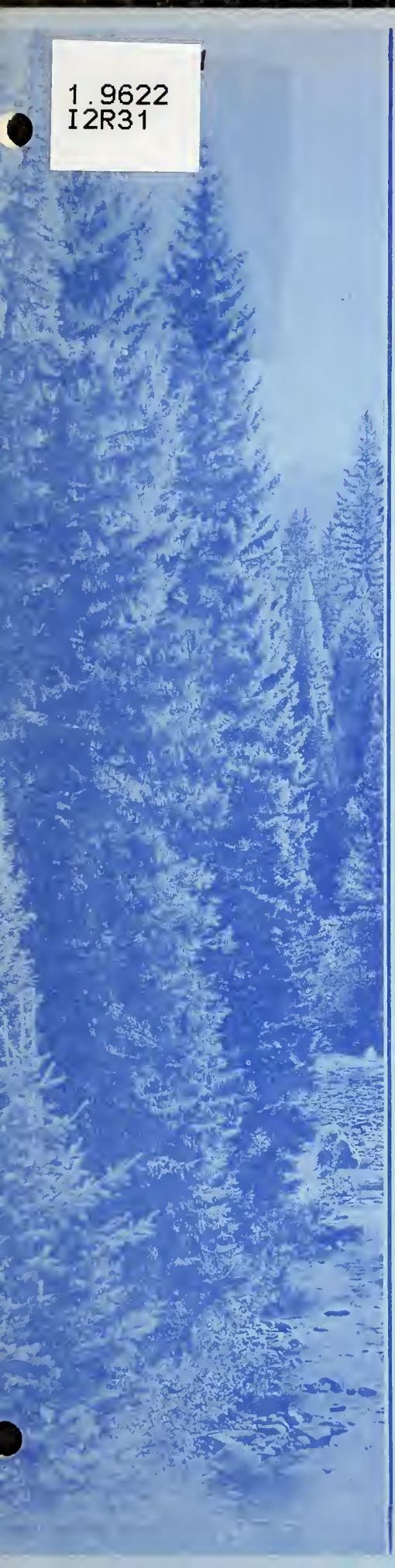

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ENGELMANN SPRUCE

ITS PROPERTIES, USES, & PRODUCTION

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ENGELMANN SPRUCE--ITS PROPERTIES, USES, AND PRODUCTION 1/

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There is a danger that all overripe virgin forests, sooner or later, will fall victim to insects or disease if the timber is not logged. Such was the fate that overtook the overmature Engelmann spruce forests of the Northern Rocky Mountain country in 1951. A vast Engelmann spruce beetle population was bred in wind-thrown spruce uprooted in November 1949 and in 1950. During its first year the infestation took a toll of over 600 million board feet of spruce timber scattered throughout western Montana and northern Idaho. It was soon evident that this epidemic could be controlled by no ordinary method such as spraying of individual trees. A task force comprised of representatives of the lumber industry and the public agencies decided that control through utilization was their only salvation. Prior to that time production of Engelmann spruce lumber in the northern Rocky Mountain area had never exceeded 35 million feet. The first year after the big flight of bugs over 300 million feet of logs were moved. During the summer of 1954 and winter of 1955 this was increased to approximately 440 million. And during the summer of 1955 and winter of 1956 it is anticipated that approximately 500 million feet of Engelmann spruce will be logged (10). It is hoped that this large-scale removal of timber from infested areas will control the epidemic by the end of 1956.

Focusing the spotlight on Engelmann spruce bug timber salvage has developed a vast backlog of information on the utilization of the species. A special committee on the utilization of Engelmann spruce was formed and worked under the guidance of the emergency salvage task force. Information was developed on the lumber grade recovery of Engelmann spruce as indicated by shipping records. A number of mill scale studies were made to determine the yield of lumber from Engelmann spruce of different ages, site classes, and degrees of stocking (2). Studies of utilization practices in the woods were made and included recommendations for log trimming allowance needed under different methods of logging Engelmann spruce. The help of the Forest Products Laboratory at Madison, Wisconsin was also enlisted. This institution produced and put into circulation, reports on the use of Engelmann spruce for house construction, mechanical and machining properties of the species, kiln and air drying of Engelmann spruce lumber, value for pulp and paper products, ties, mine timbers, and veneer and plywood. These data were so voluminous that only a brief digest of them can be presented in this paper.

