THE ORIGIN OF BASAL SCARS IN THE BRITISH COLUMBIA INTERIOR WHITE PINE TYPE [1]

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ABSTRACT

Basal scarring, a conspicuous abnormality of western white pine (Pinus monticola Dougl.) and its associated species in the Interior region of British Columbia, was found to be chiefly attributable to injury by bears, infections of Armillaria mellea (Vahl ex Fr.) Quél., fire, mechanical wounding, and the pole blight disease. Diagnostic characteristics, which facilitated classification of scars, even those of advanced age, were found and described. The implications of the various types of scarring are considered.

INTRODUCTION

Basal scarring is a conspicuous abnormality of western white pine and its associated species in the Interior region of British Columbia. Although the frequency of scars is quite variable, their incidence in some stands is sufficiently high to arouse interest concerning their origin and significance. Buckland (3)

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FIGURE 7. Resinosis at the root collar of a young Douglas fir, showing the presence of an infection of *Armillaria mellea*.

FIGURE 8. A contained infection in white pine. The arrow indicates part of the callus perimeter surrounding the infection. The face of the scar is covered by soggy mycelial fans of *A. mellea*.

FIGURE 9. An old scar on white pine showing the depression in the bark (A) overlying the scar (B). The black fan-like etching of dried mycelium is evident on the dead face. A callused margin surrounds the scar.

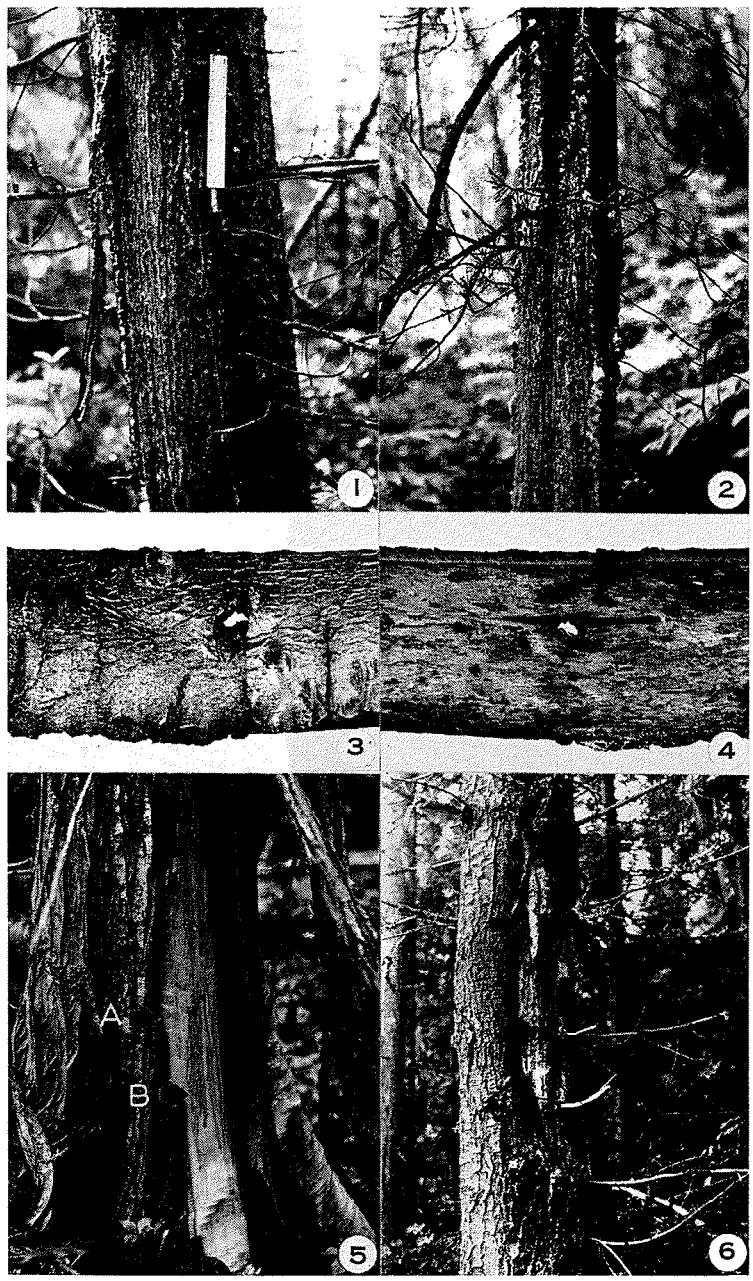
FIGURE 10. An old scar on white pine with the bark removed (A). The dead root (B) at the base of the scar shows the point of entry of the infection into the root collar.

