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Logging Costs and Cutting Methods In Young-Growth Ponderosa Pine in California

ABSTRACT.—Mixed-conifer stands at the Challenge Experimental Forest, Calif., were cut to four specifications: seed-tree, group selection, single tree selection, and clearcut. Logging costs and production rates were compared and evaluated. Cutting method had little effect on felling or skidding production; felling ranged from 1,802 to 2,019 bd ft per hour, and skidding from 3,138 to 3,761 bd ft per hour. Felling cost $3.86 per M bd ft and skidding averaged $4.57. Loading production was 5,286 bd ft per hour and averaged $2.72 per M bd ft. It varied greatly with the number of logs per load; for example, a three-log load contained 42 percent more volume but took only half the loading time of that for a 27-log load.

WHEN the forest manager plans his harvest, he is likely to ask himself: "What cutting method should I use?" Logging costs are a vital consideration in his decision. In the western United States, information about logging costs and production rates in young-growth stands is particularly needed. An increasing number of these stands are reaching harvest stage.

At Challenge Experimental Forest, in north central California, the Forest Service, and the Soper-Wheeler Company are cooperatively studying logging costs and production rates of several cutting methods in young-growth, mixed-conifer stands. Production rates allow the forest manager to apply his dollar values to estimate his own costs. In addition the cost of logging young-growth stands is presented for comparison with costs found in other operations and other timber types.

Factors Affecting Cost and Production

In terms of volume, the young-growth forest at Challenge is primarily ponderosa pine with Douglas-fir and incense-cedar secondary and lesser amounts of white fir and sugar pine. These stands average between 20,000 and 30,000 board feet per acre. The average merchantable tree is about 22 inches d.b.h. and contains five 16-foot logs. This volume per acre and average tree size indicate the many small trees and higher numbers of logs per thousand board feet often found in young-growth stands.

Other factors play a part in the production and cost of a logging operation. They include amount of underbrush and down timber, soil, slope, season of the year, and silvicultural requirements.

Amount of underbrush and down timber have relatively little effect on logging production at Challenge. Underbrush consists of small hardwoods and occasional thickets of incense-cedar. It serves more to limit visibility than to hinder logging. Large amounts of down timber are not usually associated with vigorous young-growth stands, but if present decompose rapidly.

The clay loam soil is deep and internally well drained. After a few days of drying it supports the logging equipment without difficulty. Although the terrain is rarely level, slopes range from 5 to 40 percent and are seldom prohibitive.

Season of the year is an important factor affecting logging production. Timber is usually logged at Challenge during the rainy season—late fall, winter, and early spring. During heavy storms, logging ceases, but resumes quickly because of the well drained soil and light loads that are skidded.

The variable probably least quantified in logging studies is the effect of silvicultural harvesting method on production rates and logging costs. We studied four cutting methods: clearcut (*2*), seed tree (*1*), single tree selection (*1*), and group selection (*3*). These methods are directly comparable because all took place in a relatively small area having similar edaphic, biotic, and topographic conditions.

Felling[1]

The fallers either worked alone or as a team. In the group selection method, they worked together as a two-man team—one felling, the other limbing and

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[1] For brevity, this task, which also includes limbing, bucking, and lopping, is referred to by one word.

Loading young-growth logs at Challenge Experimental Forest, California. Fully loaded, this was an 11-log load.

bucking. Each man's saw was keyed to his particular job. In the other three cutting methods, each faller worked alone—one man would fell, limb, buck, and lop a given tree. Invariably a larger, gear-driven saw was preferred when fallers worked separately.

Logs were bucked long (32 feet) wherever possible. The minimum merchantable log was 10 feet long and 10 inches in diameter inside bark at the small end. Defect was usually minor. It ranged from almost none to 2.3 percent of the gross volume trucked to the mill.

A few snags were felled in each cutting method and were included in the data. All fallers worked at a negotiated rate of $3 per M bd ft net scale (Scribner rule). Social benefits, consisting of unemployment compensation, social security, workmen's compensation, holiday, bonus (in lieu of vacation), and health insurance, increased this amount 29 percent.

Skidding

A skidding team consisted of a choker setter, a tractor operator, and a bulldozer-equipped tractor. The tractor was either a Caterpillar D-7D or an International TD-20.[2] Both were rated at about 113 drawbar horsepower—a rating probably far in excess of that needed in young-growth pine stands. This rating should be recognized as an inflating factor in the logging cost. Forest managers in California are still harvesting old-growth timber, but cutting more and more young-growth each year. Their equipment is geared to the old-growth stands but must be used in the younger stands as well. Greater efficiency can be expected when the capacity of the equipment and the requirements of the work in young timber become better matched.