1/ This paper was presented at the August 1955 meeting of the Inland Empire Section of the Forest Products Research Society.

PROPERTIES AND USES

Engelmann spruce is a most versatile wood and finds a ready market now for a host of uses. Its uses range from rough construction to fine interior finish and specialty products. While it is a very light wood it has a high strength-weight ratio which fits it for specialty uses. It is interesting to compare some of its mechanical properties with other softwood species marketed from the same producing area (11)

MECHANICAL PROPERTIES

Engelmann spruce is one of the lightest of the important commercial woods of the United States. With the exception of western redcedar it is the lightest wood marketed from the Inland Empire area. Table 1 shows that it weighs 23.7 pounds per cubic foot compared to western redcedar which weighs 23.1 pounds.

In spite of its light weight Engelmann spruce is significantly stronger than western redcedar. Table 1 indicates a modulus of rupture of 8,700 pounds per square inch for spruce as compared to 7,700 pounds for cedar.

However, the fact that one wood is lighter and somewhat weaker than many of the commonly used construction woods does not mean that it cannot be used where strength is required. For instance, in house construction 2- by 4-inch studs of Engelmann spruce at the usual 16-inch spacing will meet all requirements. Likewise, the strength of the species is entirely adequate to permit its use in ordinary 1-inch lumber for wall, roof sheathing, and subflooring and similar uses. Most of the strength properties of Engelmann spruce are comparable to ponderosa pine. Its stiffness rating is practically the same as ponderosa pine and its volumetric shrinkage is less than pine. Due to this similarity of properties Engelmann spruce is now being used interchangeably in many cases for ponderosa pine.

MACHINING PROPERTIES

Ponderosa pine and Douglas-fir are two of the principal species now being used for mill work items. Hence, it is appropriate to compare the machining of Engelmann spruce with these two species since most everyone is familiar with them. In tests recently made, spruce was somewhat below ponderosa pine in machining properties (3). It was, however, somewhat better than Douglas-fir. It was concluded that if proper precautions are taken, the machining properties of Engelmann spruce are adequate for ordinary uses. Planing tests were made of Engelmann spruce with a

Table 1.--Some mechanical properties of Engelmann spruce compared to other woods[1/]

Species	Modulus of rupture P.S.I.	Fiber stress at proportional limit P.S.I.	Hardness[2/] End	Hardness[2/] Side	Weight per cubic foot
					pounds
Engelmann spruce	8,700	5,500	560	350	23.7
Western redcedar	7,700	5,300	660	350	23.1
White fir[3/]	9,800	6,300	770	470	26.6
Lodgepole pine	9,400	6,700	530	480	28.7
Western white pine	9,500	6,200	440	370	26.6
Ponderosa pine	9,200	6,300	550	450	27.9

1/ All data computed at 12 percent moisture content.

2/ Load required to imbed a 0.444-inch ball to one-half its diameter.

3/ Average for grand fir (*Abies grandis*), California red fir (*A. magnifica*), and white fir (*A. concolor*)

modern molder having a 4-knife cutterhead with a 6½-inch cutting circle. It was found under the test conditions used that Engelmann spruce was intermediate between ponderosa pine and Douglas-fir. Most common defects developed in spruce were fuzzy and raised grain. Raising of the grain was easily corrected if the boards were seasoned down to the proper moisture content. Most of the spruce lumber shipped from the Inland Empire has a moisture content of about 12 percent and consequently contains a minimum amount of fuzziness. Engelmann spruce works very well on the shaper. Little difficulty was encountered in tests with side grain cuts and only a moderate amount of tearouts on end grain cuts. Tests also showed that Engelmann spruce was intermediate between ponderosa pine and Douglas-fir in turning on a lathe, consequently, it was considered very satisfactory for this purpose.

