

LEADER CLIPPING TRIALS FOR SPRUCE
WEEVIL, Pissodes strobi, IN SITKA
SPRUCE PLANTATIONS ON NOOTKA ISLAND
1979 - 1984: A CASE STUDY

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January 1989

PM-V-12

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1.0 Introduction

Attempts to control damage caused by the spruce weevil, Pissodes strobi (Peck), by manually clipping and removing infested leaders, in west coast Vancouver Island Sitka spruce (Picea sitchensis (Bong.) Carr.) plantations were initiated by the British Columbia Ministry of Forests(1) in 1979. These operational trials were continued until 1986 when they were terminated as an operational control tactic primarily due to inconclusive results and lack of funding.

During the late 1960's and early 1970's Sitka spruce was selected for the regeneration of forest stands after timber harvesting on the west coast of Vancouver Island (Harris 1984a). An alternative to Douglas-fir, Pseudotsuga menziesii (Mirb.)Franco, which at this time was the only species widely available from forest nurseries for planting, was required for wet, west coast sites. It was believed that due to the climatic and site conditions that prevail on the west coast, and because it is a fast-growing, highly-productive tree species, Sitka spruce would thrive and become a valuable crop. Subsequently, extensive Sitka spruce plantations were established on Vancouver Island throughout the 1970's.

Unfortunately, it appears that the potential damage to these plantations from P. strobi attack was not given adequate consideration. The spruce weevil had been previously identified as a serious pest of young Sitka spruce (Silver 1968) but it was not thought to be a serious problem in west coast plantations. Many of these plantations later developed

severe levels of weevil damage and many are now at risk of becoming totally unmerchantable (Jeklin 1979, Heppner and Wood 1984; (2)).

This paper reviews the background and development of the clipping trials conducted by the B.C. Ministry of Forests from 1979 to 1984. Although a number of other areas were involved in these trials, for the purposes of this report only the Nootka Island plantations will be detailed.

2.0 Background

2.1 Spruce weevil - the pest

Pissodes strobi, the spruce weevil, has become the most destructive pest of Sitka spruce regeneration in western North America (Wright 1960; MacSiurtain 1981; Heppner and Wood 1984). When first recorded at the turn of the century it was not regarded as a serious problem in the natural stands existing then (Burke 1904). However, extensive logging since that time, followed by natural and planted regeneration, has greatly increased the hectareage of susceptible young trees available to the weevil. Under these conditions, weevil populations appear to have expanded greatly. In the United States, this weevil has been an important problem in the management of Sitka spruce since about 1940 (Wright and Baisinger 1955). By 1955, the damage had become so severe that the advisability of planting this valuable fast-growing tree, or encouraging it in natural stands, was questioned (Wright and Baisinger 1955).

In British Columbia, Silver (1968) reported that P. strobi was a serious economic pest for several decades. However, it seems that many British Columbia foresters in the early 1970's were not aware of the potential impacts of this insect. Phelps (1973), in a literature review on Sitka spruce with reference to British Columbia, stated that, "Sitka spruce in British Columbia is attacked by a number of insects, but damage from most of them is usually not serious." Only three sentences in that report were devoted to P. strobi, none of which emphasized the importance of this pest to the management of Sitka spruce. Thousands of hectares of Sitka spruce were subsequently planted in coastal British Columbia throughout the 1970's (Jeklin 1979).

P. strobi has been found associated with spruce throughout British Columbia, Washington and Oregon, but has not been found on the Queen Charlotte Islands (Wright 1960; Silver 1968; McMullen 1976). In addition to Sitka spruce, this weevil also attacks white, Picea glauca (Moench) Voss, and Engelmann, P. engelmanni Parry, spruce, and, in eastern North America, eastern white pine, Pinus strobus L. The original three species, Pissodes strobi, P. engelmanni, and P. sitchensis, have been synonymized as one species (Smith and Sugden 1969). Although white pine weevil is now the correct common name associated with this insect, in British Columbia it is usually referred to by its former common name, Sitka spruce weevil, because it does not attack western white pine, Pinus monticola Dougl.

