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Deterioration Rates of Blowndown Timber and Potential Problems Associated With Product Recovery

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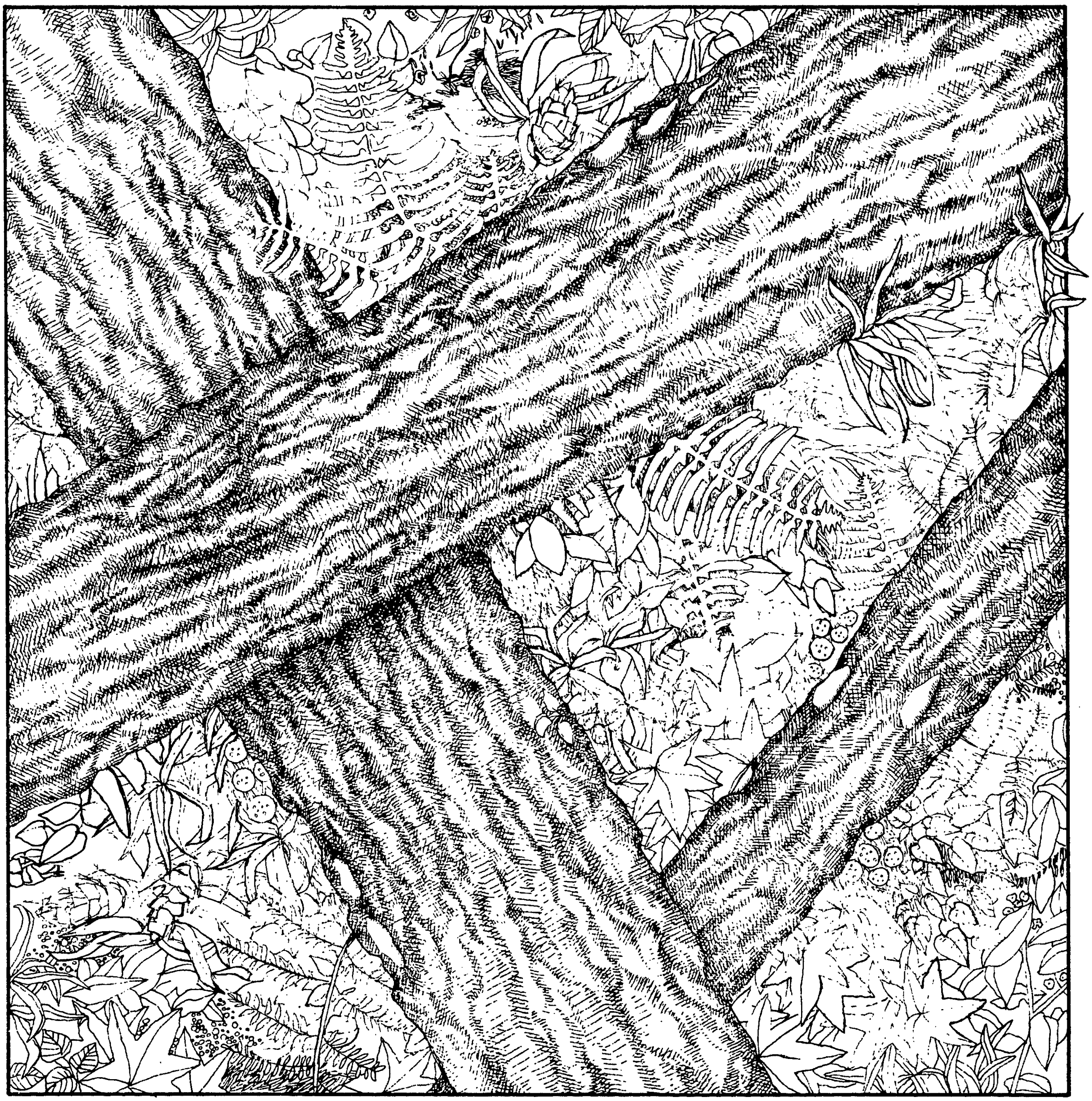

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Abstract

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This paper summarizes published reports of deterioration and product recovery studies conducted on dead timber. Decay rates experienced in blowndown timber are presented for western redcedar (***Thuja plicata*** Donn ex D. Don), Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), western hemlock ***(Tsuga heterophylla*** (Raf.) Sarg.), and Pacific silver fir ***(Abies amabilis*** (Dougl.) ex Forbes). Results from product recovery studies conducted on insect-killed western white pine (*Pinus monticola* Dougl. ex D. Don), grand fir ***(Abies grandis*** (Dougl. ex D. Don) Lindl.), Engelmann spruce ***(Picea engelmannii*** Parry ex Engelm.), and insect-damaged Douglas-fir are also presented.

Keywords: Blowdowns, decay (wood), deterioration (wood), dead timber, salvage timber, lumber recovery, lumber value.

Summary

The Pacific Northwest periodically experiences catastrophic events that kill large volumes of timber over extensive areas. One such event occurred on May 18, 1980, when Mount St. Helens erupted in southwest Washington, killing an estimated 2 billion board feet of commercial timber. Salvaging dead timber may require several years; hence, resource managers need information on deterioration rates and product recovery to help plan salvage operations. This paper summarizes published results of deterioration and product recovery studies conducted on dead timber.

In general, sapwood of all coniferous species deteriorates at about the same rate and faster than heartwood deteriorates. Second-growth trees and trees with greater sapwood-to-heartwood ratios such as western hemlock (Tsuga *heterophylla* (Raf.) Sarg.) and Pacific silver fir (Abies *amabilis* (Dougl.) ex Forbes) deteriorate fastest. The major difference in rate of decay occurs in the heartwood. Heartwood of western hemlock and Pacific silver fir deteriorates fastest, followed by that of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), and then western redcedar (Thuja *plicata* Donn ex D. Don).

Conditions resulting from or existing prior to the eruption of Mount St. Helens may cause deterioration rates to be slower than usual. These conditions include: (1) reduction of fungal inocula, (2) lack of vegetative cover, and (3) high moisture content of the sap during the time of the eruption.