FIGURE 11. A fire scar on white pine. The wood on the face of the scar is charred black.

FIGURE 12. Fire scar on white pine. The cambium of the scar face was killed without charring the overlying bark (A). The charring at the end of the twig (B) confirmed fire as the cause of this basal scar.

FIGURE 13. Mechanical damage to a pole-sized Douglas fir. The irregular scar outline and abraded sapwood are evident.

FIGURE 14. A pole blight lesion scar at the base of a white pine, after removal of the bark. The entire margin of the scar was callused (A). The end of this scar did not extend below ground line.



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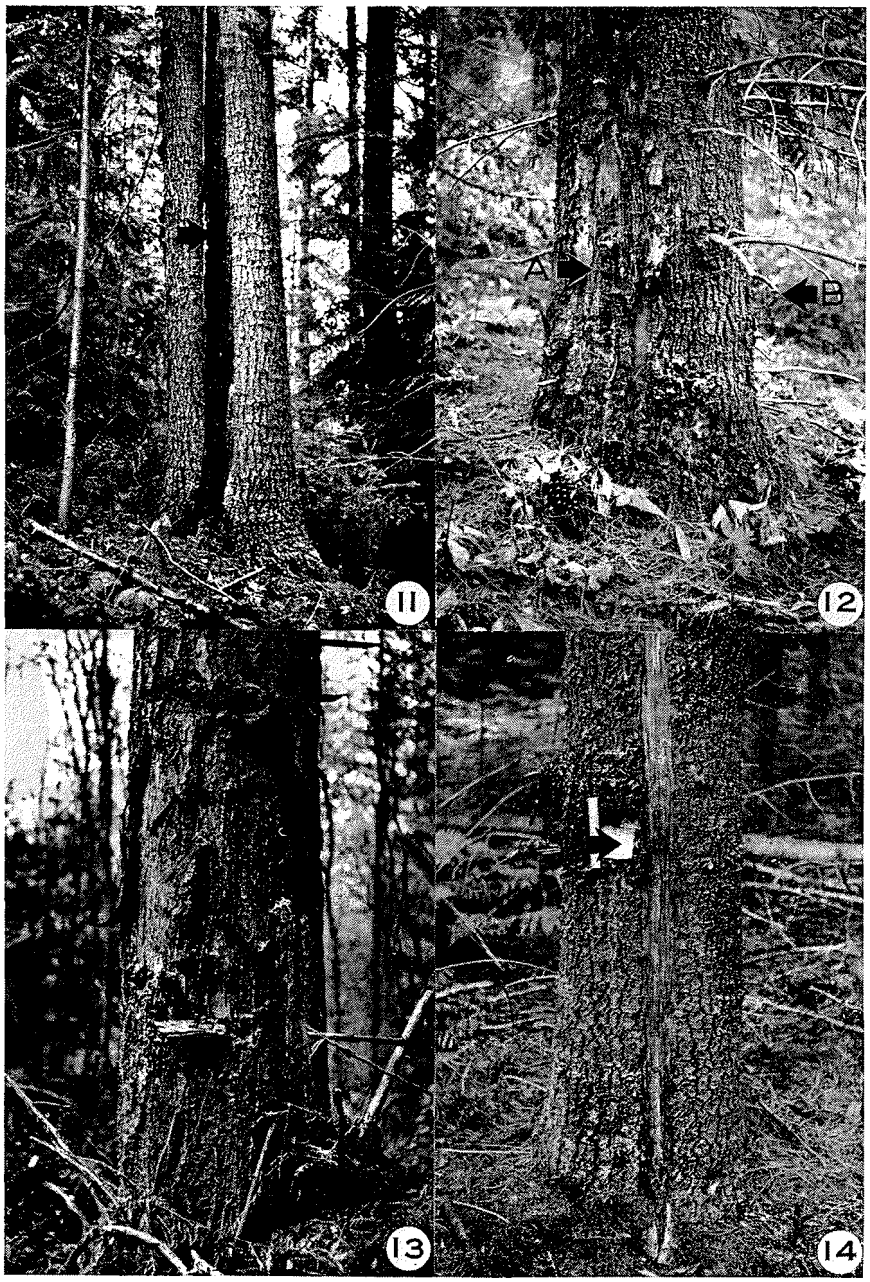

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recorded basal scars on as many as 39 per cent of the white pine examined in a stand at Mt. McPherson, near Revelstoke. The authors found an even higher incidence of damage in other parts of the Interior white pine type. Although basal scars also occur on other species in this region, white pine is most frequently damaged.