SEASONING PROPERTIES

About three-fourths of the Engelmann spruce lumber produced in this area is kiln dried and the balance air-seasoned. Most operators now follow the practice of sorting for thickness, sap and heart stock, and common and select grades. The purpose, of course, for separating sap and heartwood is to take advantage of the shorter time required to kiln dry the heart stock. Sapwood in Engelmann spruce frequently has a moisture content of 150 percent contrasting to less than 50 percent in the heartwood. Hence, the reason for separating these two classes of stock is obvious. The sapwood of logs from bug-killed trees loses its moisture rapidly and has been found in many instances to be about the same moisture content as heartwood. Hence, many operators do not separate sap from heart, particularly in 2-year-old bug-killed timber. There are no particularly troublesome problems in the kiln drying of Engelmann spruce lumber whether thick or thin (7). Drying schedules are available giving the detail of drying 4/4 select, and common lumber.

One operator has worked out a schedule that is particularly suitable for protection of knots; 8/4 sap and heart boards can also be kiln dried with a minimum of seasoning defect. About 25 percent of the Engelmann spruce lumber now being produced is air-seasoned (6). Considerable face-checking and end splits are apt to develop if air drying time is accelerated. During the hot weather of July, August, and September it is possible to dry 4/4 spruce lumber down to a moisture content of 12 percent to 14 percent in 10 to 20 days. However, this is not considered advisable. Since a great deal of seasoning defect develops, it is better to increase the drying time to at least 30 days by decreasing pile height, providing pile roofs, and manipulation of other factors such as pile spacing, flues, chimneys, etc. For instance, it is generally recognized that placing stickers flush with the ends of the boards reduces the amount of end checking.

PRESERVATIVE TREATMENT

While Engelmann spruce is sometimes considered a little difficult to treat, it has been treated commercially on a successful basis for many years. For instance, Engelmann spruce railway ties that have been carefully pressure-treated with creosote or creosote oil solutions have given an average service life of from 25 to 29 years (9). Meager information available indicates that air-seasoned Engelmann spruce takes oil treatment better than retort-seasoned material. Optimum treating temperatures are 190° to 200° F. when impregnating with creosote or creosote oil solutions.

SPECIALTY USES

Because of its high strength-weight ratio, Engelmann spruce was rated as suitable for aircraft construction during both World Wars. For years it has been a choice wood for making high-grade violins. A violin maker of Spokane, Washington recalls this incident regarding origin of violin wood: One of his clients, a violinist in one of America's greatest symphony orchestras, was highly pleased with one of his violins. He wanted to trace the origin of the wood and have a duplicate made. The wood (spruce) was secured from a musical supply firm in Leipzig, Germany. They gave the origin of the wood as a locality in northwestern United States, so the wood was probably Sitka or Engelmann spruce. The violin maker ended his recollections by saying "Good violin wood is where you find it. I have used Engelmann spruce of the Inland Empire for years and have never sold a violin for less than $500.00." Due to its resonant character Engelmann spruce is highly prized for the manufacture of musical instruments, including pianos. It is also used for paneling, interior finish, kitchen furniture, ironing boards, stepladders, and similar uses.

USED FOR TIES AND MINE TIMBERS

This species has been used in the Central Rocky Mountain area for mine timbers and crossties for many years. Woods used for ties should be hard and have good bending and compressive strength. These properties are combined in Engelmann spruce to the extent that this species is considered only slightly less suitable for ties than ponderosa pine, lodgepole pine, and woods with similar properties.

If the ties are placed on good ballast protected by tie plates, treated Engelmann spruce gives good service. While Engelmann spruce does not have the bending and compressive strength of some of the other species commonly used for mine timbers such as western larch and Douglas-fir, it gives satisfactory service for this use (9). The Forest Products Laboratory states that "Tests of Rocky Mountain mine timbers showed that the grade factor overshadowed the effect of species, so that little difference in strengh was observed between Engelmann spruce and other species." Engelmann spruce timbers have given satisfactory service for many mines in Colorado and Wyoming.