Volume and grade recovery of products manufactured from dead timber can be affected by the presence of sapwood decay, stains, weather checks, and insect borer damage. Timber blown down by the eruption of Mount St. Helens may also suffer from compression failures. The amount of degrade resulting from these defects is influenced by the type of end products to be manufactured from the timber. In general, grading rules used for high quality lumber and veneer are less tolerant of defects than are low quality grades.

Published results of product recovery studies on dead timber have shown that Scribner log scale deductions for weather checks in dead timber can be excessive. Such deductions result in low net scale estimates and create confusion regarding the product potential of dead timber.

Maximum timber volume can be salvaged from recently damaged trees by first cutting small, young-growth trees, then mature hemlock and silver fir, followed by Douglas-fir, and finally, western redcedar. Salvaging high quality, mature stands first may result in greater economic gains than cutting young stands that will decay more rapidly.

Introduction

The May 18, 1980, eruption of Mount St. Helens killed an estimated 2 billion board feet of old-growth and second-growth commercial timber on public and private forest lands in southwestern Washington. Douglas-fir *(Pseudotsuga* rnenziesii (Mirb.) Franco), western hemlock (Tsuga *heterophylla* (Raf.) Sarg.), Pacific silver fir (Abies *amabilis* (Dougl.) ex Forbes), and western redcedar *(Thuja plicata* Donn ex D. Don) are the major commercial species in the blast-damage area. Large amounts of this timber are thought to be salvageable, but harvesting this resource may be interrupted or prevented for many years by intermittent volcanic activity.

The purpose of this paper is to present decay rates published on blowndown timber for the commercial softwood species in western Oregon and Washington. Also, several product recovery studies conducted on insect-killed timber are reviewed to point out problems associated with utilizing dead timber. Although the information is intended to help resource managers plan salvage operations on Mount St. Helens, it would also be useful when considering windthrow and other catastrophic events that occur periodically in the Pacific Northwest.

Factors Affecting Rate of Decay

Factors that influence the growth and development of wood decay fungi or host-resistance to fungal attack determine the rate of wood decay. These factors have been reviewed by Aho (1974) and will be discussed here. In general, the decay process is regulated by temperature, moisture, oxygen, and environmental conditions that influence these factors.

Wood dried to less than 20-percent moisture content is unsuitable for most decay fungi. Soil type can influence humidity around downed timber and affect its moisture content, particularly when in contact with the ground. For instance, sandy and pumice soils are usually dry on the surface and may have less groundcover that provides shade. Wood in contact with these soils dries quickly, retarding decay. Clay-type soils generally retain moisture and have dense vegetation. Yet increased moisture content of woody material in contact with these soils may reduce the availability of oxygen for fungi, which may also retard decay.

Elevation influences decay of forest residues in several ways. Precipitation — much of it snow — increases with elevation, the sun's rays have a stronger effect at higher elevations, and day and night temperatures are more extreme. In general, temperatures throughout the year at higher elevations are cooler than at lower elevations; thus, there are fewer days at higher elevations when temperatures are optimal for decay. Cartwright and Findlay (1958) found that optimum growing temperatures for most decay fungi ranged between 27 and 33 °C. Where snow remains on the ground until early summer, both temperature and moisture conditions are unfavorable for decay most of the year. On dry, south and west slopes at higher elevations, the stronger effect of the sun promotes rapid drying of the surface and residues, resulting in weathering of exposed wood. Generally, slopes with northwest, north, and northeast aspects are cooler and wetter than others, but their condition may be modified by degree of slope. Steep slopes receive less direct solar insulation, thus surfaces of the soil and residue are cooler and more moist. Steep slopes, however, may be drier, resulting from rapid runoff of surface precipitation and subsurface water. Soils are often thinner, rockier, and thus drier. Russell (1983) noted that deterioration rates were affected by shading and whether or not the trees were uprooted when blown down. He found slower decay rates than expected in western hemlock and Pacific silver fir because trees shaded or not uprooted contained excessive moisture.

Differences in natural resistance to decay has been noted among various tree genera and even among species within a genus. In western Washington, western redcedar deteriorates slowest followed by Douglas-fir, and finally, Pacific silver fir and western hemlock which decay at about the same rate. Regardless of species, sapwood generally decays faster than heartwood. Small logs deteriorate faster than large logs, and top logs faster than logs lower in a tree. This is mainly because large logs and butt logs have smaller ratios of sapwood to heartwood than do small or top logs. Large and butt logs, especially from certain tree species such as Douglas-fir, have thicker bark, which retards drying of the sapwood. The high moisture content slows the decay rate. Small and top logs with thinner bark and greater surface-to-volume ratios dry faster, allowing decay to develop sooner. On dry sites at higher elevations, however, decay of top logs is impeded because they become too dry.

The rate of deterioriation of woody material is closely related to insect activity. Insects serve as vectors of fungi and create infection courts. The general pattern of deterioration begins with attacks by bark beetles and ambrosia beetles, which are vectors of staining and sapwood-destroying fungi. Staining fungi are usually confined to sapwood where they utilize the contents of parenchyma cells in wood rays. Decay fungi rapidly spread through and deterioriate the sapwood. Fungi capable of decaying heartwood, the most damaging being *Fomitopsis pinicola,* then become established. Wood borers, which penetrate deep into logs, may act as vectors of heartwood-rotting fungi and create favorable conditions for rapid spread of decay. Insect activity can also retard the rate of decay. On dry sites, severe bark beetle attacks cause the bark to slough off, resulting in drying and weathering of the exposed sapwood.

Unique conditions resulting from the volcanic blast at Mount St. Helens will undoubtedly influence the rate of deterioration of the killed timber. Because studies have not been previously made under such conditions, we can only speculate how the conditions will affect deterioration. Reduced fungal inocula and insect populations, excessive heat from the blast, deep ash cover, and lack of ,vegetation cover over the exposed dead timber will all probably slow the deterioration rate.

