

FIFTY YEAR-OLD SITKA SPRUCE PLANTATIONS WITH A HISTORY OF INTENSE WEEVIL ATTACK

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ABSTRACT

The condition of 26 plantations of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) established between 1930 and 1935, at Green Timbers, Surrey, British Columbia, which sustained repeated attack by the white pine weevil (*Pissodes strobi* Peck) was examined in 1981. The plantations were started either as pure Sitka spruce or as a mixture of spruce and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). A detailed survey was conducted in one plantation of each type for which annual infestation levels were recorded from 1936 to 1949 and which appeared to be typical of the rest of the pure and mixed plantations.

Many Sitka spruce trees were dead, having been out-competed by the other trees on the site as a result of repeated top-killing by *P. strobi*. Most surviving spruce trees were badly deformed, showed signs of severe attack, and were non-merchantable. The plantation of pure Sitka spruce contained about 176 living Sitka spruce trees/ha, but only about 14 trees/ha were potential crop trees; the rest were suppressed or deformed. This plantation contained more volume in other volunteer conifers than in Sitka spruce. The mixed plantation developed into a merchantable stand of almost pure Douglas-fir, with only 5-6 Sitka spruce trees/ha.

RESUME

En 1981, on a examiné l'état de 26 plantations d'épinettes de Sitka (*Picea sitchensis* [Bong.] Carr.), établies en 1930 et 1935, à Green Timbers, Surrey (Columbia-Britannique), et qui avaient subi pendant de nombreuses années des attaques soutenues de charançon du pin blanc (*Pissodes strobi* [Peck]). Au début, les plantations étaient soit pures, soit mêlées de Douglas taxifoliés (*Pseudotsuga menziesii* [Mirb.] Franco). On a examiné une plantation de chacun des deux types dont la gravité des infestations annuelles avait été notée de 1936 à 1949, et qui semblait représentative de la situation dans les autres plantations.

Beaucoup d'épinettes avaient péri ou avaient été supplantées à cause de la mortalité répétée de leurs cimes causée par *P. strobi*. La plupart de celles qui survivaient étaient très déformées, présentaient des signes d'attaques graves et n'étaient pas commercialisables. La plantation pure contenait environ 176 arbres vivants par hectare, mais seulement 14 pouvaient être considérés comme d'avenir; les autres étaient trop dominés ou déformés. Le volume des autres conifères qui y poussaient spontanément était supérieur à celui des épinettes de Sitka. La plantation mixte avait évolué en peuplement exploitable presque pur de Douglas taxifolie, qui ne contenait que cinq ou six épinettes de Sitka par hectare.

METHODS

INTRODUCTION

The rapid growth of Sitka spruce (*Picea sitchensis* (Bong.) Carr) makes it a very desirable species for certain low elevation, wet, coastal sites of British Columbia. However, the white pine (= Sitka spruce) weevil (*Pissodes strobi* Peck) repeatedly destroys the terminal leader of the trees, causing reduced height growth and deformed stems which affect the development of young plantations.

This paper describes the condition in 1981 of 26 Sitka spruce plantations, including two surveyed in detail, which were established in the early 1930s, at Green Timbers, Surrey, British Columbia, and had been affected by repeated weevil attack since an early age.

Plantation history and description of early studies

Between 1930 and 1935, about 5.7 ha of pure Sitka spruce in 3 plantations and 51 ha of a mixture of Sitka spruce and Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco in 23 plantations, were established in logger-over land adjoining the B.C. Ministry of Forests Green Timbers Nursery (Mathers 1938, 1939). The original forest cover included Douglas-fir, hemlock, (*Tsuga heterophylla* (Raf.) Sarg.), western red cedar (*Thuja plicata* Donn.), plus deciduous species such as broad-leaf maple (*Acer macrophyllum* Pursh) and vine maple (*A. circinatum* Pursh.). Mixed plantations were first planted to Douglas-fir in 1930 or 1931 at about 2000-25000 trees/ha and then interplanted with the

same number of Sitka spruce trees in 1932. Pure plantations were also established in two plantings (1930 and 1932 or 1935) with a total of about 5300 trees/ha. The area contained heavy logging slash and numerous large stumps which probably prevented ideal spacing. The seed source of Sitka spruce was the Queen Charlotte Islands and that of Douglas-fir was of mixed origin.

