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Recognizing and Managing Sapstreak Disease of Sugar Maple

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Abstract

Sapstreak disease is a potentially serious problem of sugarbushes and forest stands. It occurs when the causal fungus, *Ceratocystis virescens,* invades the sapwood of roots and bases of stems through wounds inflicted during logging, saphauling, or other activities. This bulletin describes how to recognize the disease, the factors that affect its occurrence and development, and management approaches to help reduce its effects.

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COVER PHOTO.--Small leaves often are the first obvious sympton of sapstreak disease.

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Introduction

Sapstreak of sugar maple *(Acer saccharum* Marsh) is a disease of the living sapwood incited by the fungus, *Ceratocystis virescens* (Davidson) C. Moreau (=C. *coerulescens* (Munch) Bakshi) (= *Endoconidiophora virescens* Davidson) (Hepting 1944). Sapstreak, first noticed in North Carolina in approximately 1935 (Hepting 1944), has since been reported in Michigan in 1959 (Kessler and Anderson 1960), Vermont in 1964 (Houston and Fisher 1964), Wisconsin in 1971 (Kessler 1972) and New York in 1978 (Beil and Kessler 1979, Houston and Schneider 1982). In each case, the disease occurred in stands where activities such as logging, road building, or sap hauling had inflicted root or lower stem wounds to the affected trees. These injuries allow C. *virescens* to invade and then kill the wood of lower portions of the stem and roots (Hepting 1944, Kessler 1978, Houston 1985). Because C. *virescens is* one of the most common fungi in northern hardwood forests (Shigo 1962), sapstreak disease has the potential to occur where the roots and lower stems of sugar maple trees are wounded during logging or other activities in these forests.

Figure 1.--A thin "transparent" crown with leaves much smaller than normal--the first indication that a tree may have sapstreak disease.

This paper presents information on (1) symptoms of the disease, (2) factors affecting disease occurrence and development and (3) management approaches to reduce disease effects. This information was obtained from published articles and a series of studies conducted from 1979 to 1991. Details of the studies are not presented in this paper.

Symptoms of the Disease

Usually, the first observed symptom of sapstreak is a distinctive "transparency" of the tree crown--a consequence of unusually small leaves, especially in upper branches but sometimes over the entire crown (Fig. 1). Often, these small leaves are normal in color, shape, and number the first year of the disease, but become off-colored and sparse in subsequent years. Branch dieback often occurs where small leaves had occurred the previous year, and this pattern of small leaves one year followed by death of supporting twigs and branches the next, can continue for several years until the tree dies (Fig. 2). Sometimes, however, symptom progression is arrested and results in trees whose upper crowns exhibit branch

Figure 2.--Progressive branch dieback may occur over several years.

dieback or even major stagheading while lower branches are fully foliated with leaves of normal size and color. Some of these trees recover with no further disease progression while others, after several years of apparent remission, again exhibit symptoms.

Figure 3.--Sapstreak disease stain, when fresh, has a watersoaked, greenish-yellow-to-tan color with scattered red flecks, and is bordered by a narrow green margin. The stain often appears to radiate outward.

Figure 4.--Well developed stain columns at the root collar and occupying most of the sapwood. By the time the crown symptoms appear, the stain is well established.

Inside the tree the diseased wood of roots and lower stems exhibits a distinctive stain (Fig. 3). Freshly exposed, the stain is greenish yellow to yellow-tan with red flecks and appears watersoaked. Often, in cross-section, the stain columns appear to radiate outward and are bordered by a thin, intermittent, dark-green margin. Soon after exposure, the stain darkens dramatically, then later fades to a light brown.

External symptoms are related closely to development of internal stain. By the time crown symptoms appear, stain columns are well established (Fig. 4), especially in root tissues, and usually can be revealed by an ax cut into the buttress roots. In many trees, especially those in remission of crown symptoms, the outward extension of stain columns appears to be limited by newly-formed rings of healthy sapwood (Fig. 5).

When trees infected by sapstreak disease are cut into lumber, the stain columns often are very noticeable and distinctive (Houston 1986). Within a few minutes of cutting and exposure to air, stain columns become dark brown (Fig. 6). As drying progresses, the columns gradually change color, becoming lighter--while the clear wood, in contrast, darkens (Fig. 7). Surface planing of dried lumber reverses these patterns and again reveals the light brown stain of diseased wood in contrast to the clear, white, healthy wood.