The time of the year that the damage occurred may also have an important effect on deterioration of the timber blown down by the volcanic eruption. Damage occurred in the spring (May) when sap was flowing in the trees. The moisture content of the sapwood was probably high, high enough to retard decay development at least during the first year after blowdown. This effect may be longer lasting for old-growth trees of all species and for species with thick bark.

Deterioration Rate by Tree Species

Table 1 lists key studies conducted in the Pacific Northwest on deterioration of windthrown or felled Douglas-fir, western hemlock, Pacific silver fir, and western redcedar. This list is a useful index of the literature available on rates of deterioration following blowdown in the Pacific Northwest.

General conclusions drawn from these studies are: (1) some cull or degrade losses will occur almost immediately after trees are windthrown or otherwise felled; (2) deterioration will vary considerably among trees or localities, depending on the immediate environment; (3) sapwood of these conifers deteriorate at about the same rate but more rapidly than heartwood; (4) major differences in the rate of decay occur in the heartwood; and (5) heartwood of western hemlock and Pacific silver fir deteriorate at about the same rate, but more rapidly than Douglas-fir and much more rapidly than western redcedar.

Table 1—Studies conducted on windthrown or felled trees in the Pacific Northwest

Study leader and year results published	Location of areas sampled [1]	Species	Age of trees	Number of trees examined	Number of years since blowdown
Boyce (1929)	Olympic Peninsula, WA	Douglas-fir	Old growth	112	5
		Western hemlock	Old growth	40	5
		Pacific silver fir	Old growth	29	5
		Western redcedar	Old growth	29	5
		Sitka spruce	Old growth	53	5
Buchanan and Englerth (1940)	Olympic Peninsula, WA	Douglas-fir	Old growth	246	5, 8, 15
		Western hemlock	Old growth	163	5, 8
		Pacific silver fir	Old growth	100	5
		Western redcedar	Old growth	49	5
		Sitka spruce	Old growth	254	5, 8, 15
Childs and Clark (1953)	Olympic Peninsula, WA	Douglas-fir	Old growth	68	5½
	Cascade Range, OR	Douglas-fir	Old growth	127	6⅓, 9+
	Olympic Peninsula, WA	Western hemlock	Old growth	46	5½
	Cascade Range, OR	Western hemlock	Old growth	49	6⅓, 9+
	Coast Ranges, OR	Western hemlock	Old growth	66	2½, 5½
	Olympic Peninsula, WA	Pacific silver fir	Old growth	18	5½
	Coast Ranges, OR	Pacific silver fir	Old growth	57	2½, 5½
	Coast Ranges, OR	Sitka spruce	Old growth	89	2½, 5½
Roff and Eades (1959)	Vancouver Island, BC	Western hemlock	Understory	[2]	2, 3, 4
	Queen Charlotte Island, BC	Western hemlock	Understory	[2]	2, 3, 5
	Vancouver Island, BC	Pacific silver fir	Understory	[2]	2, 3, 4
	Queen Charlotte Island, BC	Sitka spruce	Understory	[2]	2, 3, 5
Russell (1983)	Olympic Peninsula, WA	Western hemlock	Old growth	105	2⅔
		Pacific silver fir	Old growth	24	2⅔
Shea and Johnson (1962)	Cascade Range, southwest WA	Douglas-fir	Old growth	[3]	3
	Cascade Range, southwest WA	Douglas-fir	Second growth	[3]	3
	Cascade Range, southwest WA	Western hemlock	Old growth	[3]	3
	Cascade Range, southwest WA	Western hemlock	Young growth	[3]	3
	Cascade Range, southwest WA	Pacific silver fir	Old growth	[3]	3
	Cascade Range, southwest WA	Pacific silver fir	Young growth	[3]	3
Smith, Craig, and Chu (1970)	Vancouver Island, BC	Douglas-fir	Second growth	150	[4] 2, 4, 6

[1] WA = Washington, OR = Oregon, BC = British Columbia.
[2] Study was conducted on pieces of logging slash.
[3] A total of 48 trees were sampled; no breakdown available on species or age class.
[4] Trees were felled and bucked.

Percentages of decay were plotted over tree d.b.h. or log diameter for western redcedar, Douglas-fir, western hemlock, and Pacific silver fir (figs. 1-6). Curves were generated by regression analysis using data published on deterioration of windthrown conifers in western Washington and Oregon (Buchanan and Englerth 1940, Childs and Clark 1953). The two studies included a wide range of environmental conditons and serve to approximate the magnitude of decay in trees killed by the eruption of Mount St. Helens. Tables in the published reports present the average percentage of decay calculated on a cubic-foot basis for each tree d.b.h. or average log diameter class. The number of observations in any d.b.h. or log diameter class was used as a weighting factor in our regressions.

Western Redcedar

Sapwood of western redcedar decays as rapidly as sapwood of other tree species, but the decay essentially stops at the heartwood. Figure 1 shows decay had not gone beyond the percentage of sapwood 5 years after windthrow in the Olympic Mountains (Buchanan and Englerth 1940). Although data were not collected after 5 years, the authors noted the heartwood of western redcedar remained sound for decades after windthrow. Childs and Clark (1953) made similar observations.