The authors became interested in the cause of basal scarring during investigations of the pole blight disease of white pine in British Columbia. Although some types of scarring were found to be unrelated to pole blight, the association of other types with the occurrence of this disease made their recognition important. The purpose of this paper is to describe characteristics which may be used to differentiate the commonly occurring types of scars. While attention was primarily devoted to white pine, it was found that the diagnostic features of scars on this species were readily applicable to other trees.

Causes of Basal Scars

Most basal scars appeared attributable to bear clawing, infections of *Armillaria mellea,* fire injury, mechanical injury, and basal pole blight lesions. The frequency and importance of scarring varied according to both stand history and the species affected.

Bear Clawing

Bear clawing was found to be the most frequent and widespread cause of basal scarring in white pine and it usually caused the largest scars occurring on any species. While some stands were entirely free from scars, damage to as many as 42 per cent of the white pine over an area of 10 acres was recorded. Individual trees of other species, such as alpine fir (balsam) *(Abies lasiocarpa* [Hook.] Nutt.) and western red cedar (*Thuja plicata* Donn), were sometimes even more severely damaged than white pine; occasionally trees were entirely girdled and killed by stripping the bark. Such severe injury was a rare occurrence on white pine or Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco).

Levin (8), reporting on bear damage to Douglas fir in the South Olympic Tree Farm in the State of Washington, concluded that the stripped bark is used as food by bears. Bark fragments were found in the gut of many of the bears killed in this region during a control program. Bears may also lick the sap which flows freely from such wounds in spring. Damage to cedar, on the other hand, may be essentially fortuitous or wanton since the bark is rarely removed from the tree and sap flow in this species is not copious. The extensive stripping noted on cedar probably results from the ease with which its bark may be removed. Bark stripping by bears has been noted in other regions including California, Alaska, and Maine (5, 9, 14).

Most of the white pine examined in the present study were between 21 and 45 years old when scarring occurred, although younger and older trees were attacked. Buckland (3) found a similar age distribution in the trees he examined. Trees in this age class are probably favored because their bark strips off more readily than the tough, corky bark of older trees.

Recent bear damage was readily recognizable by the presence of strips of bark clinging to the upper end of scars (Figs. 1, 2, 5, and 6) and pieces scattered on the ground. Claw or tooth punctures were seen in some of these pieces (Figs. 3 and 4). Scar faces were generally smooth and unscored. The

apex of scars was commonly jagged or "toothed", although lateral margins were smooth. The jagged apex of scars appeared to result from both interruption of stripping by branches and the tendency of strips to narrow to a point before they broke from the tree. Few of the bear scars examined extended down to ground line. Scars which occurred on trees young enough for the bark to strip readily were triangular to fusiform in shape. Where clawing occurred on older trees, scars were commonly shorter and more rectangular in shape because the bark of such trees breaks off instead of stripping in long strands. In several cases the bark of 60-year-old Douglas fir was stripped from the bole at 40 feet above the ground. Presumably this part of the bole was attacked because its thin bark stripped more readily than the tough bark at the base of the tree. The upper crown of many of these trees had been killed by girdling. Such damage was not seen in other species than Douglas fir. Basal scarring apparently had no effect on the growth rate of the trees, even when their boles were more than one-half girdled. Healing appeared to have started immediately after stripping with the formation of a smooth callus.

Old scars were recognizable primarily by their triangular or fusiform shape and the strips of bark commonly present at their apices (Fig. 6). Curled strips of bark could also be found in the duff at the base of some scarred trees. The clean scar face, smooth regular margin, and jagged apex of bear scars were other diagnostic features persisting in old scars.