P. strobi kills the terminal leader of spruce trees by feeding gregariously as larvae between the bark and the wood. Eggs are laid in the spring into the phloem just below the terminal bud. The eggs hatch and the larvae mine downward. Pupation occurs within the leader and adults emerge

in August to October (Silver 1968). The adults overwinter in the duff and tree crown, and can live for up to four years (McMullen and Condrashoff 1973). A small proportion of the larvae ^{and unemerged adults} overwinter as larvae within the leader (VanderSar 1977). ^{personal observation}.

The tree host responds by replacing the killed leaders with lateral branches which compete for dominance resulting in crooks and forks (Wright and Baisinger 1955). Trees repeatedly attacked develop into multitopped shrublike trees of little or no economic value (Belyea and Sullivan 1956). These trees then become at risk of being overtopped by competing vegetation which can then render a plantation totally unmerchantable (Alfaro 1982).

2.2 Sitka spruce - the host

Sitka spruce, Picea sitchensis (Bong.) Carr., is native to western North America. It grows in a narrow strip along the Pacific coast, closely associated with the fog belt, from northwestern California to southern Alaska (Fowells 1965). It is a vigorous, fast-growing tree that readily overtops associated western hemlock, Tsuga heterophylla (Raf.) Sarg., and western red cedar, Thuja plicata Donn, to occupy the dominant position in the stand (Day 1957). When Sitka spruce is grown together with western hemlock it forms the basis of one of the most productive coniferous forest types in the world (Smith et al. 1984). Stand yields for these two species are higher when grown together as mixed stands than when grown individually in pure stands (Taylor 1932).

The major factor influencing the management of Sitka spruce within its natural range is, and will probably continue to be, P. strobi (MacSiurtain 1981). Its impact has resulted in the avoidance of Sitka spruce in reforestation programs throughout a very large portion of the tree's natural range. The management of Sitka spruce in British Columbia is currently confined to the northern and western extremes of Vancouver Island, the mainland mid-coast region, the lower Nass and Skeena River Valleys and the Queen Charlotte Islands. In comparison to the intensively managed plantations of Great Britain and Ireland, Sitka spruce is being underutilized in British Columbia (MacSiurtain 1981). More area of Sitka spruce is grown in Great Britain and Ireland than in British Columbia. Additionally, the higher average productivity of Sitka spruce plantations in Great Britain and Ireland, attributed to the more intensive management practices there, and the absence of the spruce weevil, suggests a much greater potential for this species in British Columbia.

The silvicultural value of Sitka spruce for reforestation purposes is high due to its very rapid establishment potential on ecologically suitable weevil-free sites (MacSiurtain 1981). Sitka spruce does best on well-drained alluvial soils within wetter coastal western hemlock biogeoclimatic subzones (Klinka et al. 1984). Its fast growth, in addition to being productive, allows it to out compete most brush species, thus, greatly reducing the requirements of brush control. Sitka spruce seedlings are also relatively hardy in their ability to withstand the stresses associated with planting (transport and storage between the nursery and planting site)(3). Their stiff, prickly needles, which repel browsing by deer, also make Sitka spruce particularly valuable where this is a concern.

2.3 Controls

Potential and attempted control techniques have been well reviewed by Cozens (1983); none to date has proven to be adequately effective and practical to implement. Many of the difficulties in achieving an operational control technique have been due to the following: adults are only 'available' for conventional control techniques for a short period during spring feeding and oviposition; the spring feeding and oviposition period is not synchronous among adult weevils but occurs over an extended period; and, adults are capable of living and producing progeny for up to four or more years.

The control tactics which have shown effectiveness generally require the individual treatment of most trees within the plantation, which is usually too labour-intensive to be practical operationally. Sitka spruce plantations are generally extremely difficult to operate in due to rough terrain, thick brush and old logging slash. Additionally, conventional 'chemical' control techniques are not viewed favourably by most forest managers today because of public disapproval. Also, because Sitka spruce plantations are usually associated with fish-bearing water systems, fisheries concerns may preclude conventional insecticide use.