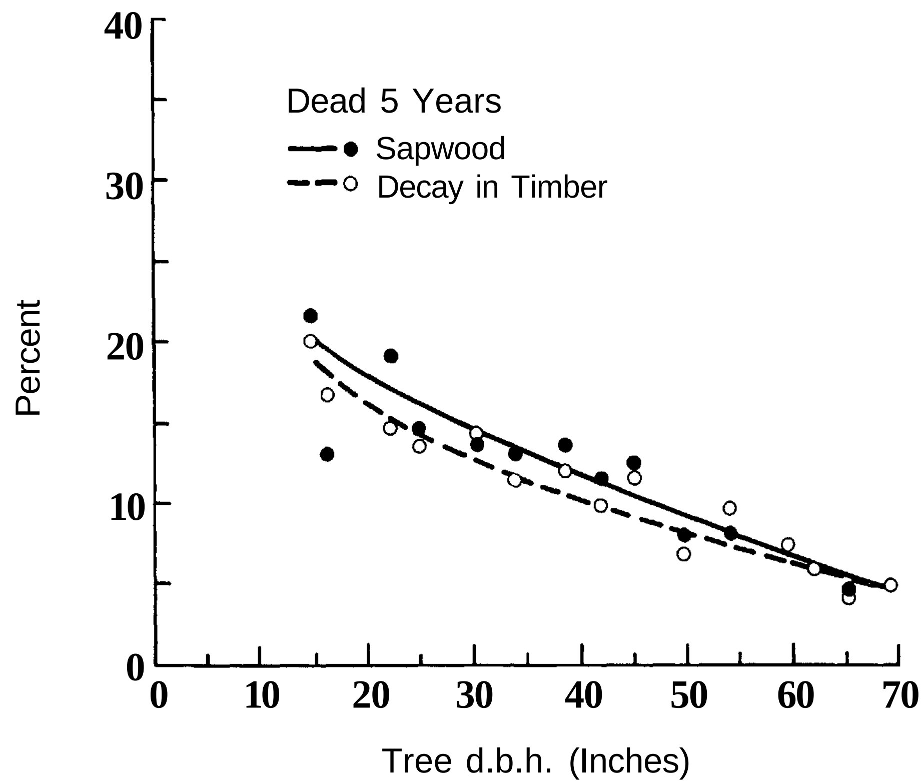

Figure 1.—Percent sapwood and percent decay of windthrown western redcedar plotted through tree d.b.h. (Data from table 7 of Buchanan and Englerth (1940).) Regression equations are:

$$\text{Percent sapwood} = 19.40 - 0.23\,\text{d.b.h.} + \frac{62.2}{\text{d.b.h.}};$$

$$\text{Percent decay} = 13.32 - 0.15\,\text{d.b.h} + \frac{118.0}{\text{d.b.h.}}.$$

Douglas-Fir

Generally, Douglas-fir decays more rapidly than western redcedar because it has a greater percentage of sapwood and the heartwood is less durable. Figures 2 and 3 show the relationship between percentage of decay and log diameter (small-end scaling diameter) for data from Buchanan and Englerth and from Childs and Clark, respectively. These figures show that smaller logs have large amounts of decay 5 years after windthrow and almost complete decay by 15 years. On the other hand, logs greater than 50 inches end diameter remain sound considerably longer, with approximately 25 percent decay after 15 years.

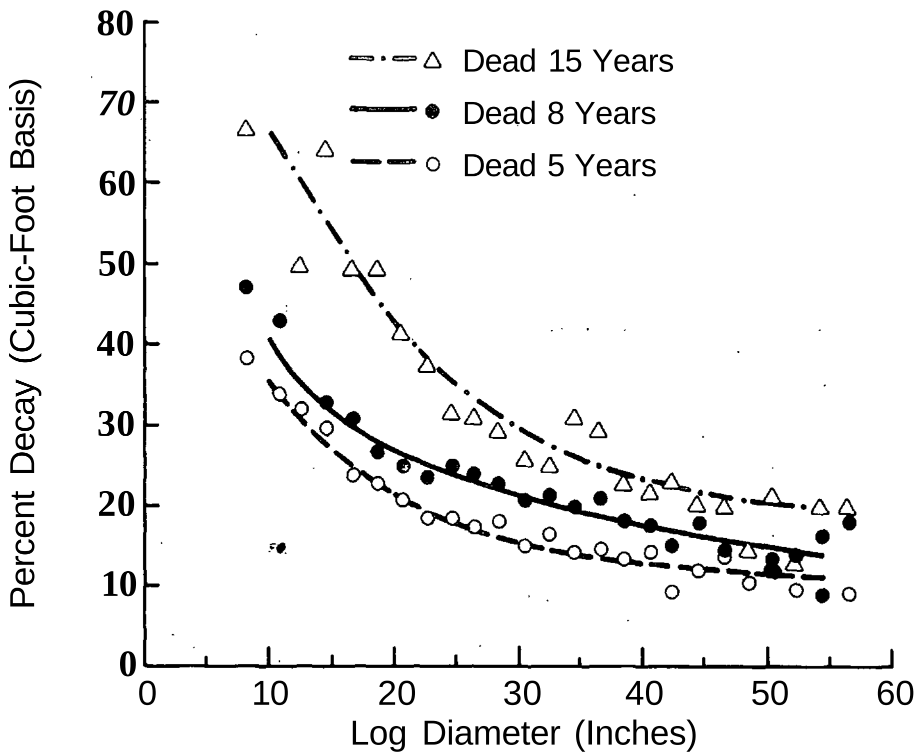

Figure 2. Percent decay of windthrown Douglas-fir plotted through log diameter. (Data from table 2 of Buchanan and Engierth (1940).) Regression equations are:

Dead 5 years: Percent decay $= -6.14 + 0.13d + \frac{600.7}{d} - \frac{2008.6}{d^2}$.

Dead 8 years: Percent decay $= 22.7 - 0.22d + \frac{133.1}{d} + \frac{655.7}{d^2}$.

Dead 15 years: Percent decay $= -22.8 + 0.31d + \frac{1504.5}{d} - \frac{6461.1}{d^2}$.

