actually greater from causes other than shoot blight. We are confident that few, if any, of the shoots we recorded as killed by other causes actually died from S. *strobilinus.* Symptoms of disease are rather distinctive (Funk 1972, Smith 1973). In addition, we found a highly significant correlation between disease levels within individual trees in April 1978 and October 1979. Such correlation does not seem unusual for a disease considered to be spread via splashing rain drops (Peterson and Smith 1975). Contrarily, the lack of such correlation for shoots killed by other causes, tends to support our determination of cause of shoot mortality.

Wicker et al. (1978) stated that damage in potential crop trees from S. *strobilinus* was greatest in the shaded, lower portion of the tree crown. Amongst all of our study trees, shoot mortality from S. *strobilinus* was highest in the lower crown in April 1978 and between April 1978 and October 1979 (table 2). When the proportions of shoots killed by S. *strobilinus* to the total number of shoots examined in each crown position was compared by crown position, however, disease caused mortality was not found to be significantly concentrated in the lower crown at either time. This lack of significance in crown location of shoot mortality was caused by between-tree variability. For example, in April 1978 only 6 of the 10 study trees had the highest level of shoot mortality from shoot blight in the lower crown while 7 of the 10 did in October 1979 (table 2).

Total shoot mortality caused by S. *strobilinus* in April 1978 and between April 1978 and October 1979 was highest in the lower crown and least in the upper crown (table 2). The proportions of shoots killed by S. *strobilinus* to the total shoots examined in each tree-crown position, however, were not significantly different in April 1978 or between April 1978 and October 1979. Disease occurrence on shoots in the lower crown was also not significantly different between interior and exterior "locations.

No terminal leaders in the 35 trees were killed by shoot blight either in April 1978 or between April 1978 and October 1979. Two leaders died from other causes.

Table 2—Number (#) and percent (%) of shoots killed by S. *strobilinus* in the Lower (L), Middle (M), and Upper (U) crowns of the 10 trees studied in stand one[1]

Tree #		April 1978 crown position			October 1979[2] crown position		
		L	M	U	L	M	U
1	#	25	14	1	11	6	4
	%	56	54	9	24	23	36
2	#	14	2	0	6	1	0
	%	28	4	0	12	2	0
3	#	8	2	5	1	0	3
	%	16	14	18	2	0	11
4	#	5	1	2	5	0	1
	%	9	3	10	9	0	5
5	#	18	10	11	18	3	3
	%	30	48	48	30	14	13
6	#	24	28	6	5	4	0
	%	33	39	26	8	6	0
7	#	33	14	1	16	3	0
	%	35	23	3	17	5	0
8	#	10	5	3	3	4	1
	%	32	15	18	10	12	6
9	#	3	2	0	4	1	1
	%	8	4	0	10	2	6
10	#	5	0	0	2	0	0
	%	8	0	0	3	0	0
Total	#	142	78	29	71	22	13
Average	%	25	20	13	13	6	8

[1]Number of shoots is actual number killed by S *strobilinus* in each crown position, % is the proportion of all shoots examined in that crown position that were killed by S *strobilinus*

[2]Shoots killed between April 1978 and October 1979

Mortality attributed to shoot blight or other causes in April 1978 was compared by correlation coefficients to new mortality from shoot blight and other causes that developed between April 1978 and October 1979 Mortality levels between lower, middle, and upper crown positions and between interior and exterior locations within the lower crown were compared by analyses of variance All tests were performed at P = 0 01

Results

Shoot mortality from S *strobilinus* occurred on all study trees in stand one (table 1) Based on individual trees, new mortality caused by S *strobilinus* (shoots killed between April 1978 and October 1979) was significantly correlated with the level of *Sirococcus* mortality present in April 1978 (r = 0 83, p <0 01) Shoot mortality from causes other than S *stobilinus* in April 1978, however, was not significantly correlated with the level of new mortality from causes other than S *strobilinus* (r = 0 09, p > 0 01) If the assumption that mortality recorded in April 1978 occurred within the previous 2 years is correct, then disease occurrence in 1978 and 1979 was markedly lower than in 1976 and 1977 For the 10 trees combined, 249 shoots were killed by S *strobilinus* in 1976 and 1977 while only 106 died from the disease in 1978 and 1979 Contrarily, mortality from causes other than shoot blight—mainly frost damage, interior crown supression, and apparent animal browsing—was markedly higher in 1978 and 1979 than in 1976 and 1977 (table 1)

Table 1—Condition of shoots in stand one in April 1978 and October 1979[1]

Tree #	Total shoots examined	Shoot condition in April 1978			Shoot condition in October 1979		
		H	S	D	H	S	D
1	82	35	40	7	45	21	16
2	112	92	16	4	93	7	12
3	90	72	15	3	81	4	5
4	107	87	8	12	92	6	9
5	104	59	39	6	60	24	20
6	159	84	55	20	112	9	38
7	186	130	48	8	137	19	30
8	81	58	18	5	62	8	11
9	105	91	5	9	78	6	21
10	107	85	5	17	98	2	7
Total	1133	793	294	91	858	106	169

[1]H = healthy S = killed by S *strobilinus* D = dead from other causes If actual terminal was dead in April 1978 the new dominant terminal was identified and observed in subsequent examinations

Literature Cited

Funk, A. Sirococcus shoot blight of western hemlock in British Columbia and Alaska. Plant Dis. Rep. 56:645-647; 1972.

Peterson, G. W., and R. S. Smith, Jr. Forest nursery diseases in the United States. Agric. Handb. 470, USDA, Forest Service. Washington, D.C.; 1975.

Smith, R. S., Jr. *Sirococcus* tip dieback of *Pinus* spp. in California nurseries. Plant Dis. Rep. 57: 69-73; 1973.

United States Department of Agriculture. Forest insect and disease conditions in Alaska in 1978. USDA For. Serv., Alaska Region Rep. No. 62; 1979.

Wall, R. E., and L P. Magasi. Environmental factors affecting *Sirococcus* shoot blight of black spruce. Can. J. For. Res. 6:448-452; 1976.

Wicker, E. F., T. H. Laurent, and S. Israelson. *Sirococcus* shoot blight damage to western hemlock regeneration at Thomas Bay, Alaska. USDA For. Serv. Res. Pap. INT-198. Ogden, Ut.: Intermt. For. and Range Exp. Stn.; 1978.

GPO 993-476