Leader clipping in 1979 appeared to be the only viable method available for immediate use (Jeklin 1979). First recorded as a recommendation as early as 1817 (Belyea and Sullivan 1956), clipping was being used operationally with success in infested eastern white pine plantations in eastern North America in the 1970's (DeBoo 1978). Leader clipping involves the manual removal of infested leaders prior to adult emergence. It is

usually carried out using hand and/or pole pruning shears. The current year's weevil brood is thus removed from the plantation and destroyed. The subsequent removal of all but one of the remaining lateral branches then eliminates competition for apical dominance minimizing crooks and associated defects from weevil attack.

3.0 Damage Assessment

Observations of increasing P. strobi damage in Sitka spruce plantations on Nootka Island(4) in 1978 raised concern about the potential impact of this weevil on west coast Sitka spruce plantations. Forestry Crew personnel of the Gold River Ranger District(5) noticed appreciable levels of weevil damage in a few older plantations. Additionally, trace levels of weevil attack were detected for the first time in a number of other Sitka spruce plantations on the island(6). Over 2,000 ha of Sitka spruce had been planted on Nootka Island since 1968, many of which were just reaching a susceptible size, with the remaining plantations following within a few years (Jeklin 1979). These plantations were only a portion of the over 5000 ha planted in the District. The apparent threat of weevil damage also posed major concerns regarding the continued use of Sitka spruce as a tree species for forest regeneration programs.

Previously, P. strobi had been recognized as a pest of young Sitka spruce. Although, other mainland areas within the Gold River Ranger District were generally showing heavy levels of damage (Jeklin 1979), the spruce weevil was not believed to be a major problem in extreme west coast areas(6). Silver (1968) and Harris et al. (1968) had both reported that weevil

attack on the west coast of Vancouver Island was light. McMullen (1976), based on the effect of summer heat, concluded that a narrow strip along the west coast of Vancouver Island including all of Nootka Island and the northern tip of Vancouver Island, was an area of low weevil hazard. Previous levels of weevil attack, however, were low most probably due to the limited amount of young susceptible Sitka spruce growing along the coast; it had only been planted in appreciable amounts since the late 1960's. Also, McMullen's (1976) predicted low hazard zone was only a rough estimate based on very widely spaced weather stations. There was, therefore, a certain degree of uncertainty regarding the magnitude of the weevil problem.

The ability to assess accurately the seriousness of weevil damage was further constrained by the lack of good damage appraisal and weevil population dynamics information(6). The long-term impacts of the weevil on the plantation and subsequent timber stand were not well known. Some thought that the weevil infestation would decline as stand height increased and that damaged spruce stems would straighten out and develop into merchantable timber once this occurred(6). There was evidence that weevil attack intensity declines as tree height increases (Wright and Baisinger 1955; McMullen 1976). Similarly, others believed that the levels of attack would not get devastatingly high on the west coast and that the stands would be able to tolerate these levels of damage. However, experiences from Green Timbers Nursery (Alfaro 1982 and references therein), other locations on Vancouver Island (Harris et al. 1968), and the United States (Wright and Baisinger 1955) where spruce plantations were essentially rendered unmerchantable, suggested that spruce weevil was a serious concern.

Forestry Crew personnel at the Gold River Ranger District office in early 1979 concluded that the risk of damage was too severe to 'do nothing' and believed that action was required to prevent the loss of the large areas of Sitka spruce plantation within the District(6). Although infestation levels on Nootka Island were still generally low, the levels of infestation had escalated from previous years and it was feared that most of the plantations would be rendered worthless unless damage could be maintained at acceptable levels. Additionally, they believed that if Sitka spruce was to continue as a major species of the reforestation program, a control method for spruce weevil damage had to be developed.

4.0 Selection of the Clipping Option

Unfortunately, in 1979 few options for weevil-infested Sitka spruce plantations existed. No proven methods of control were readily available for implementation. At that time, no chemical insecticides had been registered for controlling P. strobi in Sitka spruce (Jeklin 1980); any insecticide use would have had to have been on a research basis only, confined to areas of limited size. The conversion or rehabilitation of the plantations to alternative tree species was thought to be too expensive and impractical(6). A more operational option was required.