Figure 5.--Internal stain column that is well compartmentalized by annual ring boundaries.

Figure 6.--Boards cut from the log of a sapstreak diseased tree. Note extensive columns of dark discoloration.

Figure 7.--As drying progresses, the dark stain columns fade to a light greyish tan (right side or board) and healthy tissues gradually darken (left side of board). Note the dark smudgy strip where C. *virescens* (large arrow) has grown out onto wood surface near the edge of the stain column, and the blotchy colonies of saprophytic mold fungi (small arrows) growing exclusively on the sapstreak diseased wood.

When *C. virescens* grows on board surfaces, where it sometimes sporulates, it usually occurs near the outer margins of the stain columns and often on clear wood immediately adjacent to stain columns (Fig. 7). The dark, smudgy appearance of the fungal growth is distinctive and develops within a few days of sawing. As drying continues, the surfaces of the sapstreak stained columns become heavily colonized by numerous common molds; clear wood remains free of such growths (Fig. 7).

Figure 8.--Basal injuries typical of those on sapstreak diseased trees adjacent to skid trails.

Disease Development within Individual Trees

Infection and Importance of Wounds

Infection occurs primarily through wounds to the roots, buttress roots, or the lower portion of stems near the ground during logging, saphauling, or other activities (Figs. 8, 9) (Hepting

Figure 9.--Buttress roots and roots close to the soil surface typical of those damaged by traffic in the sugar bush; these roots are at risk to infection by the sapstreak fungus.

1944, Houston 1992, Meilke and Charette 1989). Stump wounds, created when sprout members are removed in thinning, can provide the fungus access to otherwise unwounded residual members (Fig. 10). A few cases have been observed where the fungus apparently entered the tree through roots injured by cattle trampling.

Injuries associated with sapstreak are nearly always close to the ground. Even though stem tissues can be infected, and invasion of upper portions of stems from infections originating in the roots or stem bases can occur, no definitive cases have been found where infection has occurred naturally through broken branches or other wounds of upper crowns or stems. No cases have been observed where, in practice, tapholes have become infected by sapstreak, and only rarely (2 of 142 times) did this occur when the fungus was placed experimentally into tapholes (Houston 1992). In each instance where infection did occur, its development around tapholes was sharply limited by the tree (Fig. 11).

Results from several studies suggest that wounds made in the late spring and early summer may be more readily infected by *C. virescens* than wounds made at other times. Other tree species are known to be most susceptible to vascular pathogens at this time. Meilke and Charette (1989) found no significant differences in the number of trees affected by sapstreak in Wisconsin stands logged during frozen versus nonfrozen conditions, although no records were available concerning the number of trees wounded or the actual conditions of the roadways when logging occurred.

A few cases have been observed where the fungus moved across functional root grafts from wounded, diseased trees to adjacent, nonwounded neighbors (Houston 1991).

Disease Progression within Individual Trees (Patterns and rates)

Within individual trees, the appearance of initial crown symptoms and the rate of their progression varies greatly.

Figurel O.--The injury created when one member of a sprout clump was removed served as an infection court for the sapstreak fungus. Note sapstreak stain revealed by the ax cut at the root collar of the tree.

Figure 11.--A rare instance of sapstreak disease when the fungus was placed in the taphole (arrow); the fungus was contained by the tree and discolored columns were limited. Spread probably attributable to tangential orientation of the taphole, which cut across normally effective ray boundaries.

Some trees exhibit severe crown dieback for many years before they die, while others become symptomatic and succumb rapidly, often within 2-3 years. Trees that die quickly and possess severe symptoms usually are extensively invaded by C. *virescens* (Fig. 12). In most such trees, vascular staining is present throughout the roots and much of the stems, and the fungus sometimes can be isolated from xylem tissues in the upper portions of stems, often up to 30-45 ft.

Sometimes disease progression, as revealed externally by crown symptoms, is arrested and recovery ensues, even in trees with more than 40 percent crown dieback. Some trees with root-stain patterns characteristic of sapstreak disease never developed severe foliar symptoms during the course of a 10-year study. In such trees, the columns of discoloration usually appear strongly restricted by the tree (Fig. 13).

