

SILVICULTURE AND SWISS
NEEDLE CAST: RESEARCH AND
RECOMMENDATIONS

by

Gregory Filip

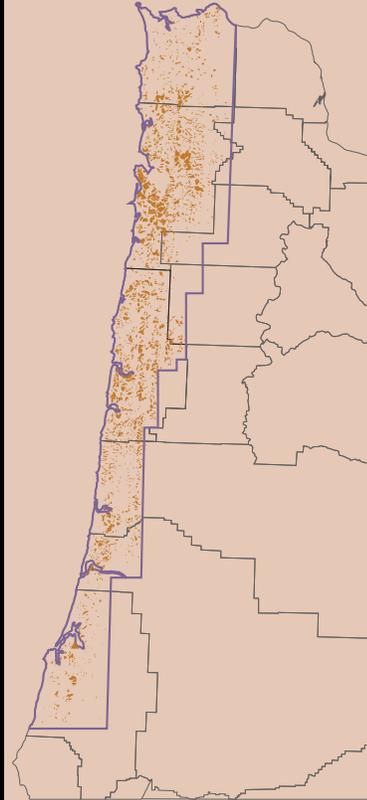
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ACKNOWLEDGMENTS

We thank the members of the Swiss Needle Cast Cooperative for their continued financial support for research on Swiss needle cast. We also thank the reviewers of this paper, Jerry Beatty, Bill Voelker, and Tim Tompkins and our editor, Laurel Grove, for their many fine suggestions. Thanks go to Carrie Ward and Sue Nall for text processing and to Gretchen Bracher for layout. Cover photo by Alan Kanaskie.

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June 2000

SILVICULTURE AND SWISS NEEDLE

CAST: RESEARCH AND RECOMMENDATIONS

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ABSTRACT

Filip, G, A Kanaskie, K Kavanagh, G Johnson, R Johnson, and D Maguire. 2000. *Silviculture and Swiss Needle Cast: Research and Recommendations* Research Contribution 30, Forest Research Laboratory, Oregon State University, Corvallis.

For the past ten years, Douglas-fir on the Oregon and Washington coast has shown a progressive decrease in height and diameter increment as a result of Swiss needle cast, which is caused by *Phaeocryptopus gaeumannii*. In this contribution, we discuss the effects of silvicultural operations on Swiss needle cast and recommend specific actions to reduce the severity of the disease. We also suggest a method of assessing the severity of Swiss needle cast damage to a stand based on years of needle retention. Our recommendations are based on disease severity and are designed to discriminate against Douglas-fir when planting, thinning, and harvesting stands suffering low, medium, and high Swiss needle cast severity. These recommendations are based on our collective observations and research being conducted by the Swiss Needle Cast Cooperative.

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INTRODUCTION

Douglas-fir along the Oregon and Washington coast is experiencing severe damage from Swiss needle cast (SNC), a native foliage disease caused by the pathogenic fungus *Phaeocryptopus gaeumannii*. Damaged trees are chlorotic, lose their older needles prematurely, and often show a progressive loss in height and diameter growth. SNC affects only Douglas-fir.

The disease, and the fungus that causes it, were first described in 1925 on Douglas-fir introduced from the United States to Switzerland (Gäumann 1930). The first survey for SNC in the western United States and Canada was conducted in 1938 (Meinecke 1939). The fungus was found in many locations but at low, non-damaging levels. In the 1970s, SNC began to cause significant damage to Christmas trees, coincident with the increase in Douglas-fir acreage and intensive culturing of Christmas trees in western Oregon and Washington (Hadfield and Douglass 1982; Michaels and Chastagner 1982). In the late 1970s and early 1980s there were scattered unpublished reports that SNC was causing damage in forest plantations. By the late 1980s, damage was severe at several locations along the northern Oregon coast (Kanaskie, unpublished). In the 1990s, damage intensified dramatically along the Oregon and Washington coast; in 1999, some 295,000 of 2.9 million acres (119,387 of 1.2 million hectares) that were aerially surveyed in coastal Oregon were classified as severely infected (Kanaskie et al. 1998; Hansen et al. 2000). A similar survey in coastal Washington found 200,000 of 2.3 million acres (80,940 of 930,810 million hectares) with SNC (Omdal and Moore 1999).