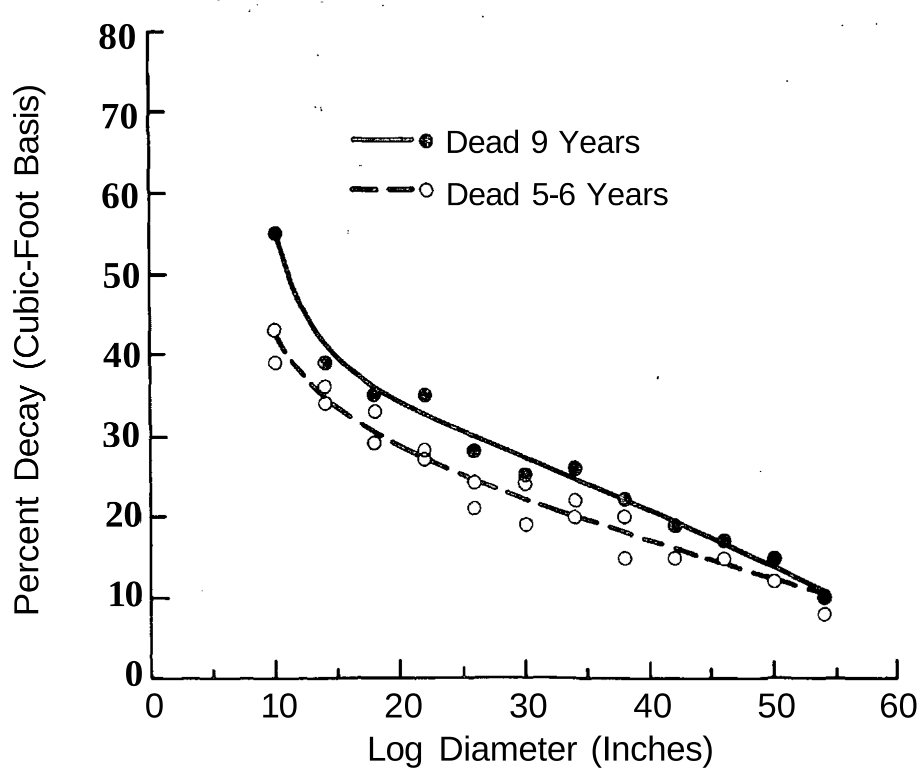

Figure 3.—Percent decay of windthrown Douglas-fir plotted through log diameter. (Data from table 2 of Childs and Clark (1953).) Regression equations are:

Dead 5-6 years: Percent decay $= 35.0 - 0.46d - \frac{6.28}{d} + \frac{1266.8}{d^2}$.

Dead 9 years: Percent decay $= 64.5 - 0.83d - \frac{554.6}{d} + \frac{5383.2}{d^2}$.

The percentages of decay for timber dead 5 years were pooled from both studies and regressed over log diameter (fig. 4). The average percentages of decay shown cover a wide range of environmental conditions and represent over 800 logs examined for the presence and extent of sap decay.

Western Hemlock

Western hemlock has more sapwood and less durable heartwood, consequently it decays faster than Douglas-fir or western redcedar. Figure 5 shows the percentage of decay plotted over log diameter for data from Childs and Clark. To illustrate the effect of geographic areas on decay rates, separate curves are shown for each area sampled during their study. The percentage of decay measured on trees dead 5½ years on the Oregon coast (Necanicum area) had almost the same amount of decay as trees dead over 9 years in the Cascade Range of Oregon (Cedar Creek area). Childs and Clark concluded there would be little merchantable volume remaining in even the largest hemlock logs 15 years after windthrow. Buchanan and Englerth reported similar decay rates for western hemlock in the Olympic Mountains of Washington.

Pacific Silver Fir

Pacific silver fir has about the same amount of sapwood and durability as western hemlock, hence the decay rates were similar. Figure 6 is based on data from Childs and Clark and illustrates the difference between sample areas. As with hemlock, percentages of decay for the Necanicum area were high. Only a single curve was fitted to the diameter class averages because the data from Quilcene was limited to logs less than 26 inches end diameter. Average decay 5½ years after windthrow ranged from approximately 80 to 90 percent for 10- to 18-inch logs and from 60 to 65 percent for 38- to 42-inch logs.

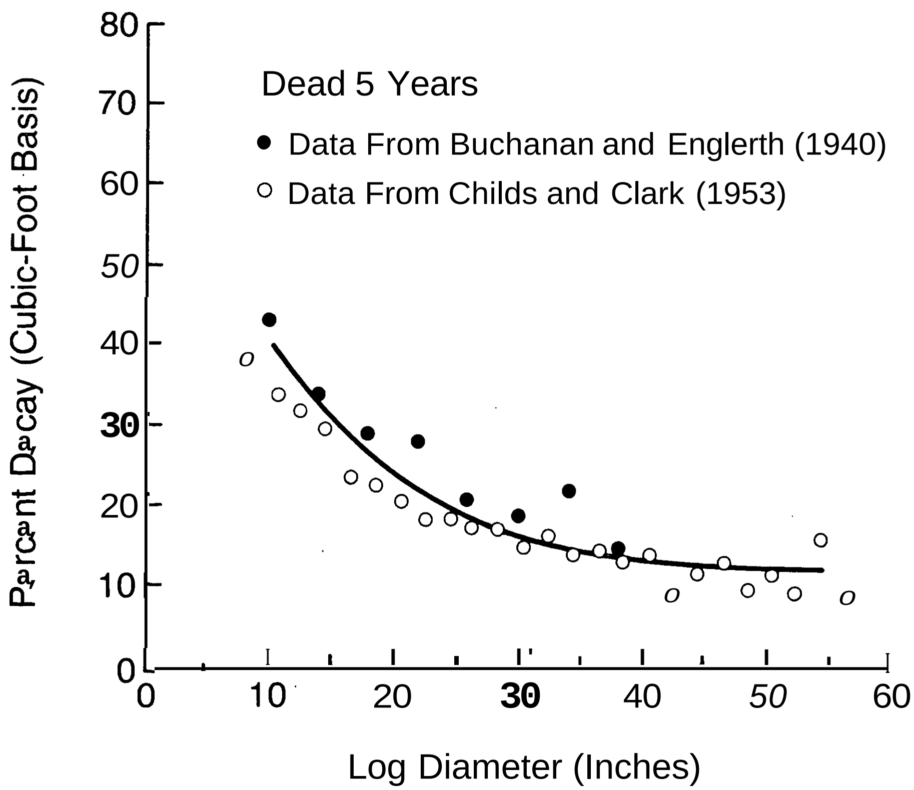

Figure 4.—Percent decay of windthrown Douglas-fir plotted through log diameter. (Data is from table 2 of Buchanan and Englerth (1940) and table 2 of Childs and Clark (1953).) Regression equation is:

$$\text{Percent decay} = -21.17 + 0.32d + \frac{974.11}{d} - \frac{3932.7}{d^2}$$