The removal and destruction of infested leaders had been recommended by MacAloney (1930), and Belyea and Sullivan (1956). They found it a successful method of minimizing infestations to levels below that necessary to cause economic damage in infested eastern white pine. Rhodes (1963) also found clipping effective but reported that infestations had to

be below 4% of the stems infested for this tactic to be effective. Although unproven in Sitka spruce, clipping seemed to be a sound technique worth trying. It was also something that the local staff could do themselves relatively easily and the level of attack appeared to still be low enough for clipping to be feasible. Forestry Crew staff, therefore, decided to give clipping a try(6).

The objective of the planned trials was to attempt to control weevil populations to levels low enough to allow a significant number of trees to escape attack. The concern for the poorer stem form resulting from weevil attack and clipping was considered secondary to the goals of preventing attack on the remaining undamaged trees (Jeklin 1979). Four to five hundred attack-free trees per ha was the target(6). These trials, however, were very much operational rather than experimental. They wanted to achieve control while, at the same time, testing the technique.

Because adult weevils live and reproduce for up to four or more years it was recognized that clipping would probably have to be maintained for a number of years before any reductions in attack levels would be obvious. Additionally, it was thought that clipping may have to be continued until the stand height reaches 10 m. It was hoped that at this height the amount of weevil damage would have declined to an acceptable level and at least one damage-free log would have been achieved (Jeklin 1979).

The developed plan was to treat all spruce plantations in the Beano Creek and Crawfish/Ewart Lakes areas on Nootka Island during the summer of 1979 prior to adult emergence. A few spruce plantations near Marvinas Bay on

Nootka Island were not chosen for treatment because it was thought that they were already too heavily infested to be controllable. Check stands to compare treated plantations to untreated plantations were not specifically set up. All plantations within each treatment area had to be clipped to prevent weevil build-up and spread into treated areas. However, the excluded plantations near Marvinas Bay were thought to be similar to the treated areas and adequate for comparison(6). It was also optimistically believed that the technique would work and the results would be obvious.

An additional factor which supported the decision to act was the availability of funds, excess from other planned silviculture projects. This project started as a Silviculture Section project(6); in 1979 the Ministry of Forests did not have a pest management section.

5.0 Clipping Project

5.1 1979

Commencing in July 1979, all Sitka spruce plantations within the Beano Creek and Crawfish/Ewart Lakes areas planted prior to 1976 were field checked for evidence of weevil attack (Jeklin 1979). Plantations which showed evidence of attack were then slated for treatment. Weevil development within spruce leaders was monitored. A judgement based on the weevil development periods reported by Silver (1968) was then made regarding the commencement of clipping. To optimize available resources and ensure a thorough treatment, clipping was delayed until most infested leaders were thought to be showing detectable symptoms, but, started soon

enough to complete the operations prior to adult emergence expected sometime during the beginning of September.

During the last week of July, forestry crew personnel from the Gold River office commenced clipping within the Beano Creek plantations. After two weeks, due to the unexpected high levels of infestation, it became apparent that it would be impossible to finish this area as well as the Crawfish/Ewart Lakes area prior to adult emergence. Operations were then switched to the less heavily infested Crawfish/Ewart Lakes area. It was felt that this area had a better chance of success due to the lower level of infestation. The Beano Creek area was then reactivated late in August but was not completed prior to adult emergence September 3. A total of 534 ha were clipped, 216 ha within Beano Creek and 318 ha in the Crawfish/Ewart area. Unfortunately, 323 ha in Beano Creek failed to receive treatment (Jeklin 1979). The clipped leaders were counted, piled and burned.

During the operations, treated areas were reinspected two weeks after the initial clipping in an attempt to ensure that no infested leaders escaped treatment. These inspections revealed that up to 30% of the original number of infested leaders were missed due to a late display of infestation symptoms. Unfortunately, only a small proportion of these missed leaders were subsequently clipped (Jeklin 1979).

Funding for 1979 treatments was from excess funds from the Silviculture program which were available for reallocation(6).

5.2 1980

Preliminary field inspections and weevil development monitoring resulted in the commencement of the 1980 clipping project on August 5. Infestation levels increased and the weevil population spread into areas previously uninfested. This was thought to be due to the failure to remove all the infested leaders in the plantations during the 1979 treatments. This resulted in a greater emphasis being placed this year on complete and thorough coverage to reduce the incidence of omitted leaders. The project terminated with the emergence of a large proportion of the adults August 30 (Michaelson 1981).