The causes of the intensification of SNC are largely unknown, but research is being conducted to determine possible factors (Capitano 1999; Stone et al. 1999; Hansen et al. 2000). In January 1997, the Swiss Needle Cast Cooperative was formed with the purpose of conducting research and disseminating information on SNC for forest landowners and managers in Oregon and Washington.

In this contribution, we present the best of our current knowledge, based on our collective observations and research on the effects of silvicultural operations on SNC. The silvicultural systems and operations used to manage Douglas-fir in the Pacific Northwest include several regeneration methods, vegetation management techniques, fertilization, precommercial and commercial thinning, artificial branch pruning, partial cutting techniques, and clearcutting. Uneven-age silviculture also is attracting some interest in western Oregon and Washington. We consider each of these practices and recommend some specific methods to reduce the severity of SNC.

SEVERITY OF STAND DAMAGE CAUSED BY SWISS NEEDLE CAST

The choice of silvicultural systems and operations typically is determined by stand, site, and economic factors and by management objectives. The choice of systems and operations may also be influenced by the severity of pest outbreaks in a stand or forest. In the case of SNC, severity can vary widely within a region, forest, or drainage. Two criteria can be used to estimate the severity of stand damage from SNC: 1) the amount of needle retention and 2) the degree of needle discoloration. A third criterion, the location of the stand, may be used to rate the stand's hazard for future damage from SNC.

NEEDLE RETENTION

The best indicator of SNC severity is the premature loss of needles, which correlates with a reduction in tree growth (Maguire et al. 1998; Hansen et al. 2000). In the Coast Range, healthy Douglas-fir typically retains 3 to 4 annual cohorts, and sometimes more (Figure 1). When SNC is severe, only 1 annual cohort may be present (Figure 2). Needle retention is best estimated during April and May, by examination of lateral branches in the middle to upper parts of the tree crown, usually at about the fifth to seventh whorls below the top of the tree. Averaging the needle retention of at least 10 randomly chosen dominant or codominant trees gives a mean needle retention for the stand or plantation.



Figure 1. In the Coast Range, healthy Douglas-fir, such as this, retains 3 to 4 annual cohorts of needles. Photo credit: A Kanaskie.

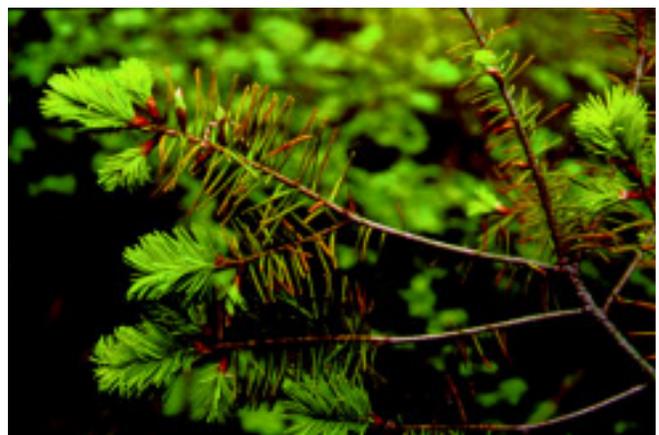


Figure 2. In trees with severe needle cast, only 1 annual cohort may be present, as seen here. Photo credit: A Kanaskie.

FOLIAGE COLOR

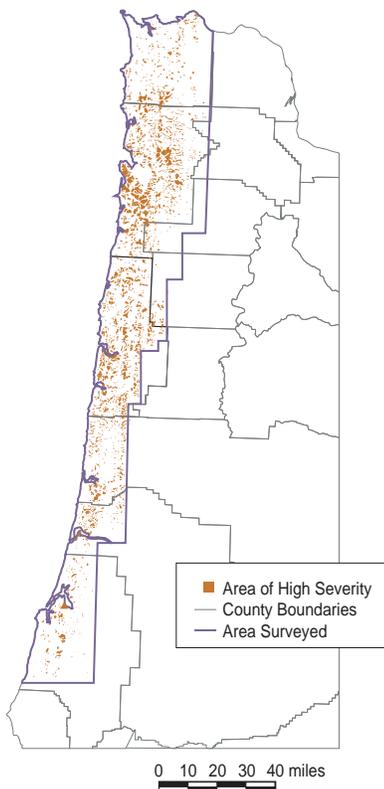
The needles on trees with SNC are yellow to yellow-brown in late winter and early spring (Figure 3). This discoloration often is the first noticeable symptom of SNC. Obvious discoloration that is uniformly distributed across the stand is accompanied by abundant fruiting of the fungus on the underside of needles (Figure 4) and indicates that the trees



Figure 3. The needles on trees with Swiss needle cast are noticeably yellow to yellow-brown, as in these severely infected trees, in late winter and early spring. Photo credit: A Kanaskie.