SUITABILITY FOR PULP AND PAPER

To date Engelmann spruce has not been widely used for pulp and paper making, although the paper industry regards it highly. It has a long fiber, a relatively light color, and an absence of resinous substance which makes it readily pulped by the sulfite, sulfate, and groundwood processes. While Engelmann spruce is somewhat lower in density than the white and black spruce commonly used in the eastern paper industry, its lower density is offset to a great extent by a relatively high solid volume of wood per cord resulting from its thin bark and straightness. Hence, its yield of pulp on a cord basis is comparable to the other spruces. It has been determined that dead Engelmann spruce trees killed by Dendroctonus beetles are satisfactory for paper making if salvaged before extensive decay takes place. Surveys to date have indicated that on many sites of the Engelmann spruce forests of the northern Rocky Mountain areas, bug-killed spruce trees will remain suitable for pulp and paper making for as long as 15 years. Hence, it is hoped that much of the timber killed in recent years that has not been salvaged for lumber will be used for pulp and paper. High-grade newsprint can be made from Engelmann spruce and is now being produced by the Inland Empire Paper Company of Spokane. Excellent quality book papers are also being made. The strength and brightness of papers made from Engelmann spruce are above average. Table 2 gives some typical yields obtained from Engelmann spruce when pulped by the different methods. For instance, the yield of groundwood pulp is 1,970 pounds per cord of wood used (8). This is a rather high yield.

Table 2.--Typical yields per cord obtained in pulping Engelmann spruce[1/]

Sulfate pulps[2/]	
Yield unbleached kraft	940 - 1,020 pounds
Yield bleached kraft	855 pounds
Sulfite pulps[2/]	
Yield unbleached pulp	980 pounds
Yield bleached pulp	920 pounds
Groundwood pulp[2/]	
Yield of pulp	1,970 pounds

1/ Wood weighed 20 pounds per cubic feet--basis oven-dry and green volume.

2/ Basis air-dry pulp--not adjusted for loss from barking, sawing, and mill effluent of commercial operation.

USE FOR HOME CONSTRUCTION

Homebuilders are using a large share of the Engelmann spruce lumber being produced today. For this purpose it can be used interchangeably with such western woods as ponderosa pine, sugar pine, Idaho white pine, western redcedar, and white fir. It has many properties that make it desirable to the homebuilder (5). In nailholding properties it is classed with ponderosa pine and white fir. It is classified as a low-shrinkage wood and at identical moisture content it behaves about the same as ponderosa pine. It is also relatively free from warping, light in weight, and easy to work. It is a uniformly white wood that has a pleasing knots pattern and a rather even distribution of small sound knots, hence, it is adaptable to use as interior wall paneling. Other uses in the house are for exterior trim, roof boards, sidings, wall sheathing, shelving, subflooring, and framing. Since it is somewhat low in strength compared to wood like Douglas-fir, this fact must be taken into consideration when it is used for floor joists and roof rafters. Shorter spans can be used and if that is not practical, size of joists can be increased to compensate for the strength deficiency. Engelmann spruce can, however, be used in the same stud size as any of the heavier and stronger species. It is also practical to use Engelmann spruce for floor and roof decking in house construction. It is thought that the material of 2 and better common grade 4-inch thick, 5-inch wide, end-jointed, and tongue-and-grooved, will make satisfactory roof and floor decking that will meet any normal strength requirement in home construction. This would be true, of course, provided the span is compatible with good framing requirements.

VENEER AND PLYWOOD

At the present time no rotary cut veneer is being produced from Engelmann spruce. Normally the trees do not have very much clear length of bole and the clear wood is not very deep radially. Hence, it does not appear practical to consider Engelmann spruce as a source of peeler stock throughout its production range. It is, however, considered as an excellent wood for production of slicing cants. Informed individuals have estimated that at least 50 million feet of slicing cants could be produced in the northern Rocky Mountain area. It is estimated that 1 million feet of cants makes from 6 to 8 million square feet of knotty plywood panel, hence a sizeable industry could be built on Engelmann spruce for this class of plywood.