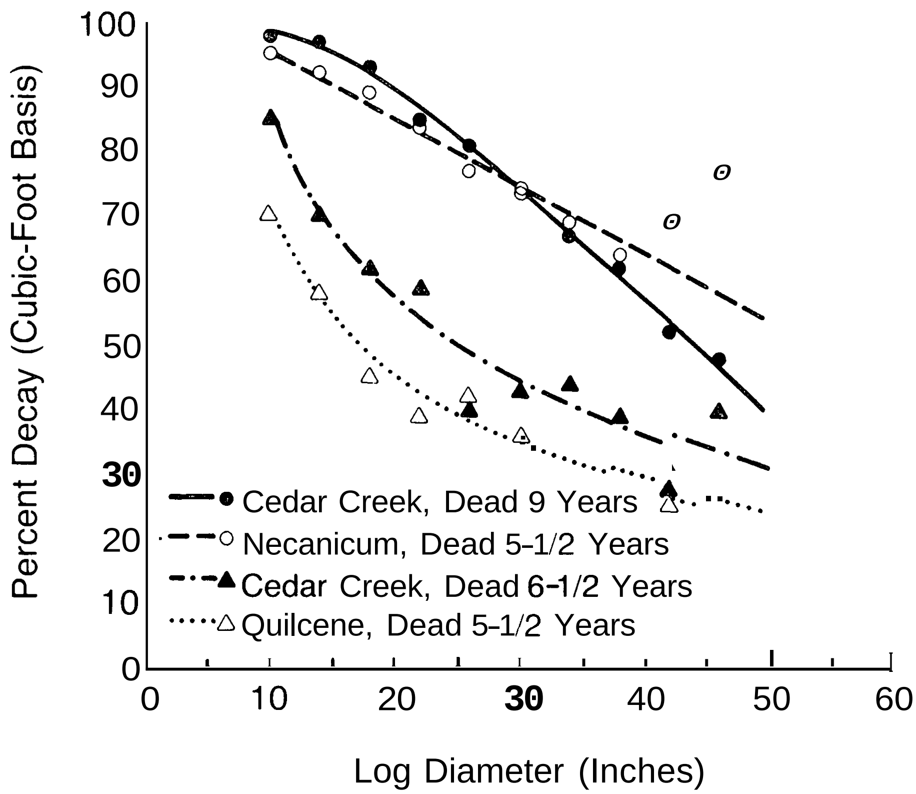

Figure 5.—Percent decay of windthrown western hemlock plotted through log diameter. (Data from table 4 of Childs and Clark (1953).) Regression equations are:

Cedar Creek, dead 9 years: Percent decay $= 136.5 - 1.86d - \frac{195.2}{d}$;

Necanicum, dead 5½ years: Percent decay $= 106.0 - 1.04d$;

Cedar Creek, dead *6%* years: Percent decay $= 42.6 - 0.45d + \frac{473.1}{d}$;

Quilcene, dead 5% years: Percent decay $= 25.8 - 0.22d + \frac{478.1}{d}$.

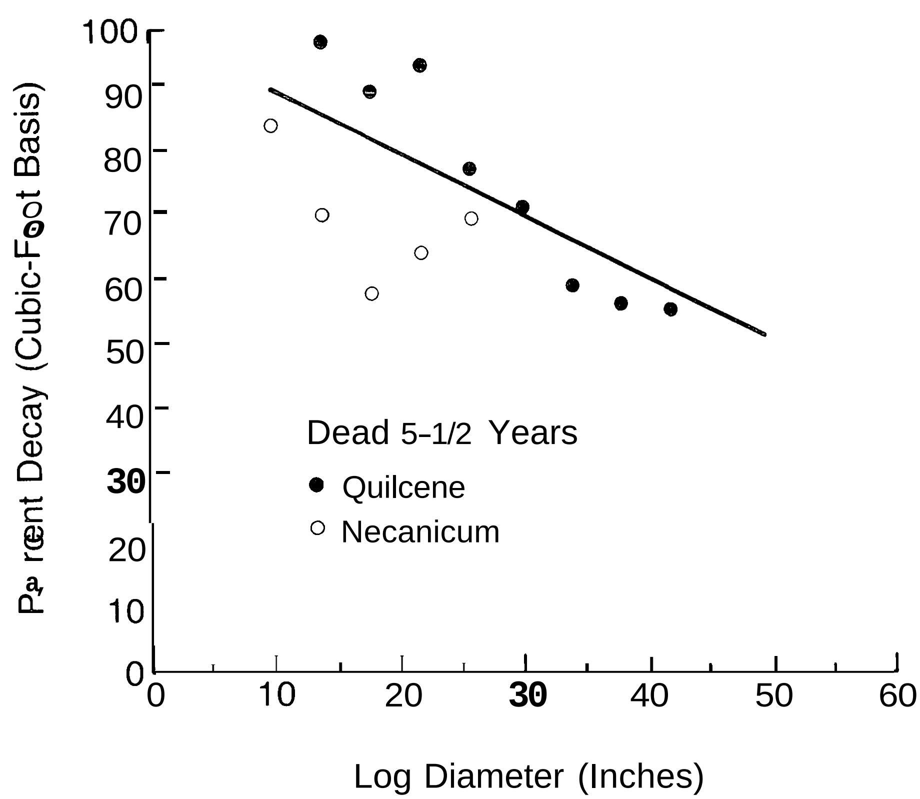

Figure 6.—Percent decay of windthrown Pacific silver fir plotted through log diameter. (Data from table 5 of Childsand Clark (1953).) Regression equation is:

Percent decay $= 100.2 - 0.97d$

Product Recovery From Dead Timber

Defects such as sap decay, stains, weather checks, and holes made by insect borers may cause product degrade and loss in product volume. Results published from several product recovery studies on dead timber follow. Although results of these studies may not be directly applicable to the blowndown timber near Mount St. Helens, a general understanding of the findings should help resource managers minimize losses.