Figure 4. The undersides of infected needles have an abundance of small black fruiting bodies (pseudothecia), as seen on these needles. Photo credit: A Kanaskie.



Acres surveyed: 2,891,000

Acres with highly severe damage: 295,000

Figure 5. Aerial surveys have detected severe damage in coastal Oregon, as seen on this map.

are being damaged by SNC. Although other factors, such as nutrient deficiencies and root diseases, can also cause yellowing, they do not occur uniformly across a stand. Older stands that are severely infected may not show needle discoloration as clearly as younger stands; therefore, needle retention may be a better estimate of damage severity in older stands.

STAND LOCATION

Damage from SNC has been recorded for stands from the coast to the Cascade Mountains in Oregon and Washington. In general, stands closer to the coast have more damage than stands farther inland (Hansen et al. 2000). The area where severe damage has been observed during aerial surveys in Oregon is shown in Figure 5. Any Douglas-fir stands in this area have the potential to be subject to significant damage from SNC. Observed damage has been most severe within about 18 miles (29 kilometers) of the coast, but not all stands within that distance are severely damaged (Kanaskie et al. 1998; Hansen et al. 2000). Other climatic and geographic factors, such as high maximum temperatures in November, low maximum temperatures in June, high precipitation in June, steep slopes, low and medium slope position, and SE, S, SW, and W aspects, have been found to be associated with more severe SNC on the north Oregon Coast (Rosso and Hansen 1999). In British Columbia, high rainfall in May-July was positively correlated with high levels of SNC (Hood 1982).

For the discussions of silvicultural treatments that follow, SNC stand damage severity classes are based on needle retention ratings. Low-severity stands have trees with 2.6 to 3.5 years of needle retention. Medium-severity stands have trees with 1.6 to 2.5 years of needle retention. High-severity stands have trees with 1.5 years or less of needle retention (Table 1).

Table 1. Silvicultural recommendations for stands damaged by Swiss needle cast.

Silvicultural treatment	Stand damage severity*		
	Low	Medium	High
Regeneration methods	Local seed only	Douglas-fir less than 50% of seedlings	Douglas-fir less than 20% of seedlings
Vegetation management	Yes, if needed	Yes, if needed	Yes, if needed
Fertilization	Test soil and foliage before fertilizing	No	No
Precommercial and commercial thinning	Thin lightly and retain non-Douglas-fir species	Thin lightly and retain non-Douglas-fir species	Retain only non-Douglas-fir species; otherwise, do not thin
Artificial pruning	Prune only healthiest trees	No	No
Regeneration cutting in seed-tree and shelterwood systems	Retain only the healthiest trees and non-Douglas-fir species	Retain only non-Douglas-fir species	Retain only non-Douglas-fir species
Clearcutting	When desired	At appropriate economic point	As soon as possible
Uneven-age silviculture	Encourage non-Douglas-fir species	Encourage non-Douglas-fir species	Encourage non-Douglas-fir species

*Severity measured by needle retention: low = 2.6-3.5 years; medium = 1.6-2.5 years; high = <1.5 years.

REGENERATION METHODS

Forest regeneration methods include planting, natural regeneration, and retention of advance regeneration. Regeneration is generally done after clearcutting or partial cutting, but it may also be done by interplanting in young stands or by underplanting in older stands. Regeneration with species other than Douglas-fir reduces stand-level damage simply by denying the fungus its only host species, Douglas-fir. Stand composition, however, appears to have little effect on damage to individual Douglas-fir trees.