Disease development within trees also can be monitored nondestructively. Sapstreak stained wood characteristically is very low in electrical resistance (ER) (50 K ohms and often as low as 5 to 10 K ohms) compared to healthy tissue (100-700 K ohms) (Houston and Schneider 1982). Tissues infected by sapstreak disease can be identified reliably by their ER measurements (Table 1) [1].

[1] Electrical resistance was measured with a Shigometer (Model OZ-67, Osmose Wood Pres. Co., Buffalo, New York) and twisted wire probe) (Shigo and Shigo 1974). The method utilized the fact that as wood becomes discolored, cations increase in concentration and electrical resistance decreases (Tattar et al. 1972). Holes 2.4 mm in diameter are drilled to depths of from 2 to 4 inches in up to four buttress roots on opposite sides of the tree. The probe is inserted and resistance readings are taken at 0.25-inch intervals.

Figure 12.--Bolts, 1 meter long, sequentially cut (from root collar up and placed in that order for photo) from a tree that died within 18 months after being infected with C. *virescens.* The dark fungus has grown out from the columns of stained xylem onto the cut ends of the bolts.

Figure 13.--In this tree both developing columns of discoloration are limited strongly by compartmentalization.

Table 1.--Comparison of electrical resistance (k-ohms) of buttress-root tissues of a healthy tree and a tree with sapstreak disease

Electrical resistance (K ohms) - July 1980

Depth (inches) into root wood

	Root	.25	.50	.75	1.0	1.25	1.50	1.75	2.0
Healthy tree	1	180	190	210	290	260	230	240	200
	2	250	230	160	210	256	200	260	260
	3	500	400	330	280	280	500	300	
	4	320	220	230	240	240	250	340	500
Diseased tree [a]	1	21	34	18	27	22	46	21	
	2	15	18	23	17	13	13	9	
	3	80	80	70	80	70	-		
	4	100	80	70	90	50	60		

[a]The tree had severe crown symptoms in 1980 and was still alive in 1981.

Development of the disease usually is more rapid and extensive in roots than stems. Often, extension of the stain columns into stems is sharply limited even when roots and root collar regions are severely colonized (Fig.14). Repeated measurements on individual trees reveal the disease pattern in a sugar maple root system, July 1980 to July 1981 (Table 2).

Figure 14.-- Sometimes spread of the fungus upward into stem tissues is limited even though tree roots and root collars are severely colonized.

Table 2.-- Electrical resistance in two successive years in buttress roots on different sides of a diseased tree reveal progression of the disease. Numbers below 50 indicate sapstreak disease.

Tree 68: Electrical resistance (k-ohms) of buttress roots

Depth (Inches into rootwood)

Date measured	**Side of tree**	.25	.50	.75	1.0	1.25	1.50	1.75	2.0
July 1980	N	24	45	35	110	80	35		
Symptoms in extreme top	W	500	500	450	380	300	500	500	-
	S	450	250	180	170	250	190	380	200
	E	40	100	130	150	**110**	110	190	80
July 1981	N	55	60	70	60	55	65		
Symptoms same as 1980	W	100	175	45	40	40	38	40	-
	S	140	180	280	280	210	220	220	190
	E	20	12	12	8	7	6	5	4

Speed and extent of column discoloration may relate to the severity and orientation of infection court and other wounds near expanding columns. In some trees, dramatically and greater discoloration occurs when fungus invades deep wounds across the tangential face of the tree stem or root, compared to wounds oriented toward the center. Deep tangential wounds disrupt more preestablished compartment barriers (Shigo 1977, 1979). In some trees, however, the fungus is limited regardless of the wound orientation, suggesting that trees vary in retarding the invasion process.

Finally, other organisms appear to influence the rate at which sapstreak diseased trees succumb. Trees dying of sapstreak disease almost always are colonized at their roots or root collars by *Armillaria* sp. (Fig. 15), *Xylaria* sp. (Pers.: Fr.) Grev. (Fig. 16) , or, rarely, both (Hepting 1944, Houston 1985). These root fungi, ubiquitous inhabitants of long

Figure 15.--The thin, white, girdling mycelial "fan" of shoestring root rot fungus, Arm/I/aria sp., beneath the bark of sapstreak infected tree.