A comparison of log values per gross cubic foot between logs cut from green trees and logs cut from standing dead trees provides an estimate of the magnitude of dollar losses. The values in this case are derived from the actual value of the products manufactured. Table 2 shows the average percent loss in dollars per cubic foot for timber in various conditions.

Table 2—Average percent loss in dollars per cubic foot from dead softwood timber

Species and location	Condition of dead timber	Product manufactured	Percent loss in value
True fir (eastern Oregon)	Dead 0-2 years	2-inch lumber	24
White pine (Idaho)	Dead 0-2 years	1-inch lumber	26
	Dead 3-6 years	1-inch lumber	41
	Dead 7 + years	1-inch lumber	64
Engelmann spruce (Colorado)	Dead 20 + years	2-inch lumber	39
Douglas-fir (Vancouver Island, BC)	Decked 6 months	1-and 2-inch lumber	3
Western hemlock (Vancouver Island, BC)	Decked 6 months	1- and 2-inch lumber	6

Sources: Snellgrove and Fahey (1977), Snellgrove and Cahill (1980), Cahill (1980), and Dobie (1978).

Product Degrade and Volume Loss

Logs processed in a grand fir *(Abies grandis* (Dougl. ex D. Don) Lindl.) study (Snellgrove and Fahey 1977) were cut from Oregon timber killed by tussock moths during an outbreak in the Blue Mountains of Oregon and Washington. There was little sap decay present in the timber; however, weather checks present in the logs showed up as splits in the finished lumber. Splits often cause lumber degrade from Standard-and-Better to Utility and Economy grades. Stains did not contribute to loss in value; there was little stain present in the logs and it is not a grading factor in structural lumber grades.

Lack of stain in the grand fir study contrasts with a white pine (*Pinus monticola* Dougl. ex D. Don) study (Snellgrove and Cahill 1980) in which blue stain was a major factor in loss of value. White pine trees killed by a combination of blister rust and mountain pine beetles were processed in a mill producing Shop and Board items. In these products, for which appearance is important, stains caused the lumber to drop from the Shop, 1 & 2 Common grades to 3, 4, and 5 Common. The 64-percent loss in the older dead pine shows the combined effect of stain, checking, sap decay, and damage from insect borers.

An Engelmann spruce *(Picea engelmannii* Parry ex Engelm.) study (Cahill 1980) was conducted on trees killed over 20 years ago by an epidemic of the Engelmann spruce beetle in western Colorado. The 39-percent loss in the value of dead spruce was largely the result of weather checks. The harsh climate of the Colorado Rocky Mountains tended to reduce the incidence of sap decay in the logs but caused severe weather checking.

A recovery study conducted by Dobie (1978) examined dollar loss in high quality Douglas-fir and western hemlock from Vancouver Island, B.C., caused by the presence of ambrosia beetles. Ambrosia beetles burrow into the sapwood of downed logs, causing small pinholes that degrade Select and Shop lumber items. His data showed that moderate amounts of beetle attacks (15 to 50 holes per square foot) caused C Clear and Better lumber to drop to D Clear, resulting in a 3- and 6-percent loss in value for Douglas-fir and western hemlock, respectively.

Scaling Problems

A problem common to all utilization studies of dead timber results from estimating net Scribner scale for dead logs. Previous studies (Snellgrove and Cahill 1980, Cahill 1980) have shown that Scribner deductions for weather checks are excessive. Many dead logs containing weather checks are considered culls by Scribner scaling rules, yet they recover substantial amounts of lumber. This causes erroneous estimates in overrun and increases the difficulty of appraising dead timber.

Alternative measures of net scale, such as "net equivalents" (Combes 1978), have been used by the USDA Forest Service in some areas to help reduce appraisal problems.

Setting Priorities for Salvage Operations

Other Utilization Problems

An additional problem in utilization may result from the presence of compression failures, sometimes known as timber breaks, which are caused by the compression of wood fibers during extreme flexure. Compression failures show up as thin lines in lumber and severely weaken structural lumber. Structural lumber with compression failures can be downgraded to Utility and Economy grades. This defect has little or no effect on the Select, Shop, and Board grades if the appearance of the piece is not impaired. The extent of this problem in the blowdown timber near Mount St. Helens is not known, but historical evidence from windstorms suggests an increase in the occurrence of timber breaks.

Snellgrove and others (1982) found the volume lost to breakage in the blast zone of Mount St. Helens was typical of that found in normal clearcutting operations, but that log segments shorter than used in normal industrial practices might be more frequent, especially on steep terrain. Shorter segments could be a problem at a stud or veneer mill where losses would occur when cutting to multiples of 8 feet.

The presence of ash and dirt in crevices and checks in Mount St. Helens timber may cause increased wear on saws. Initial concerns about rocks and ash penetrating the wood were unfounded (Snellgrove and others 1982). An analysis made by the Forest Products Laboratory on several wood specimens cut from downed logs supported on-the-ground observations of Snellgrove and others (1982).

Catastrophic events, such as the May 18, 1980, eruption of Mount St. Helens, that kill timber over extensive areas create many problems for resource managers. One immediate concern is the planning of salvage operations that usually span several years. The following points, taken from our review of deterioration and product recovery studies, should help resource managers set logging priorities that will maximize the value of damaged timber.

Age and Species of Timber

Young-growth timber contains a greater percentage of sapwood than old-growth and, hence, will deteriorate faster. This is common knowledge in the timber industry and is well documented in the literature. Past research shows that western hemlock, and Pacific silver fir deteriorate fastest, followed by Douglas-fir, then western redcedar.