Armillaria mellea Infections

Investigations by Molnar and McMinn (10) have shown that infections by *Armillaria mellea* may be arrested and die out even when extensive cambial killing has occurred in the root collar region of the host. Such restricted lesions, found on both white pine and Douglas fir, subsequently callused and formed basal scars. The ubiquity of arrested *Armillaria* infections in the white pine type is unknown, however, since they are not easily detected and no reference to their occurrence was found in the literature. In some stands contained infections of *A. mellea* were very frequent. Near Arrow Park, for example, 20 per cent of the dominant and codominant white pine examined in a 5.2-acre sample plot had scars of recent origin. The high frequency of contained infections in this 65-year-old stand was probably associated with the apparent recovery of some trees from the pole blight disease. However, since some of these trees may yet die, a lower frequency may be expected as the stand reaches maturity. Near Silverton, in a 5.6-acre sample plot on a different site, only 1 per cent of the dominant and codominant white pine had basal scars resulting from *Armillaria* infections and other stands appeared to be devoid of *Armillaria* scars. Scars resulting from arrested infections of this fungus may well occur in other regions and on other species than white pine and Douglas fir with improvement of the conditions which predisposed the host to infection by this extremely widespread fungus. While the fungus is known to attack hosts of any age under appropriate conditions (1), host recovery and basal scar formation was noted only on trees ranging from 18 to 73 years old.

Active *Armillaria* infections extending into the root collar zone of affected trees were discernible by the pitch streaming or resinosis which occurred on the bark surface (Fig. 7). Removal of this pitch-soaked bark revealed the characteristic mycelial fans of *A. mellea* beneath. Arrested infections could be

differentiated from infections in which the fungus was still active by the presence of a perimeter of callus tissue around the damaged area (Fig. 8). Such callusing was absent from the lower margin of the affected area since the fungus invades from an infected root. In contained infections, mycelium on the inner bark and cambium had deteriorated and turned soggy by the time callus formation had developed. However, even ten years following death of the fungus mycelium, a black, fan-like etching of dried mycelium was usually discernible on the scar surface.

When the pitch, characteristic of active infections, had dried up and weathered away, damaged areas were difficult to recognize. Even the pitch that soaked the duff and soil at the base of the tree eventually deteriorated. Dead faces originating on young trees could, nevertheless, be distinguished by the depression of smooth bark (Fig 9). In pole-sized trees, such areas contrasted with the adjacent corky bark characteristic of the remainder of the root collar. However, once evidence of resinosis had disappeared, *Armillaria* scars originating in trees with corky bark were distinguishable only when the bark overlying the dead face had been sloughed off by the increase in the diameter of adjacent tissue. Before sloughing-off occurred, dead faces could sometimes be detected by tapping the root collar in a suspected area to reveal the presence of a hollow section.

Old *Armillaria* scars were recognizable by their short length and broadly triangular shape, their extension below ground line to join a decayed and often almost disintegrated root, and an etching of blackened, dried-up mycelial fans on the scar face (Figs. 9 and 10). Most *Armillaria* scars differed from bear scars in all these features, although a few of the *Armillaria* scars examined did reach 3 feet up the bole. Radial increment in trees with *Armillaria* scars was normally reduced for several years prior to the period of scar formation and for some years thereafter, another feature distinguishing such scars from those originating by bear clawing or fire.

Fire Injury

Basal scars resulting from fire injury were observed in several widely scattered localities. Even light ground fires, which usually do not damage thick-barked species such as Douglas fir, may cause basal scarring on white pine because of its thin bark.

When charring was present on a scarred tree, fire could easily be recognized as the cause of injury (Fig. 11). In some examples, however, the heat of the fire appeared to have killed the cambium without charring the bark (Fig. 12). Although the dead bark of such fire-damaged trees curled somewhat as the dead face dried out, some bark remained adhering to the scar for many years following injury. Careful examination of such trees usually revealed charring at the ends of twigs and charred fragments in the duff. Even when all evidence of charring has disappeared, fire can be suspected as the cause of injury when all scars originate in the same year. Such a coincidence in time of damage occurrence is unlikely to occur through agencies other than logging or fire, and logging damage can be differentiated by other evidence. Also, fire-scarred trees commonly show increased radial increment through release following the fire, another feature in common with logging scars but absent in the other forms studied.