In Beano Creek 339 ha were clipped and 703 ha were clipped in the Crawfish/Ewart Lakes area. Infestation levels ranged to 20% in Beano Creek and to just over 5% in the Crawfish/Ewart Lake area. The incidence of weevil attack in the incompleated stands in 1979 increased in 1980, whereas in plantations clipped in 1979 the incidence decreased in over 50% of them (Michaelson 1981). Only one treatment pass was made over each plantation. Again this year infested leaders which were not showing adequate symptoms at the time of the treatment pass were missed. Funding was again supplied from the Silviculture budget(6).

5.3 1981

In 1981 significant changes occurred to the Forest Service and the clipping program. The Forest Service's operational structure was substantially reorganized. The Gold River Ranger District was amalgamated into the larger Campbell River Forest District and Forestry Crew functions

were now carried out by Forest District staff. Also, with the creation of a pest management component within the Protection Section, the responsibilities for the clipping project transferred from Silviculture Forestry Crews to the Protection Section of the Campbell River Forest District. Funding was, therefore, from the Protection budget(7).

Another new initiative this year, was the strategy of using two treatment passes two weeks apart instead of only one pass through each plantation. This was an attempt to capture those infested leaders with delayed infestation symptoms that had been missed during clipping operations of the previous two years. Weevil clipping began on August 5 and ended September 4. All areas treated within the Crawfish/Ewart Lakes area received two passes approximately two weeks apart. All but one plantation in the Beano Creek area received two treatment passes (Dumas 1981).

Also, this year for the first time, Tahsis Co. Ltd. was persuaded to become involved in the clipping program. Because the Nootka Island plantations were within Tahsis' chart area, company expenses could now be funded via credits to stumpage provided for within Section 88 of the Forest Act (1979). This newly instituted funding mechanism then allowed the Forest Service's clipping resources to be directed to additional plantations elsewhere within the District that were just beginning to develop weevil infestations. At this point, due to the increasing demand for weevil control, the clipping trials more or less became operational (7). The Forest Service clipped 613 ha at Port Eliza, Chamiss Bay and Union Island. Tahsis Co. Ltd. (later called CIP Inc. and now known as Canadian Pacific Forest Products Ltd.) was unable to complete the Beano Creek area due to a forestry workers' strike. Fortunately Forest Service

crews were able to cover the unfinished areas. In the Beano Creek area 643 ha were clipped and in the Crawfish/Ewart Lakes area 703 ha were clipped (Dumas 1981).

The infestation level within the Crawfish/Ewart area remained little changed over 1980. However, infestation levels in Beano Creek increased by 50%. This again was thought to be due to the considerable number of leaders which were inadvertently missed in 1980. The report from this year stated that the area was now considered heavily-infested and that control via clipping seemed "almost futile" (Dumas 1981). This report also recommended that treatment areas continue to be checked and clipped until the third or fourth week of September for late developing weevil broods.

5.4 1982

It was decided this year that clipping in the Beano Creek plantations would be terminated. It was judged that the level of attack had become too high to be controllable by clipping and that it would be better to reallocate clipping resources into other areas(6). Tahsis Co. Ltd. via Section 88 stumpage credits, with Forest Service supervision, clipped 900 ha in the Crawfish/Ewart Lake area. Two passes were completed on all areas. The Forest Service also continued clipping at Port Eliza, Union Island and Chamiss Bay, but due to a B.C.G.E.U. strike were unable to complete two passes on Union Island (Harris 1982). The level of attack in the Crawfish/Ewart area more than doubled this year, but was still maintained below an average of 1% of the trees attacked.

5.5 1983

Again this year, Tahsis Co. Ltd., via Section 88, took responsibility for clipping the Crawfish/Ewart area with 900 ha receiving two treatment passes. The level of attack was reduced from 1982 by approximately 25%. The consensus at this time was that if clipping had not been initiated this area would now have been severely damaged by the spruce weevil (McCutcheon 1983). Also, a large portion of the trees were reportedly too tall to be clipped with the available fourteen-foot pole clippers and had to be climbed to reach the infested leaders. Forest Service crews continued clipping at Port Eliza and Chamiss Bay but not on Union Island (Harris 1983).