Figure 16.--The fruiting structures of *Xylaria* sp., a root decay fungus often found on trees dying from sapstreak disease, evoke its common name "dead man's fingers."

established maple stands, are maintained in root systems of stumps and dead trees. Root system "food bases" of large trees probably are more important for longer survival and vigor of root pathogens than are those of small trees whose roots are more quickly consumed. Although their actual role in sapstreak disease has not been demonstrated, it is likely that these fungi contribute significantly to the death of sapstreak affected trees.

The ability of *Armillaria* spp. to invade and kill trees weakened by stress factors, especially insect defoliation, is well known (Wargo and Shaw 1985) . Presence of these pathogens and perhaps others, such as *Hypoxylon deustum* (Hoffm.: Fr.) Grev. and *Ganoderma applanatum* (Pers.) Pat., on dying trees and their apparent absence from severely affected, but recovering trees, suggests that their attacks may determine which sapstreaked trees die or recover.

Severely affected trees often are attacked by Ambrosia beetles. Initial concentrations usually are near the buttress roots and lower bole with columns of sapstreak discoloration near the cambium (Fig. 17). The role of these insects or their fungal associates in the disease is not known; their great abundance in later stages of disease suggests they hasten the demise of diseased trees.

Figure 17.--Long streaks (between vertical split and arrow) of sapwood discolored by sapstreak disease sometimes occur near the cambium. The cambium touched by these streaks dies, and cankers (not yet obvious in this recently infected sampling) may form. Often, Ambrosia beetles penetrate these areas into the underlying sapwood (arrow).

Disease Development in Sugarbushes

In sugarbushes, sapstreak disease rarely results in large numbers of trees dying at one time. Rather, it appears to affect a few trees, now and again. The following description is based on observations in many different bushes, in particular, those made annually over 11 years in two typical sugarbushes in northern New York.

In sugarbushes, sapstreak disease is not related directly to the tapping process but to associated activities that result in wounds to roots and lower stems. Vehicles or equipment that bruise or cut shallow or buttress roots to expose sapwood appears the most important factor. The close association of sapstreak diseased trees to roads used for saphauling in a New York sugarbush is shown in Figure 18.