Mechanical Injury

Most basal scarring resulting from mechanical injury was attributable to logging activities, road construction, and windthrow. Log skidding, falling trees, and direct abrasion by bulldozer blades and other machinery may all cause injury which later results in basal scarring. The incidence of such damage depends largely on the type of logging and the care with which the operation is carried out. In addition to roadside injury caused by road construction machinery and falling trees, some basal scars were found to result from boulders rolling downhill and striking the base of trees. The damage caused by windthrown trees was similar to that caused by felling during logging operations. The frequency of such damage depends largely on the occurrence of trees prone to windthrow, which in turn is related to stand age, stand composition, soil characteristics, and other factors, including the prevalence of strong winds.

Basal scars caused by mechanical injury could usually be distinguished by their rough, irregular outline, the bruised and shredded bark adhering to the periphery of the scar, and, in many cases, the abraded wood on the face of the scar (Fig. 13). Branches close to and above the injury were frequently broken, especially when the damage was caused by a falling tree. In the case of windthrown trees, the stem which caused the damage could usually be identified. Despite the heavy callusing commonly present around old scars, the distinguishing characteristics associated with mechanical injury usually served to identify the cause of scarring.

No evidence of growth reduction was seen following mechanical injury. On the contrary, in areas selectively logged, accelerated growth of the residual stand subsequent to scarring was commonly discernible as a direct result of release.

Basal Pole Blight Lesions

Among the symptoms commonly associated with the pole blight disease of western white pine are long, narrow lesions of dead bark and cambium running longitudinally up the bole (2). The occurrence of healing lesions on white pine has recently been reported (10). They occurred on slow-growing trees and most of the lesions observed were less than 10 years old. Very narrow lesions may have callused over without a crack having developed in the overlying bark which would reveal their presence. Wider lesions, on the other hand, now appear as a dead face bordered by callus tissue (Fig. 14). Although most pole blight lesions occur well above the root collar (7) occasional lesions extend to the ground line, and more rarely even below the soil surface. If the trees on which such basal injury occurred continued to live, the exposed face would eventually become a basal scar.

The frequency of scars resulting from healing pole blight lesions can only be surmised. In recent years trees showing signs of recovery from pole blight have been noted (10). If this recovery trend continues, pole blight lesion scars may become relatively frequent, for the disease is widespread.

Pole blight lesions are usually quite long, narrow, and fusiform and occur most commonly on the mid and upper bole (2, 7). Basal lesions are also fusiform in shape, although some are fairly wide toward the base. A positive diagnostic feature of pole blight lesion scars was their alignment with the grain of the wood. Considerable growth reduction was normally evident beneath lesions.

Summary and Discussion

While the cause of injury in scars of recent occurrence could readily be determined, in many cases callusing and weathering obscured the more easily recognizable diagnostic features of older scars. However, a number of persistent characteristics enabled recognition of most scars. These are summarized for comparison in Table 1. Thus, the presence of bark strips at the apex of scars or in the duff provides positive identification for bear scars. Similarly, a dead root at the base of a scar and remains of mycelial fans indicate *Armillaria mellea* as the causal agent. While evidence of charring is sometimes hard to find, some charcoal is usually present on or near fire-scarred trees. A single year of origin for scars in the same vicinity also suggests fire as the cause of scarring when no scars characteristic of mechanical injury are present. Pole blight lesion scars are generally longer and narrower than those caused by the other agents discussed and such lesions usually follow the spiral grain of the wood, a feature peculiar to this type of injury.

Although the present paper is intended primarily to draw attention to those characteristics which are diagnostic in the differentiation of the various types of scars commonly encountered in the Interior white pine type of British Columbia, it seems appropriate to consider their significance with respect to the amount of associated cull. Any injury which kills sapwood may provide an entrance court for decay-producing fungi. However, investigations on various species have shown that different amounts of decay are usually correlated with different types of scarring (3, 4, 6, 11, 12, 13). Parker (12), for example, found that locality, species, and diameter of the affected tree, and scar size (area), depth, position, and age were all factors in the incidence of infection and decay development. Since the scars examined in the present study differed according to several of these factors, it can be anticipated that differences in the amount of associated decay would occur.