QUALITY OF ENGELMANN SPRUCE LUMBER

The emergency spruce utilization as a Dendroctonus beetle control measure has stimulated studies in the quality of Engelmann spruce lumber produced from spruce stands of varying characteristics (2). Studies were of course, primarily directed toward learning the extent of depreciation due to bug infestation. Particular emphasis was placed on the rate of deterioration of the timber. Considerable information was developed on lumber grade recoveries for Engelmann spruce trees, 1, 2, and 3 years after being struck by beetles.

Considerable other tree and log quality information was secured in connection with these spruce depreciation studies. For instance, it was found that age, site, and degree of stocking have a very significant effect on lumber grade recoveries, hence, influence the value of the lumber produced from a stand very materially. Naturally, as an Engelmann spruce tree grows in size and age it also grows in terms of the value of the lumber produced. On good, well-stocked sites, Engelmann spruce trees were noted that had developed as much as 2 and 3 logs clear length in the butt portion of the tree. Naturally, these trees produced a high percentage of D and better select lumber. However, as the trees grow older more defect comes into the picture and defect can often eliminate or at least neutralize the effect of age on quality of lumber produced.

Practically all of the grade recovery studies were confined to overmature old-growth timber. This timber ranges in age from 225 to 300 years of age. Like Idaho white pine, Engelmann spruce is also considered old or overmature at this age. The influence of age on Engelmann spruce is also very similar to Idaho white pine. Sites of this old overmature timber were classified in accordance with Forest Survey standards of the United States Forest Service into good, medium, and poor sites. Table 3 gives a comparison of the lumber recovery for these different three sites. It was found that the lumber recovery from poor sites in this old overmature type of timber was only 84 percent as valuable as the lumber produced from trees on good sites. For a number of reasons, classification of Engelmann spruce timber by sites and age is probably a more practical way of quality appraisal than individual tree or log appraisal. First, on the better sites, Engelmann spruce trees are often 8 or 9 logs in height. It would be quite difficult to ascertain the character of the logs 4 or 5 logs high in the tree. One can, however, determine the general quality of the tree by the first 2 or 3 logs, but the process is much more timeconsuming than classification by site and age.

Table 3.--Comparison of lumber recovery and estimated lumber value of overmature Engelmann spruce stands on good, medium, and poor sites[1/]

Site class	Select and better	Common		Total 3 com. & better	Common		Selling value[2/]
		1 & 2	3		4	5	
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Good	20	18	35	73	20	7	100
Medium	7	28	38	73	22	5	93
Poor	2	20	40	62	30	8	84

1/ Site classification based upon Forest Survey standards of United States Forest Service.

2/ Selling values converted to percentage basis using value of lumber from the good site as 100 percent.

In table 3 it will be noted that the good site produced 20 percent of D and better select lumber. The stand was considered well stocked and contained a volume of 20 to 25 thousand feet per acre. Slightly over 30 percent of the volume of the study was from trees having 1 clear log, while 6 percent of the volume of the trees had 2 clear logs.

The medium site class only produced lumber having 7 percent D and better select. Here only 3 percent of the volume of the study trees had 1 or more clear logs contrasted to 37 percent for the trees in the study classed as good site. Hence, it is evident that clear length plays a very important part in grade recovery. If quality appraisal were being attempted on a small area containing only a few acres, classification or grading on a tree basis would, no doubt, be necessary. However, where 40 acres or more of each classification are involved, it is believed that sufficiently accurate information can be obtained on lumber quality by using the site classification method of appraisal combined, of course, with age and adjusted for any unusual defect factor.

If data were available on Engelmann spruce stands at rotation age, which is 120 years, and somewhat below rotation, say at 90 years of age, similar to that contained in table 3, it would be complete enough for accurate quality appraisals of Engelmann spruce stands throughout the Rocky Mountain area. There is little information on grade recoveries of Engelmann spruce timber at 120 years of age or less. Indications are that yields as high as 60 percent of 1 and 2 common lumber can be expected from this age of timber. Quality should also be more uniform in these younger age classes since they are less affected by defect and other mortality and depreciation factors. A high recovery of 1 and 2 common will also tend to bring these stands up in value to that of the older and overmature timber. Smallness of size, however, will be a penalizing factor because small timber costs more to log as well as to manufacture into lumber in the sawmill.