Geographic Location

The rate of decay can vary depending on the immediate environment around the dead timber. Soil type, elevation, aspect, temperature, precipitation, insect activity, and the amount of shading can sffect the rate of decay in dead timber. As a general rule, Wright and others (1967) found that decay of beetle-killed Douglas-fir was greater in the Cascade Mountains of Oregon and Washington than in the Coast Ranges. They also noted the rate of decay in the southern part of the Douglas-fir subregion was greater than in the north.

End Products

It is important for the resource manager to recognize that dollar losses in lumber and veneer manufactured from dead timber is caused by a combination of product degrade and loss in product volume. Both factors can be important if the salvage area contains old-growth and young-growth timber. Ambrosia beetles can infest dead timber within 2-3 years after blowdown, causing degrade of the high-valued outer portion of old-growth logs. Beetle damage in young-growth timber does not cause the same magnitude of degrade because the primary products are structural grades of lumber and veneer.

Putting these facts together to form rigid recommendations for salvaging dead timber would be a mistake. Each salvage operation has a variety of economic, biological, and practical considerations that make each situation unique. This compilation of key findings from the literature should help provide resource managers with the information needed to set logging priorities that fit their own situation.

Metric Equivalents

1 inch = 2.54 centimeters
1 foot = 0.304 8 meter
1 cubic foot = 0.028 32 cubic meter
5/9(°F-32) = °C

Literature Cited

Aho, Paul E. Decay. In: Environmental effects of forest residues management in the Pacific Northwest—a state-of-knowledge compendium. Gen. Tech. Rep. PNW-24. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; **1974:** Q-1 to Q-17.

Boyce, J. S. Losses in windthrown timber. The Timberman. 28(10): 2-8; **1927.**

Boyce, J. S. Deterioration of wind-thrown timber on the Olympic Peninsula, Washington. Tech. Bull. 104. Washington, DC: U.S. Department of Agriculture; **1929.** 12 p.

Buchanan, T. S.; Englerth, G. H. Decay and other volume losses in windthrown timber on the Olympic Peninsula, Washington. Tech. Bull. 733. Washington, DC: U.S. Department of Agriculture; **1940.** 30 p.

Cahill, James M. Prelimim[n]ary lumber recovery from dead and live Engelmann spruce. Res. Note PNW-365. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; **1980.** 11 p.

Cartwright, K. St. G.; Findlay, W. P. K. Decay of timber and its prevention. 2d ed. London: Her Majesty's Stationery Office; **1958.** 332 p.

Childs, T. W.; Clark, J. W. Decay of wind-thrown timber in western Washington and northwestern Oregon. For. Path. Spec. Release 40. Beltsville, MD: U.S. Department of Agriculture, Agriculture Research Administration; **1953.** 20 p.

Combes, J. A. Valuation alternatives for dead timber. In: Symposium: the dead softwood timber resource: 1978 May 22-24; Spokane, WA. Pullman, WA: Washington State University; **1978:** 169-174.

Dobie, J. Ambrosia beetles have expensive tastes. DC-P-24. Victoria, BC: Pacific Forest Research Center; **1978.** 5 p.

Roff, J. W.; Eades, H. W. Deterioration of logging residue on the British Columbia coast. Tech. Note 11. Vancouver, BC: Vancouver Laboratory, Forest Products Laboratories of Canada; **1959.** 37 p.

Russell, K. Deterioration of blowdown timber on the Olympic Peninusla from the Lincoln day storm. DNR Rep. 36. Olympia, WA: Washington State Department of Natural Resources; **1983.** 9 p.

Shea, K. R.; Johnson, N.E. Deterioration of wind-thrown conifers three years after blowdown in southwestern Washington. For. Res. Note 44. Centralia, WA: Weyerhaeuser Company; **1962.** 17 p.

Smith, R. B.; Craig, H. M.; Chu, D. Fungal deterioration of second-growth Douglas-fir logs in coastal British Columbia. Can. J. Bot. 48: 1541-1551; **1970.**

Snellgrove, T. A.; Fahey, T. D. Market values and problems associated with utilization of dead timber. For. Prod. 27(10): 74-79; **1977.**

Snellgrove, T. A.; Cahill, J. M. Dead western white pine: characteristics, product recovery, and problems associated with utilization. Res. Pap. PNW-270. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; **1980.** 63 p.

Snellgrove, T. A.; Snell, J. K. A.; Max, T. A. Damage to National Forest timber on Mount St. Helens. J. For. 81(6): 368-371; **1983.**

Wright, K. H.; Hawey, G. M. The deterioration of beetle-killed Douglas-fir in western Oregon and Washington. Res. Pap. PNW-50. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station: **1967.** 20 **p.**

Aho, Paul E.; Cahill, James M. Deterioration rates of blowndowntimber and potential problems associated with product recovery. Gen. Tech. Rep. PNW-167. Portland, OR: U.S. Department of Agriculture, Fores?Service, Pacific Northwest Forest and Range Experiment Station; **1984.** 11 **p.**

This paper summarizes published reports of deterioration and product recovery studies conducted on dead timber. Decay rates experienced in blowndown timber are presented for western redcedar *(Thuja plicata* Donn ex D. Don), Douglas-fir *(Pseudotsuga rnenziesii* (Mirb.) Franco), western hemlock *(Tsuga heterophylla* (Raf.) Sarg.), and Pacific silver fir *(Abies amabilis* (Dougl.) ex Forbes). Results from product recovery studies conducted on insect-killed western white pine (*Pinus rnonticola* Dougl. ex D. Don), grand fir *(Abies grandis* (Dougl. ex D. Don) Lindl.), Engelmann spruce *(Picea engelmannii* Parry ex Engelm.), and insect-damaged Douglas-fir are also presented.

Keywords: Blowdowns, decay (wood), deterioration (wood), dead timber, salvage timber, lumber recovery, lumber value.

The **Forest Service** of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

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