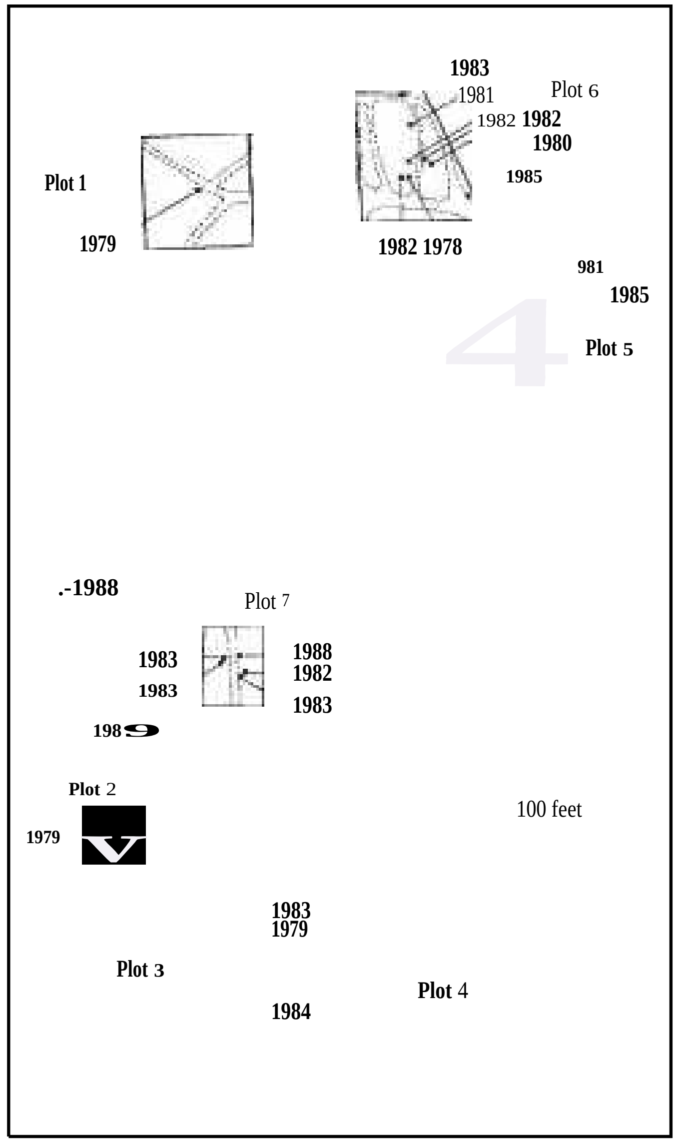

Figure 18.--Locations of sapstreak diseased trees (boxed outlines) and the years when symptoms were first observed in a New York sugarbush. Main access and saphauling roads (dash lines) lead to the sugarhouse near plot 6.

In other sugarbushes, sapstreak disease has occurred in trees with roots injured by cattle and by log skidding. In one instance, a tree, located adjacent to a field, developed sapstreak symptoms a few years after its roots had been injured when the field was plowed and disked.

Whether the injuries that led to sapstreak disease were made during saphauling or at some other time is not known. The fact that very few cases of sapstreak have been observed in sugarbushes employing tubing collection systems could be due either to reduced saphauling traffic or to less traffic at other times. Regardless of the sap collection system used, the disease often is most severe near the sugarhouse where traffic and other activities are concentrated (Fig. 19). Other factors, including a possible buildup of the pathogen on wood from diseased trees stacked near the sugar house, also may contribute to infection of nearby wounded trees. The fungus often is found colonizing (Fig. 12) recently cut surfaces of stumps and logs (Ohman and Kessler 1963, Shigo 1962).

Disease Development in Forest Stands

In forest stands as in sugarbushes, sapstreak diseased trees usually have severely injured roots or lower stems. The patterns of occurrence in forest stands, however, usually differ from those in sugarbushes in ways that reflect the less frequent, but more severe, wound-inflicting disturbance associated with harvesting operations. In the area within a harvested stand in northern New York that was near the log landing, 27 trees were found with sapstreak disease in 1985 (Fig. 20). All of these trees were immediately adjacent to skid

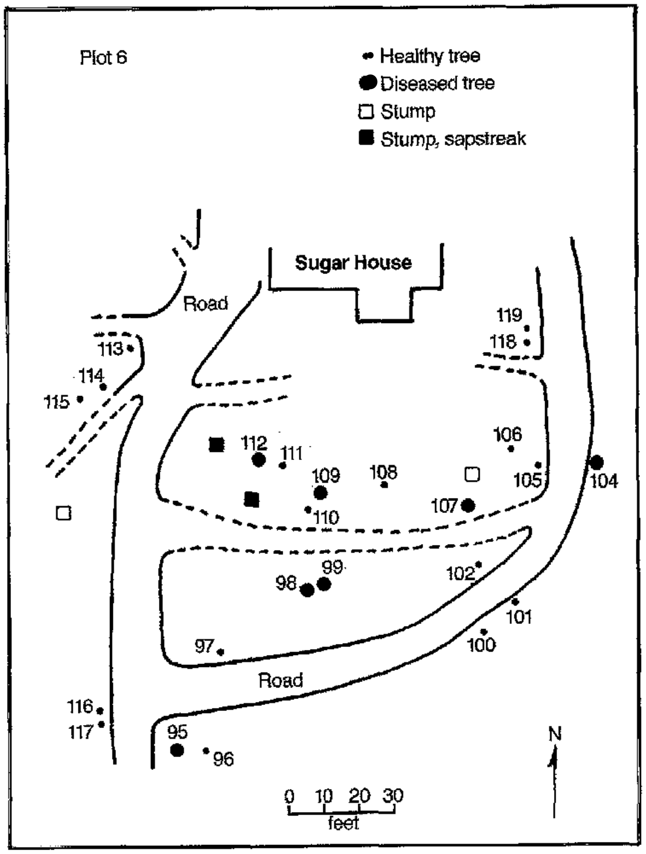

Figure 19.--Plot 6 in a New York sugarbush. Numbered trees (large solid circles) became diseased during the decade of observation (1980-1990).