5.6 1984

During the spring of 1984 each plantation within the Crawfish/Ewart Lake area was surveyed to assess which areas were still suitable for control treatments (Harris 1984a). The clipping program had now run for five years in this area and it was felt that it was time for a reappraisal (7). Ecological criteria, proportion of alternative species and tree height were studied. Most of the plantations were found to be ecologically 'off-site' for Sitka spruce, and many contained an adequate stocking of naturally regenerated alternative tree species, and/or were too tall to be capable of being clipped with current resources (Harris 1984a; (8)). At the time it was thought that the continuation of clipping could not be justified in 'off-site' spruce or in plantations where Sitka spruce is not required for stocking. Only 55 ha were clipped in this area this

year (Harris 1984b). The Forest Service clipped the Crawfish/Ewart area as well as the Pt. Eliza area. Clipping at Chamiss Bay and Union Island were discontinued.

Additionally, and which in all probability strongly influenced this year's decisions, was the fact that funding within the Forest Service had become increasingly more difficult to obtain due to a general government restraint on spending. There was, therefore, a pressure from Forest Service management to limit clipping expenditures(7).

5.7 1985 - 1987

All clipping by the Forest Service was discontinued after 1984. This was the result of a number of factors: the continued funding restraints by government; the inability to prove clipping as efficacious and thus the difficulty in convincing forest managers that it should be continued; and, a general disenchantment with clipping because field staff found it physically strenuous and unpleasant work of dubious benefit(9). Neither operational nor managerial staff wanted to continue it. So, even though there seemed to be some evidence of success, the program lost its impetus to continue.

CIP Inc. (formerly Tahsis Co. Ltd.), however, due to the continued availability of indirect funding via Section 88 stumpage offset, continued clipping areas within their Tree Farm Licence No. 19 that they had been clipping operationally for a number of years. In early 1987, again due to financial constraints and the inability to show that clipping worked,

Forest Service management terminated all funding for clipping as an operational control technique.

5.8 Summary

Leader clipping commenced in 1979 in the Nootka Island spruce plantations and ran for six years in the Crawfish/Ewart area and three years at Beano Creek. The average level of attack within the Crawfish/Ewart area was well under 1% when clipping commenced and was maintained under 1% for the length of the clipping project. Conversely in the Beano Creek area, clipping started when the level of attack in some of the areas was well over 10% of the trees attacked. Additionally, the Beano Creek area was not clipped as thoroughly; a number of heavily-infested plantations were not completed due to an underestimation of the level of attack and the time required to treat them. Subsequently, attack levels in the Beano area could not be adequately controlled and expanded to a level thought to be uncontrollable by clipping (Table 1).

A major problem encountered during the project was the failure to clip infested leaders which contained late-developing weevil broods. These leaders would appear healthy during the treatment passes, only showing symptoms later in the season. These missed leaders then provided a source of weevils to maintain the infestation the following year.

Costs of clipping ranged from \$16.29 to \$43.32 per ha ($x = \$20.60$) (Table 1). This price included both treatment passes plus crew accommodation and transportation by boat and aircraft to the island.

TABLE 1.0 CLIPPING STATISTICS SUMMARY(10)

AREA/YEAR	AREA CLIPPED (HA)	LEADERS CLIPPED (#)	COSTS PER HECTARE (\$)
<u>CRAWFISH/EWART</u>			
1979	318	854	21.35
1980	703	2,039	22.08
1981	703	1,803	16.29
1982	900	4,609	19.41
1983	900	3,466	22.08
1984	65	206	43.32
<u>BEANO CREEK</u>			
1979	216	7,179	21.35
1980	339	10,619	22.08
1981	643	23,108	16.29

6.0 Evaluation

A formal evaluation of these clipping trials has not been conducted and no analysis of the clipping data has been done with any rigor. Due to the fact that control areas were not set up, and nearby unclipped plantations have not been surveyed to record natural infestation levels and trends, it has been difficult to determine conclusively the effects of the clipping project(7). However, from observations and casual assessments of the data, it has been concluded tentatively that clipping can be effective if started when infestation intensities are low and there are no adjacent infested plantations to supply weevils to the treated area (Carlson et al. 1984).