In bear damage the infrequency of injury below ground line and lack of scoring on the scar face may limit the amount of decay associated with this type of scarring. On the other hand, the large size of many bear scars may offset these limiting factors, especially in decay-susceptible species. Buckland (3), for example, recorded infections in 46 and 67 per cent of the wounded white pine examined in two 70-year-old stands near Revelstoke and predicted the loss of the 16-foot butt-log by the time affected trees had reached 100 years. Childs and Worthington (4), on the other hand, attributed only minor amounts of cull to bear damage in a 110-year-old Douglas fir stand in the State of Washington. Even 70 to 90 years after the initial damage only 7 per cent of the wounded trees had decay beyond the face of wounds. Four per cent of the unwounded trees in the same stand contained rot. On the other hand considerable mortality in Douglas fir following bear injury was reported by Levin (8) in the same State.

Trees with basal scars resulting from *Armillaria* infections can be expected to show an appreciable volume of decay since these scars are in contact with the ground. Retention of the bark for a long period after scar formation also helps to maintain conditions favorable for decay. Furthermore, such trees are probably poor risks since the loss of one or more roots is liable to render them more susceptible to windthrow than uninfected trees.

The importance of pole blight lesions as entrance courts for decay is currently unknown. However, most scars formed in this way are narrow so that

TABLE 1

SUMMARY OF DIAGNOSTIC CHARACTERISTICS DIFFERENTIATING VARIOUS TYPES OF BASAL SCARS PREVALENT IN THE INTERIOR OF BRITISH COLUMBIA

Origin	Specific Features	Scar Shape	Scar Face
BEAR INJURY	Bark strips at apex (Fig. 6). Strips of bark with claw marks in duff at base of tree (Fig. 3).	Triangular to fusiform; apex more or less pointed or with several apices (Fig. 2); stripped portions commonly terminating at branch stubs. Base of scar commonly above ground line.	Free from bark, except for strips hanging from apex of scar. Dead face unscored. Branches projecting from scar face and generally uninjured.
CONTAINED *ARMILLARIA* INFECTION	Decayed root at base of scar (Fig. 10). Blackened, dried-up mycelial fans of *A. mellea* on dead face beneath bark covering (Fig. 9).	Usually close to ground line and broadly triangular or occasionally rectangular. Base extends below ground line, with no healing at lower margin of scar (Fig. 10).	Bark retained over face for many years but completely separated from dead face. Hollow sound when knocked.
FIRE INJURY	Charred bark, wood, or twig ends, charred debris in duff (Figs. 11 and 12).	Roughly triangular. Commonly extending below ground line, but healing from below.	Open and charred, or bark may adhere for many years, gradually flaking off in patches (Fig. 12).
MECHANICAL INJURY	Scored or gouged sapwood (Fig. 13). Broken branches at or above face. Presence of suitably positioned windfall.	Very irregular. Base may be ground contact or below, but lower margin as well as sides callused.	Face commonly scored or gouged, with bark at edges shredded or split. If bark present on face it is scored or split.
POLE BLIGHT LESION (pine only)	Scar spirals with grain of wood (Fig. 14).	Narrowly fusiform; commonly extends well up bole, though rarely below ground line, unless in conjunction with an *A. mellea* infection.	Bark breaks as longitudinal crack with narrow lesions, but sticks to faces with wide lesions and peels off gradually.

fairly rapid healing may be expected. The volume of associated cull may also be small because most pole blight lesions are not in contact with the ground. Wide lesions, however, which expose a large area of dead wood, and long lesions, which frequently check deeply, would constitute a high decay hazard.

Both fire and mechanical injury scars are known to be associated with decay. Since scars resulting from ground fires usually contact the ground, infection almost invariably follows (11,12). Ground-contact logging scars likewise are reported to be very susceptible (12).

Conclusions

Scars on living trees, particularly basal scars, are generally recognized as important courts of entry for wood-destroying fungi. It is, therefore, a desirable objective of forest management to keep basal scars to a minimum in any forest operation. A knowledge of the specific causes of basal scarring is prerequisite to any measures taken for its prevention. This investigation has shown that it is possible to determine the cause of most basal scars 20 or more years after they were produced.

Ready determination of the cause of basal scars should also have a research value. The occurrence of scarring from *Armillaria* infections, for example, probably indicates that the affected stand has undergone a period of adverse conditions. Pole blight lesion scars on white pine would have a similar indicator value. Basal fire scars may help to explain peculiarities of stand composition and growth pattern. Similarly, other types of basal scars may help to interpret various happenings during stand development.

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