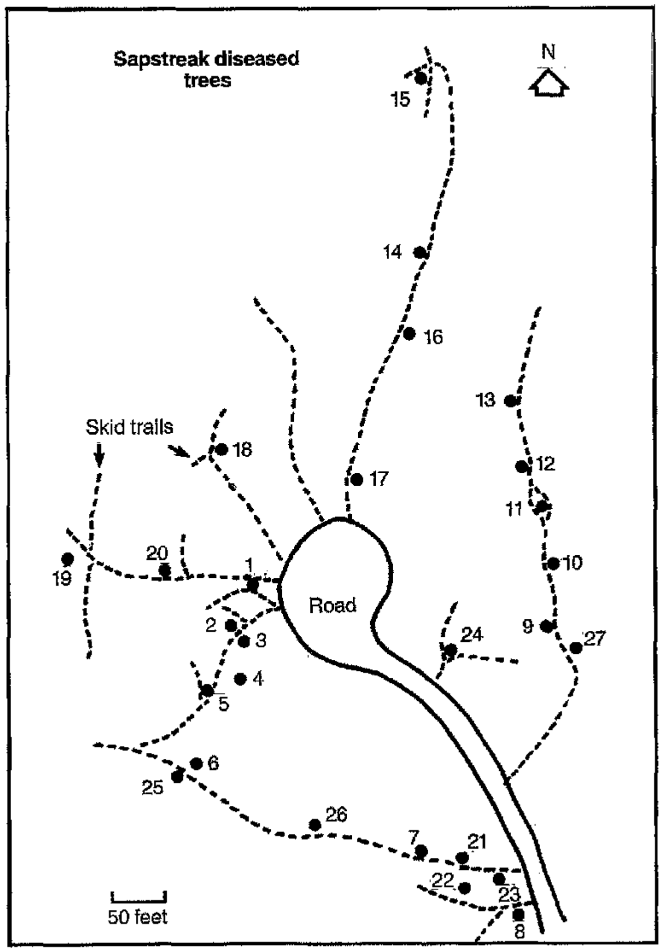

Figure 20.-- Locations of sapstreak diseased trees in a forest area in northern New York, a portion of which was logged in 1981.

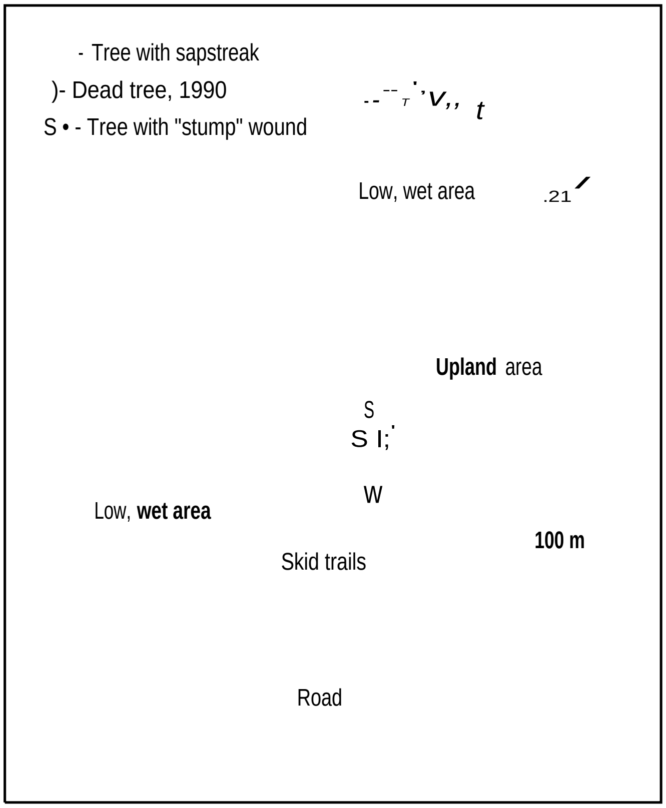

Figure 21.--Locations of sapstreak diseased trees in a 30-acre portion of a forest stand in northern New York. The stand was thinned in 1980. Trees not dead by 1990 are in remission and appear to have recovered

trails created when the stand was logged in early summer of 1981. This "flush" pattern, in which a large number of diseased trees occurs at one time (from infection of wounds during heavy skidding activity), is in contrast to the occasional infection of trees in some sugarbushes, in which annual, but less damaging, intrusions into the stand may result in new or repeated wounding of additional trees.