White pine weevil was first reported attacking Sitka spruce trees in 1936 (Mathers 1938). In 1937, a study project directed by G. R. Hopping, with the collaboration of W. G. Mathers and R. H. Longmore, was started by the Vancouver Sub-laboratory of the Dominion Insect Laboratory (now Canadian Forestry Service), to conduct detailed observations of the biology of the weevil and to determine the intensity of the damage (Mathers 1938, 1939; Hopping 1939). Annual infestation levels were determined each year until 1949, for one pure spruce (No. 68) and one mixed plantation (No. 84). These two plantations were also studied by Silver in 1960 (Silver 1961, 1968).

1981 study

All plantations at Green Timbers were located and inspected by entering about 40 to 50 m into the plantation, at three different points, and making a visual assessment of the condition and abundance of the Sitka spruce. Then the pure and mixed plantations studied in the past (Nos. 68 and 84, respectively) (Mathers 1939, Silver 1968), were surveyed in detail. Visual inspection of the other plantations in the area suggested that these were typical of other plantations, at Green Timbers.

The two plantations were sampled systematically by establishing plots of variable radius (No. 5 BAF prism) spaced every 20 and 40 m in the pure and mixed plantation, respectively. The pure plantation covered 1.26 ha, was very open, and highly variable, whereas the mixed plantation covered 3.4

ha, was more uniform, and apparently no longer contained living Sitka spruce. Twenty-two and 17 plots were established in the two plantations, respectively.

All conifer species in the plots were recorded and diameters and heights measured. Five increment cores were collected from each conifer species in the pure plantation, for growth determination. Each living Sitka spruce trees was classified into one of two categories: straight enough to become a crop tree, or defective to the point where no merchantable saw timber would be obtained from it by harvest time.

The number of conifers/ha was determined using the tables for variable plot sampling by Wilson and Robbins (1969); volumes were obtained from the B.C. Forest Service Volume Tables (1976).

RESULTS

Early studies

Annual infestation levels up to 1949, for the pure and mixed plantations were summarized by Graham *et al.* (undated) and Graham (1951) and are presented in graphic form in Figure 1. The percentage of trees attacked in both plantations increased rapidly until about 1940, and then remained around 30% in the pure Sitka spruce, but declined rapidly in the mixed plantation. The higher infestation levels in the mixed plantation early in the infestation (Fig. 1) were apparently also observed in the rest of the mixed stands and were attributed by Mathers (1939) to a difference in tree size between the two types of plantations, with the trees in mixed plantations being taller. Mathers noticed that the percentage of trees attacked increased with the height of the trees in the plantation.

Silver (1961, 1968) indicated that the attack level in 1958 and 1959 in a plot established within plantation No. 68, had declined to 4.9 and 8.6% respectively, and that only 22% of the trees in this

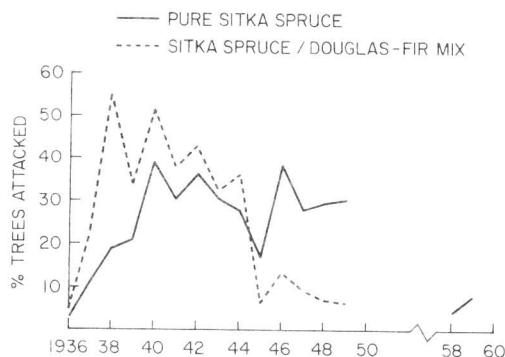


Fig. 1. Infestation intensity in a pure Sitka spruce plantation (Plantation No. 68) and a Sitka spruce/Douglas-fir mixture (Plantation No. 84) at Green Timbers, Surrey, B.C. (From data presented in table form by Graham (1951), Graham *et al.* (undated), Silver (1961) and Silver (1968)). Percentage trees attacked refers to new attacks. The same trees were attacked many times.

TABLE 1. Number of stems and gross volume per hectare, diameters, heights and periodic increment at Green Timbers pure Sitka spruce plantation No. 68 (N = 22 plots).

Species	Stems			Gross volume			Mean DBH		Mean height		Mean ^a annual radial increment
	No./ha	%	S.D.	m ³ /ha	%	S.D.	cm	S.D.	m	SD	(mm)
Sitka spruce	14.4 ^b	12.3	35.8	11.9	14.1	27.3	33.7	11.0	29.9	14.3	2.2
Douglas-fir	64.2	54.7	149.2	33.3	39.3	74.0	31.6	10.6	21.0	4.7	3.3
Western hemlock	14.2	12.1	21.5	20.6	24.3	28.6	43.6	11.7	27.3	4.8	3.4
Western red cedar	24.6	20.9	49.9	18.9	22.3	45.0	42.4	10.6	24.4	3.9	3.3
Total	117.4	100.0		84.7	100.0						

^a Last 10 years of growth.