Logs were ground skidded, with only slight differences in average skidding distance occurring among cutting methods.

The tractor-use rate was $8.55 per hour.[3] The hourly wage rate for the tractor operator was $3.01 and for the choker setter, $2.80. Social benefit expenses increased these rates 32 percent to $3.97 and $3.70 per hour, respectively.

Loading

Flexibility is the key in loading young-growth tim-

[2] Trade names are mentioned solely for necessary information. No endorsement by the U. S. Department of Agriculture is implied.

[3] Adjusted to 1965 rates for comparability.

(A) A 60-foot diameter opening in a group selection cut. In background, a view of young-growth stand before logging. *(B)* After seed-tree harvest, with slash disposal by pile and burn.

Table 1.—Logging Data for Various Cutting Methods, Challenge Experimental Forest, California, 1965

Item	Clearcut	Seed tree	Group selection	Single tree selection
		Volume		
Average volume[1] per acre logged .... bd ft	19,956	27,348	24,711	10,380
Average log[2] volume .... bd ft	314	367	304	355
		Felling production		
Volume per man-hour .... bd ft	1,829	2,019	1,802	1,841
Man-hours per M bd ft .... hours	0.55	0.50	0.55	0.54
		Skidding production		
Volume per tractor-hour .... bd ft	3,668	3,421	3,761	3,138
Volume per man-hour .... bd ft	1,834	1,711	1,880	1,570
Tractor-hours per M bd ft .... hours	0.27	0.29	0.27	0.32
Man-hours per M bd ft .... hours	0.54	0.58	0.53	0.64
		Costs per M bd ft[3]		
Felling .... dollars	3.86	3.86	3.86	3.86
Skidding				
Labor cost .... dollars	2.09	2.14	2.04	2.44
Tractor cost .... dollars	2.33	2.26	2.27	2.72
Total skidding cost .... dollars	4.42	4.40	4.31	5.16
Total cost, felling and skidding .... dollars	8.28	8.26	8.17	9.02

[1] Gross log scale, board feet (Scribner rule); other volumes in this table are net log scale, board feet (Scribner rule).
[2] Primarily long logs (32 feet); others of variable lengths.
[3] 1965 rates.

ber. To accomplish this, the landings are both numerous and small—cheaply constructed and strategically sandwiched into natural flats and openings near the main skid roads. The loader was a 113 drawbar horsepower tractor equipped with hydraulic Drott forks. Sorting consisted mainly of separating long logs from the shorter ones. Incense-cedar was often sorted individually as well. However, a recent development—payment of a better price for larger logs—is sure to result in more sorting in the future.

Loading, then, consisted of decking each skid, sorting the logs, and loading the trucks. All loads were legal weight loads. If time permitted, the loader operator also "bumped" a few knots. The loader operator's pay scale, including social benefits, was $4.36 per hour. The loader use rate was $10 per hour. As in both felling and skidding, the operator was well experienced at his trade.

Comparability of Harvesting Systems

Although selection systems require repeated cuts, the operations studied here were initial applications, hence single cuts, except in the seed-tree method. When combined with seed-tree removal the method becomes a two-stage logging "show." The logging costs and production rates of seed-tree removal were combined with those from the original cut. These figures, plus the loss in production while returning to the same area the second time, represent the seed-tree method.[4]

Cut Volume Has Little Effect

For many years, cutting of a high volume per acre was thought not only necessary for profitable logging but also directly related to its cost. Of the cutting methods studied, a range of 10,000 to 27,000 bd ft per acre created little difference in the logging cost (Table 1).

The average log volume, an item which significantly affects costs, varied only slightly among cutting methods—probably because of a relatively narrow range in tree diameters, a factor typical of young-growth stands.

Felling cost, in this study, is based only on a negotiated rate. Most fallers in young-growth stands prefer this rate because (1) they like the challenge of extra pay for hard work, and (2) the state of the art is new and they do not yet know what wages to expect. If felling had been performed on an hourly basis, differences in cost among the different cutting methods would probably result.