In forest stands, sapstreak diseased trees usually exhibit initial symptoms from 3 to 6 years after the injury-causing event. While the period over which diseased trees dies frequently is more protracted, the trees that are going to die will have done so within 6 to 8 years after they became infected.

In less heavily trafficked areas within forest stands, or in stands where fewer trees are being harvested, for example, in improvement cuts or light thinnings, fewer trees are apt to become injured and diseased (Fig. 21). In general, diseased trees often are concentrated in wet areas where roots are more severely damaged. Residual members of thinned sprout clumps occasionally are infected by the sapstreak fungus, apparently through the stump wounds created by the thinning (Figs. 10, 21).

The following relationships, gleaned from our observations and studies and from earlier work by others, are pivotal to the development of management guidelines to prevent or reduce losses from sapstreak disease in sugarbushes and forest stands.

• There is an almost universal association of wounds and the occurrence of sapstreak disease. The disease rarely occurs in nonwounded trees (see Forest Stands).

<u>Location</u>

Wounds of great importance are those near the ground--roots, buttress roots, and lower stems.

Wounds of little or no importance are those of branches and upper stems--branch stubs, pruning wounds, and tapholes.

<u>Causes</u>

Activities that result in wounds (in order of importance) include skidding logs, hauling sap and wood, building and maintaining roads, thinning sprout clumps, and trampling by cattle.

<u>Timing</u>

Wounds made during spring and early summer may be more important than those made at other times.

Wounded trees, on rare occasion, become diseased when the sapstreak pathogen invades their roots through functional root grafts with closely adjacent diseased trees.

Trees that die of sapstreak disease also almost always are invaded by root pathogens, especially *Armillaria* sp. and *Xylaria* sp.

These relationships are reflected in the following management options and guidelines for reducing losses from sapstreak disease in sugarbushes and forest stands,

Management Options and Guidelines to Reduce Losses from Sapstreak Disease

Sugarbushes

<u>Reduce infection courts</u>

• Avoid wounding of roots, buttress roots, and lower portions of the stem.

• Employ tubing collection systems when feasible.

• Use permanent access and haul roads.

• Avoid travel with heavy equipment during spring-early summer mud season and wet periods.

<u>Avoid creating other infection courts</u>

• When conducting thinnings or stand improvement operations either leave or take all members of sugar maple sprout clumps.

<u>Avoid susceptible period</u>

• Conduct thinnings, stand improvement operations, wood hauling, and other activities that may result in injuring trees, in late summer, fall, and winter when trees seem to be less susceptible to infection.

Avoid build-up of sapstreak disease inoculum

- Monitor sugarbush to detect diseased trees.
- Concentrate surveys to trees along roadways and near sugarhouse.
- Remove diseased trees promptly (see above for best periods).
- Avoid stacking infected wood near the sugarhouse. If possible, dry diseased wood in large open areas away from areas where trees are apt to be injured.

Reduce threat from mortality-associated root pathogens

- Ideally, establish sugarbush at early age to reduce the need to remove large trees in later thinnings and consequently reduce large stump food bases for root decay organisms.
- Monitor sugarbush to track populations of defoliating insects. When necessary, arrange to control outbreaks of insects whose effects will predispose trees to invasion by root pathogens.

Forest Stands

Reduce infection courts

- Avoid wounding roots, buttress roots, and lower portions of stems.
- Establish permanent skid trails and haul roads. If possible, use trees other than sugar maple as bumper trees.
- Schedule forest operations to avoid mud season or periods when soil is saturated and soft.
- For stands rich in sugar maple, schedule operations to avoid the late spring-early summer period when trees appear to be most susceptible.
- Don't thin sugar maple sprout clumps that are pole-sized or larger--leave them all or remove them all.

Reduce effects of associated root pathogens

- Monitor climatic factors such as open, cold winters; drought; late spring frosts; and biotic factors such as insect defoliator outbreaks known to predispose trees to root pathogens.
- When possible, schedule forestry operations to avoid conducting them during, or soon after, stress events.

Reduce inoculum and losses

- Revisit stands 4 to 5 years after logging operations to monitor the occurrence of sapstreak.
- Focus surveys on trees adjacent to skid trails or landings, and especially on those trees with basal skidding injuries.
- If feasible, remove diseased trees taking care not to create additional new injuries. (See infection courts above).