Because particular forest pathogens or insects tend to severely affect only one tree species, with minor or no effects on other species, several tree species should be regenerated on any



Figure 6. Differences in susceptibility to Swiss needle cast are seen in these infected Douglas-firs. Photo credit: A Kanaskie.

site. Such regeneration strategies will reduce the risk that insect damage or disease will cause unacceptable impacts. In the case of SNC, western hemlock and Sitka spruce are immune. Although planting a mixture of hemlock, spruce, cedar, and Douglas-fir will not decrease SNC damage to Douglas-fir, it will reduce its economic and ecological impact on the stand level. Sitka spruce is a good alternative to Douglas-fir on the coast, but young stands are highly susceptible to spruce weevil, especially when open grown. Research and trials are being conducted to find weevil-resistant spruce.

Within the western Coast Range, planting of Douglas-fir, especially from non-local seed sources, greatly increases the risk of stand damage from SNC (Hansen et al. 2000; Figure 6). If genetically resistant Douglas-fir can be identified and bred, it may eventually

be possible to plant it in low to moderately affected areas. Current research by the Swiss Needle Cast Cooperative is screening for resistant families that may lead to the breeding of resistant trees (Johnson and Temel 1998; Kastner et al. 2001).

When regenerating low-severity stands, use Douglas-fir seedlings grown from local seed sources only (Table 1). In medium-severity stands, Douglas-fir should make up no more than 50% of the regeneration. In high-severity stands, Douglas-fir should make up no more than 20% of the regeneration. Douglas-fir planted from local seed sources and kept at minimal levels may help to maintain historical levels of Douglas-fir if future environmental changes reduce SNC severity.



Figure 7. Removal of competing vegetation, as seen here, ensures better growth and survival of regenerating trees. Photo credit: Scott Ketchum, Oregon State University.

VEGETATION MANAGEMENT

Management of unwanted vegetation has a long history in Pacific Northwest forests. Removal of undesirable plants ensures better survival and growth of regenerated trees (Figure 7). The Swiss Needle Cast Cooperative is testing the hypothesis that removal of unwanted vegetation, making more water, light, and nutrients available to the Douglas-fir, will allow the Douglas-fir to better defend against SNC (Rose et al. 1999). Even if vegetation management proves to have no effect on the severity of SNC, treated trees might still benefit from the reduction in competition.

Although research results are not yet available, vegetation management is recommended. If vegetation management is applied as a silvicultural operation, it probably will not increase SNC severity and may benefit the seedlings and saplings. Furthermore, if a severely infected stand must be replaced, regeneration will be much easier and less costly if unwanted vegetation has been reduced.

FERTILIZATION

Fertilizers, especially urea, have been used for many years in the Pacific Northwest. Fertilization is often done in conjunction with precommercial thinning. Although there have been observations that fertilizing with plant nutrients such as nitrogen improves the color and growth of SNC-affected Douglas-fir, production of SNC fruiting bodies and spores may also increase. The Swiss Needle Cast Cooperative is therefore testing the effects of balanced fertilizers that contain several nutrients, both with and without vegetation control (Rose et al. 1999). The Swiss Needle Cast Cooperative is also testing the application of elemental sulfur to SNC-affected trees (Rose et al. 1999) and exploring how calcium and magnesium levels relate to SNC severity.

In low-severity stands, test soil and foliage for nutrient deficiencies before applying fertilizer. Until more information is gathered, we recommend against fertilizing medium- to high-severity stands.

PRECOMMERCIAL THINNING

Precommercial thinning is a standard silvicultural treatment in Douglas-fir stands in the Pacific Northwest. By definition, precommercial thinning is the removal of trees that are too small to be merchantable. As standards change and smaller-diameter trees become merchantable, an early commercial thinning may replace precommercial thinning. Precommercial thinning makes additional space, water, and nutrients available to selected crop trees at an early age (Figure 8). Its effects on stands damaged by SNC in the Pacific Northwest are unknown. In New Zealand, 5 years after severely infected 17-year-old stands were thinned to 90 and 300 stems per acre (220 to 740 stems per hectare), the severity of SNC as measured by pseudothecia presence, needle retention, and needle density was equivalent to that in unthinned plots with 1200 stems per acre (2990 stems per hectare) (Hood and Sandberg 1979).



Figure 8. Precommercial thinning, as seen in this plantation of Douglas-fir, provides trees with additional space, water, and nutrients at an early age. Photo credit: A Kanaskie.