Felling and Skidding Unaffected

Of major importance are the felling and skidding production rates. Felling production was nearly similar except in the seed-tree method. It was greater in that cutting—chiefly because of the higher production rate incurred in seed-tree removal. In terms of man-hours

Table 2.—Important Variables in Loading Young-Growth Logs, Challenge Experimental Forest, California

Load class (No. logs)	Ave. diam. inside bark small end	Ave. volume per load	Elapsed time per load
	inches	*bd ft*	*minutes*
3	32.7	5,110	12.0
5	24.4	5,020	11.2
7	20.4	5,360	15.5
10	16.1	4,900	18.7
12	15.6	4,630	21.2
13	15.1	4,580	20.3
15	14.2	4,530	21.8
17	13.5	4,910	22.2
20	13.0	4,380	26.4
24	11.7	4,240	27.7
27	11.2	3,580	28.2

[4] McDonald, Philip M. Harvesting costs and production rates for seed-tree removal in young-growth, mixed-conifer stands. MS. in preparation. 1967.

and tractor-hours per M bd ft, the single tree selection method had the lowest production rate, and the group selection the highest. But dissimilarities among cutting methods were not statistically different. Logging cost was independent of silvicultural method.

Loading Cost The Key Is Number of Logs Per Load

The cost of loading young-growth timber at Challenge has not been previously reported—primarily because loading is the same regardless of cutting method. However, "return-to-woods" for seed-tree removal would slightly decrease the loading production rate for the seed-tree method as a whole. The loading data which follow are based on 89 loads timed by stopwatch.

The larger the average log diameter, the fewer the logs and the greater volume per load with a corresponding savings in time (Table 2). Compaiing loads with the largest (27) and smallest (3) number of logs shows a time differential of 16 minutes and a volume difference of 1,527 bd ft. The advantage of the latter is two-fold; the trucker hauls 42 percent more volume, and the time to load is halved. If the shorter loading time results in an extra load per day, then its effect is even more important. The average load consisted of 13

Ecological Requirements of In the Santa Ana

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ABSTRACT. Big-cone Douglas-fir is the most ubiquitous tree in the Santa Ana Mountains and is commonly associated with chaparral. It ranges from canyon bottoms to ridges, with an average stand elevation of 3,280 feet. Slopes of stands vary from 2 to 90°, with an average angle of 34.5°. Big-cone Douglas-fir occurs on all exposures but is most common on north faces. North-facing slopes support the highest tree densities, but the fastest growth takes place on open level sites with a southern exposure. Big-cone reproduction occurs on a wide variety of sites. Germination is enhanced by above-average rainfall. Greatest seedling densities occur in dense big-cone stands and in burned stands. Seedlings are suppressed by a shading overstory and are most vigorous following fire. An outstanding adaptation of big-cone Douglas-fir is its ability to produce trunk resprouts after it has been burned. Trunk meristems are protected from fire by the tree's thick bark. Although big-cone Douglas-fir is widely distributed in the Santa Ana Mountains, it prefers mesic sites within this semiarid region and is only secondarily confined to less favorable sites by chaparral competition and recurring fires.

THE purpose of this study was to determine quantitatively the range of site tolerances for big-cone Douglas-fir (*Pseudotsuga macrocarpa* [Vasey] Mayr) within the Santa Ana Mountains of southern California. This mountain range was chosen because big-cone Douglas-fir is the most important tree species and the mountains offer a representation of undisturbed sites.

Pseudotsuga macrocarpa has been called big-cone spruce (*15*), a common name that indicates some of the uncertainty in its past classification. It was once placed in the genus *Abies* and has also been classified as *Pseudotsuga douglasii* var. *macrocarpa* Engelm. and *P. californica* Flous. (*15*).

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Big-cone Douglas-fir is limited to southern California, ranging from the Santa Ynez Mountains in eastern Santa Barbara County and the Tehachapi Mountains in southwestern Kern County down to the mountains of San Diego County (*15*). Sudworth (*19*) reported that big-cone Douglas-fir occurred farther south in the San Pedro Matir Mountains of Baja California, Mexico, but Ira L. Wiggins[1] claims that this does not seem to be the case; Sudworth's distribution may be based on a specimen with a misinterpreted locality. Field observations indicated that the species reaches its southern limits on the desert side of San Diego County mountains in the vicinity of Banner and San Felipe Canyons. On its northern edge big-cone Douglas-fir was separated from the closely related Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) by a discontinuity of 70 miles, which is the width of San Louis Obispo County (*14*). Griffin (*5*), however, reported a new locality for Douglas-fir in the Purisima Hills, which reduces the known geographic separation of the two species to 21 miles. These species are not known to hybridize naturally due to geographic isolation, but will readily hybridize in a laboratory situation (*2*). Hybrids possessing qualities of both species might provide new planting possibilities.