^b Only potential crop trees included; i.e., suppressed and defective trees were excluded. Total number of living Sitka spruce trees per/ha was estimated to be 176.

plantation were considered straight enough to develop into suitable sawlog trees. By this date, only two trees in the plantation had never been attacked, one of which, because of its excellent form and growth, was thought to be somewhat resistant to weevil attack. This tree was also mentioned by Graham *et al.* (undated).

1981 study

Visual inspection of the plantations showed that none of the pure Sitka spruce plantations developed into merchantable stands. Most living Sitka spruce showed evidence of several weevil attacks, contained defects such as crooks and forks, and were non-merchantable. They shared the canopy with Douglas-fir, western red cedar, western hemlock, vine and broad leaf maple. In mixed plantations, Sitka spruce was almost absent, the resulting stand being mainly Douglas-fir, with some hemlock, western red cedar, and the maples. Spruce mortality in both cases was attributed to interspecific competition. Surviving spruces were mostly on the edges of the plantations.

The detailed survey of the pure plantation (No. 68) demonstrated the extent of the weevil damage. Dead trees showing severe attack could be found everywhere, many still with their numbered metal tags placed by Hopping and his co-workers in the 1930s. About 176 Sitka spruce trees/ha were estimated to be still alive in this plantation in 1981, about 17% of which were suppressed and 75% defective due to repeated weevil attack; the most common defects were fork and crook. The remaining potential spruce crop trees were estimated to number 14.4/ha with a gross volume of 12.3 m³/ha (Table 1). The sampling error for the stems/ha and volume estimates were about 28 and 23% respectively. Volunteer conifers, which were numerous, yielded volumes equal to or larger than Sitka spruce, and were about equal in diameter, height and growth to spruce (Table 1). This plantation

contained five Sitka spruce trees of exceptionally good form, but since their metal tags were lost, it was not possible to determine which one was the so-called resistant tree mentioned by Graham *et al.* (undated) and Silver (1968).

Mixed plantation No. 84 developed into a merchantable stand of almost pure Douglas-fir. It was estimated that this plantation contained about 408 Douglas-fir trees/ha which totalled 389 m³/ha and only 5.5 Sitka spruce trees/ha, with a volume of 1.43 m³/ha. The spruces were probably eliminated in the competition with Douglas-fir.

DISCUSSION

The infestation levels at Green Timbers were remarkably high. Spruce trees are generally not available for re-attack for at least two years after their terminals have been killed, i.e. for the time it takes to produce a new leader suitable for the weevil. Therefore, a constant 30% annual infestation rate, such as that experienced in the pure plantations (Fig. 1) implies that about 90% of the trees were attacked every three years. The faster decline in the attack incidence in the mixed plantation (Fig. 1) was not explained in the records, but it may have been caused by the death of host trees due to competition with Douglas-fir.

Virtually all Sitka spruce planted at Green Timbers was badly damaged by *Pissodes strobi*. We now know that such severe damage could be expected on this site, because it is distant from the cooling influence of the open ocean and is thus prone to severe damage by this insect (McMullen 1976).

The records do not clarify the rationale for mixing Sitka spruce and Douglas-fir. Belyea and Sullivan (1956) indicated that mixing eastern white pine, *Pinus strobus* L., with deciduous species would reduce the incidence of attack by the eastern *Pissodes strobi*, because of a shading effect that would create an environment less suitable for the weevils. However, the mixing with Douglas-fir was

not likely intended as a silvicultural method to provide shade for Sitka spruce. An even-aged mixture with Douglas-fir would probably provide little initial overstorey shadowing at the terminal leader level to provide a significant change in the optimum microclimatology for the weevil and, therefore, would not reduce weevil attack. Another reason for rejecting Douglas-fir as an appropriate mixture to reduce *P. strobi* attack is that this species is the alternate host of the Cooley spruce gall aphid (*Adelges cooleyi* (Gillette)), which is also a pest, although of minor importance, of Sitka spruce (Furniss and Carolin 1977, Wood 1977).

Nevertheless, shading reduced weevil incidence at Green Timbers and was noticed by Hopping (1939) who stated that:

"The degree of shade has also been found to be an important factor governing attack in that the weevils have shown a distinct preference for exposed tops". However, he cautioned that "the effec-

tiveness of shade from deciduous growth, such as vine maple and willow which have come in naturally on the plantation, is minimized by the fact that the weevils invariably attack in the spring before the foliage appears. Instances of spruce completely enclosed in clumps of vine maple, having been weeviled, were observed."

The destruction by weevils of the plantations at Green Timbers as well as the deplorable status of other Sitka spruce plantations in British Columbia clearly show that unless an effective control method for this pest is designed, Sitka spruce should not be used in areas with high susceptibility to attack by *P. strobi*.

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