A composite of the grade recoveries of Engelmann spruce as indicated by average shipments of one of the older operators in the northern Rocky Mountain area is interesting. Table 4 which presents this information shows that about 7 percent of D and better select lumber was shipped. This is somewhat below production of Idaho white pine selects but the production of 1 and 2 common and 3 common are practically the same. As in the Idaho white pine, the higher common grades carry the bulk of the value in Engelmann spruce lumber. This, of course, is an exception in the old overmature stands grown on the better sites.

Table 4.--Percentage of grades of Engelmann spruce lumber shipped by an average spruce producer during a 3-year period

Grade	Percent
D and better select	7.0
1 and 2 common	24.5
3 common	36.2
4 common	16.3
5 common	6.8
Shorts	7.8
Other	1.4

PRODUCTION AND AVAILABLE VOLUME

There is still a substantial volume of Engelmann spruce lumber remaining in the forests of the Rocky Mountain area, and Engelmann spruce lumber will be on the market for many, many years in the future. Spruce is the dominant species on about 730,000 acres of commercial forest land of all ownership in this area. It is widely distributed in other timber types and is one of the faster growing trees, hence, there is not much need for apprehension over the future supply provided there is good management. About 78 percent of the spruce volume is contained on national forest land where allowable annual cuts are developed by working circles. Conservative estimates indicate that at least 250 million board feet of spruce lumber can be produced each year indefinitely from the northern Rocky Mountain area. Much of the spruce stands of today are old growth and overmature. They are being rapidly opened up with new utilization roads, and as logging progresses more slash is created and potentially greater bug risks develop than existed before, hence, the remaining virgin stands are still quite vulnerable to bug attack and natural decadence. However, roads make timber accessible for current logging. Trees infested in the future can be logged before deterioration takes place. Market conditions of the future will also influence the annual cut of Engelmann spruce to a certain extent. The foregoing statements apply to only the northern Rocky Mountain area including Montana, northern Idaho, and eastern Washington.

Engelmann spruce is also found in substantial commercial quantities in Colorado, Utah, and Wyoming. New mills are fast becoming established in these areas which will accelerate spruce lumber production.

Considering these facts and the trends occurring in the production of other western softwood species it is estimated that the total production of Engelmann spruce lumber throughout the entire range of the species will vary between 300 and 500 million feet per year between now and 1975, depending upon the market and the incidence of bugs, disease, and fire. Due to the bug epidemic, the future cut will be somewhat erratic geographically. Some localities have suffered much greater damage than others. This erratic pattern of damage will be reflected for the next 50 years in that some communities that heretofore produced small amounts of Engelmann spruce will be producing much more than others because the remaining spruce supply is closer at hand.

SUMMARY

The bug epidemic in Engelmann spruce has accelerated the marketing of this species. It is expected that from now on out, Engelmann spruce lumber will assume its place alongside such other western softwood species as Idaho white pine, white fir, western larch, and ponderosa pine in the western lumber economy. It is a most versatile species, being used for specialty items and house construction. Because of its long fiber, it is particularly desirable as a groundwood pulp. It will also continue to supply the small knotted type of common board in competition with ponderosa pine and Idaho white pine. It is expected that as the more remote areas of Engelmann spruce are opened up for utilization the quality of lumber production will also include greater volumes of select grades. There are also no appreciable areas of young or rotation age Engelmann spruce in the region and it will probably be 50 years before production of this class of material is a significant factor on the lumber market.

Engelmann spruce lumber production will probably exceed 300 million feet annually between now and 1975, and substantial volumes of bug-killed spruce will be salvaged for pulpwood.

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Figure 1.--Overmature Engelmann spruce trees sometimes produce 2 or 3 surface clear logs.

Figure 2.--Selected cutting of bug-infested trees is sometimes done by small mill operations.

Figure 3.--Engelmann spruce logs are light and straight so big loads of 10 thousand feet per truck load are common.