The Swiss Needle Cast Cooperative is testing the hypothesis that precommercially thinned stands are better able to defend against SNC because additional site resources are available for each tree (Kanaskie et al. 1998). On the other hand, some observations suggest that the stress of thinning in stands already damaged by SNC may actually be harmful to residual trees. Also, because severely infected trees cannot compete as well with brush, they may not respond adequately to thinning. These alternative hypotheses are also being tested by the Swiss Needle Cast Cooperative.

Given the ambiguous evidence currently available, we recommend that low- or medium-severity stands be thinned lightly and that species other than Douglas-fir be favored, if possible. High-severity stands should not be precommercially thinned unless 80% of the residual trees are species other than Douglas-fir.

COMMERCIAL THINNING

With recent changes in timber availability and markets in the Pacific Northwest, commercial thinning has gained in popularity. A stand may undergo one or more commercial thinnings during a rotation. Like precommercial thinning, commercial thinning provides additional space, water, and nutrients to selected crop trees, but at a greater age. The effects of commercial thinning on stands damaged by SNC are mostly unknown. Again, it has been hypothesized that stands thinned before the onset of severe damage are better able to defend against SNC because additional site resources are available to increase the vigor and defense capability of residual trees. If SNC damage has already occurred in the stand, however, the stress of thinning may exacerbate disease effects and harm the tree.

Low- and medium-severity stands should be thinned only lightly, and species other than Douglas-fir should be favored, if possible. High-severity stands should not be commercially thinned unless 80% of the residual trees are species other than Douglas-fir.

ARTIFICIAL PRUNING

Artificial pruning of lower crown branches, both living and dead, is sometimes done in the Pacific Northwest to improve wood quality and value. Pruning is usually combined with thinning to increase tree growth and accelerate sealing of branch stubs. Besides improving wood quality and value, pruning can improve stand access and remove and prevent certain disease pathogens such as white pine blister rust (not a problem in Douglas-fir). If pruning is done improperly, however, decay, disease, and insect problems can occur.

The effects of artificial pruning on SNC are unknown. Theoretically, removing lower-crown branches should reduce humidity below that required for SNC spore germination and infection. On the other hand, branch removal may stress trees already stressed by SNC, further reducing their growth and survival rates. Therefore, we recommend against pruning medium- to high-severity stands. In low-severity stands, prune only the healthiest trees with the best needle retention.

REGENERATION CUTTING IN SEED-TREE AND SHELTERWOOD SYSTEMS

Partial cutting of stands for the purpose of stand regeneration is typically applied within the context of classical seed-tree or shelterwood systems. The purpose of the regeneration cut is to ensure an adequate supply of seed and, in the shelterwood system, to provide some shade for natural regeneration. Neither seed-tree nor shelterwood systems are generally used in wind-prone areas because they significantly increase the probability of windthrow of the residual trees. Where regeneration cuts are viable, they offer the advantages of favoring non-Douglas-fir species in the overstory and encouraging natural regeneration of these species, especially those that are more shade tolerant.

For partial cutting in low-severity stands, retain only the healthiest Douglas-fir and favor other species, if possible. In medium- to high-severity stands, retain only non-Douglas-fir species.

CLEARCUTTING

Clearcutting has been the dominant silvicultural system in the Pacific Northwest for many decades. Its obvious advantage for treating SNC is that it removes infected trees and makes it possible to replace them with non-host species. To improve regeneration success and growth rates, clearcutting is usually done in combination with vegetation management.

If clearcutting is the system of choice, treat low-severity stands as usual. Medium-severity stands should be grown to an appropriate point based on economic analyses and then clearcut. High-severity stands should be clearcut as soon as possible and replaced with a mixture of species in which Douglas-fir makes up less than 20%.

UNEVEN-AGE SILVICULTURE

Uneven-age silviculture has not been widely practiced in western Oregon and Washington, but it is gaining acceptance. Uneven-age systems are intended to promote and retain three or more age classes of trees in a stand. In coastal forests, leaving overstory trees tends to decrease Douglas-fir in the understory and increase the more shade-tolerant species, such as hemlock, grand fir, or cedar, depending on seed source. By decreasing the relative abundance of Douglas-fir, uneven-age systems may reduce the stand-level severity of SNC.

Wherever silvicultural objectives require an uneven-age system, non-Douglas-fir species should be favored.

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