The remoteness, inaccessibility, and scattered nature of stands of big-cone Douglas-fir in steep, chaparral-clad mountains have made lumbering economically unfeasible. These same factors seem to have affected general interest in this species, because little silvicultural or ecological research has been completed. Despite this, some physiological research has been done by Lockhart and Bonner (*13*), and Hellmers (*6*). Seed viability has been discussed by the U. S. Department of Agriculture (*20*) and Holmes and

[1]Personal communication with Ira L. Wiggins, professor emeritus at the Dudley Herbarium, Stanford University.

logs, 4,700 bd ft per load, and time to load of 20 minutes—statistics typical of young-growth stands.

In this operation, skidding and hauling are balanced by consistently putting out nine loads per 8-hour day. On the basis of an average load of 4,700 bd ft, loading production becomes 5,286 bd ft per hour. The cost is $2.72 per M bd ft.

Thus logging costs from standing tree to truck range from $10.90 to $11.75 per M bd ft. And logging costs in these young-growth stands did not differ appreciably with cutting method. Therefore the forest manager is free to choose a cutting technique on the basis of other management and silvicultural considerations.

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Pseudotsuga Macrocarpa Mountains, California

Richard J. Vogl

Busweiz (*7*). Paleontological studies involving this species were conducted by Mason (*14*), Axelrod (*1*), and Savage and Downs (*18*). Big-cone Douglas-fir warrants more intensive study because it possesses drought and fire resistant properties which may make it desirable for future reforestation and planting in the semiarid Southwest.

Description of Area

The Santa Ana Mountains, one of the southern California Peninsular Ranges, are located 40 miles southeast of Los Angeles. The Orange-Riverside County lines roughly coincide with the main crest of the range. The range varies from four to 13 miles in width and covers approximately 400 square miles. It is 20 miles from the ocean and directly exposed to the coast. High points are Santiago and Modjeska Peaks (5,850 and 5,481 ft.). The mountain crest averages 3,500 feet in height (*17*). Due to their relatively narrow width, the mountains rise abruptly and possess knife-edged ridges and steep dry slopes with little level land. The Mediterranean climate is characterized by winter rain and summer drought tempered by marine air. Ocean-facing slopes are moister and cooler than inland-facing exposures. The majority of study sites were located within the Cleveland National Forest portion of the range.

Methods

A total of 31 big-cone Douglas-fir stands or sites, representing major combinations of slopes, exposures, and elevations, were sampled. A check list was made of the plants in each stand. Nomenclature of species follows Munz (*15*). Trees and saplings were sampled by the point-centered quarter method (*3*). Ten sample points were used in smaller stands and 20 points in larger stands. A total count of all trees and saplings was taken in stands under one acre in size. Seedlings, when present, were sampled with 1/40th acre circular quadrats. Dominance (basal area) was taken by placing trees into four size classes: 4-16 inch d.b.h., 17-28 inch d.b.h., 29-40 inch d.b.h., and 41-62 inch d.b.h. Tree, sapling, and seedling ages were taken from cuttings or increment borings. The degree of slope, the exposure, and elevation were determined for each stand.

Results

Distribution.—Big-cone Douglas-fir ranged from canyon floors (1,000 ft. elevation) to the highest parts of the Santa Ana Mountains. Elevations of sample stands, however, ranged from 1,800 ft. to 4,400 ft. with the average elevation for all stands 3,280 ft. Trees were distributed from Ortega Highway (Calif. State 74) in the south end of the range to the canyons emptying into the Santa Ana River on the northern limits of the mountains. A comparison of big-cone Douglas-fir with other major trees, bigleaf maple (*Acer macrophyllum*), white alder (*Alnus rhombifolia*), Tecate cypress (*Cupressus forbesii*), flowering ash (*Fraxinus dipetala*), knobcone pine (*Pinus attenuata*), Coulter pine (*P. coulteri*), sycamore (*Platanus racemosa*), coast live oak (*Quercus agrifolia*), canyon oak (*Q. chrysolepis*), interior live oak (*Q. wislizenii*), and California bay (*Umbellularia californica*), revealed that big-cone is the most widely distributed in range and elevation in the Santa Ana Mountains and thus is the most ubiquitous tree species.

Big-cone trees were found on sites varying from broad, sandy river washes to narrow rocky gorges; and from xeric rocky outcrops and talus slopes to moist, shady sites with deep soils and mesic microenvironments. Big-cone Douglas-fir occurred on a diversity of slopes and exposures. Although these two factors are interrelated, they were treated separately to determine the influence of each on big-cone growth habits.