Literature Cited

Beil, J. A. ; Kessler, K. J., Jr. 1979. **Sapstreak disease of sugar maple found in New York State.** Plant Disease Reporter. 63: 436.

Hepting, G.H. 1944. **Sapstreak, a new killing disease of sugar maple.** Phytopathology. 34: 1069-1076.

Houston, D.R. 1985. **Sapstreak of sugar maple: How serious is it?** Maple Syrup Digest. 25(2): 24-27.

Houston, D.R. 1986. **Sapstreak of sugar maple: appearance of lumber from diseased trees and longevity of *Ceratocystis coerulescens* in air-dried lumber.** Phytopathology. 76: 653. Abstract.

Houston, D.R. 1991. **Spread of the sugar maple sapstreak disease pathogen, *Ceratocystis coerulescens,* via root grafts between *Acer saccharum.*** Phytopathology. 81: 122. Abstract.

Houston, D.R. 1992. **Importance of buttress root and taphole wounds as infection courts for the sugar maple *(Acer saccharum)* sapstreak pathogen, *Ceratocystis coerulescens.*** Phytopathology. 82: 244. Abstract.

Houston, D.R.; Fisher, K.D. 1964. **Sapstreak of sugar maple found in the northeast.** Plant Disease Reporter. 48: 788.

Houston, D.R.; Schneider, B. 1982. **Sapstreak disease of sugar maple in N.Y. sugarbushes.** Phytopathology. 72: 262. Abstract.

Kessler, K., Jr. 1972. **Sapstreak disease of sugar maple found in Wisconsin for the first time.** Res. Note NC-140. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 2 p.

Kessler, K., Jr. 1978. **How to control sapstreak disease of sugar maple.** St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 5 p.

Kessler, K., Jr.; Anderson, R.L. 1960. ***Ceratocystis coerulescens* on sugar maple in the Lake States.** Plant Disease Reporter. 44: 348-350.

Meilke, M.E.; Charette, D.A. 1989. **The incidence of sapstreak disease of sugar maple in Menominee County, Wisconsin, and its relationship to wounds and season of logging,** Northern Journal of Applied Forestry. 6: 65-67.

Ohman, J.H.; Kessler, K.J., Jr. 1963. **Current status of the sapstreak disease of sugar maple in the Lake States.** Res. Note LS-10. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Lake States Forest Experiment Station. 4 p.

Shigo, A.L. 1962. **Observations on the succession of fungi on hardwood pulpwood bolts.** Plant Disease Reporter. 46: 379-380.

Shigo, A.L. 1977. **Compartmentalization of decay in trees.** Agric. Inf. Bull. No. 405. Washington, DC: U.S. Department of Agriculture, Forest Service. 73 p.

Shigo, A.L. 1979. **Tree decay: an expanded concept.** Agric. Inf. Bull. No. 419. Washington, DC: U.S. Department of Agriculture, Forest Service. 73 p.

Shigo, Al.; Shigo, A. 1974. **Detection of discoloration and decay in living trees and utility poles.** Res. Pap. NE-294. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 11 p.

Tattar, T.A.; Shigo, Al.; Chase, T. 1972. **Relationship between the degree of resistance to pulsed electric current in wood in progressive stages of discoloration and decay in living trees.** Canadian Journal of Forest Research. 2: 236-243.

Wargo. P.M.; Shaw, C.G., III. 1985. **Armillaria root rot. The puzzle is being solved.** Plant Disease. 69: 826-832.

Houston, David R. 1993. **Recognizing and managing sapstreak disease of sugar maple.** Res. Pap. NE-675. Radnor, PA: U.S. Department Agriculture,Forest Service, Northeastern Forest Experiment Station. 11 p.

Sapstreak disease, a potentially serious problem of sugarbushes and forest stands, occurs when the causal fungus, *Ceratocystis virescens,* invades the sapwood of roots and bases of stems through wounds inflicted during logging, saphauling, or other activities. Describes how to recognize the disease, the factors that affect its occurrence and development, and management approaches to help reduce its effects.

Keywords: *Ceratocystis virescens,* root and buttress-root wounds, vascular disease, sugarbush, forest management.

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