Infestation levels within the Crawfish/Ewart area, which had less than 1% attack at the start, were maintained below 1%, while the Beano Creek plantations, which started out with much higher levels of attack, could not be maintained at static levels. Additionally, unclipped plantations in other areas commonly show a rapid escalation of infestation levels once attack begins (Heppner and Wood 1984). It appears that clipping did provide a significant level of control in the Crawfish/Ewart Lakes area and it is probable that maintaining infestation levels below 1% would be quite acceptable.

As an operational trial without a multiyear plan, the leader clipping project actually provided a significant measure of success. Much was learned regarding the logistical aspects of carrying out a clipping operation and it gave good evidence that the technique will work under some conditions. It undoubtedly could have been better planned, i.e. check blocks should have been better identified and set-up; however, the urgency and desire to protect the plantations, the short planning time frame available and the lack of pest management expertise precluded an experimental project.

In retrospect it would have been better to have left the Beano Creek plantations untreated for comparison and concentrated efforts in the Crawfish/Ewart area. However, the initial objective of the clipping effort was to try to protect all of these stands from significant damage. Additionally, both of these areas should have been surveyed for a number of years after the termination of clipping to determine infestation trends. Also, the plantations near Marvinas Bay which never received clipping treatments should have been surveyed annually. This survey

information would have provided much better information with which to compare and assess the effects of leader clipping.

Although replication of the Nootka Island trials would have been beneficial, probably in this case the additional areas, Port Eliza, Union Island and Chamiss Bay, should not have been clipped as it would have been better to concentrate the available resources on clipping and surveying the Nootka Island plantations.

Another significant concern identified from the project, was the difficulty of clipping infested leaders once tree heights reach approximately 5 m. Beyond this point clipping physically becomes very difficult and costly. Not only are the leaders difficult to reach with unwieldy extended pole clippers, but, because Sitka spruce retains its branches, which become intermeshed between trees, travel through the stand becomes increasingly difficult. Clipping trees until they reach ten meters in height will be a difficult objective to achieve. For these reasons alone clipping will have its limitations.

As a recommendation from this case study, to assess the effects of leader clipping better, surveys of the clipped and unclipped areas should now be conducted to determine the infestation history of each area. Utilizing this survey information a more formal analysis of the clipping data should be carried out.

NOTES

1. Also referred to as the British Columbia Forest Service, the B.C. Forest Service, or the Forest Service.
2. Weevil assessment surveys conducted by the author August 1988.
3. Personal interview with Dave Weaver, R.P.F., Field Forester, MacMillan Bloedel Ltd., Port McNeill, B.C.
4. Located off the west coast of Vancouver Island, west of Gold River B.C.
5. Prior to the reorganization of the Ministry of Forests, which occurred between 1979 and 1980, the Gold River area was managed by Ranger staff and Forestry Crew staff stationed at Gold River, B.C. The area is now managed by staff of the Campbell River Forest District headquartered in Campbell River, B.C.
6. Personal interview with Eric Jeklin, R.P.F., consulting forester, White Rock, B.C. - formerly of the Gold River Forestry Crew, Gold River, B.C. - one of the key instigators of the clipping project in 1979.
7. Personal interview with Paul Wood, R.P.F., consulting forester, Vancouver, B.C. - formerly Pest Management Coordinator, Vancouver Forest Region, Ministry of Forests, Burnaby, B.C.

8. Telephone interview with Doug Harris, R.P.F., consulting forester, Duncan B.C. - formerly Resource Assistant Protection, Campbell River Forest District, Ministry of Forests, Campbell River, B.C. - conducted the clipping operations 1982/84.
9. Telephone interview with Bill Hardy, Resource Assistant Silviculture, Campbell River Forest District, Ministry of Forests - formerly Resource Assistant Protection in the same office 1984/86.
10. Compiled from Ministry of Forests file information, Burnaby, B.C.

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