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Migration *and* Settlement

ON THE

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LAND CLEARING WITH THE BULLDOZER

UNITED STATES DEPARTMENT OF AGRICULTURE

U.S. BUREAU OF AGRICULTURAL ECONOMICS

This publication is one of 12 proposed reports dealing with the problems of migration and settlement on the Pacific Coast. The study of these problems of migration and settlement is being undertaken jointly by three divisions of the Bureau of Agricultural Economics. The studies have three major segments: State-wide surveys of migration to the Far Western States; detailed field surveys on a sample basis of the economic situation and prospects of migrants who have re-located in these States; and an appraisal of the more important public policies affecting the settlement of the migrant group.

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LAND CLEARING WITH THE BULLDOZER

By Willard W. Troxell
and
Harry J. Voth 1/

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PRELIMINARY CONSIDERATIONS

Before the white man came with his saw and axe, almost the entire area of Oregon and Washington west of the Cascade Mountains was covered by a dense forest of big trees, principally Douglas fir, but also cedar, spruce, and other species. The forest has been the base of the economy of this region, but to settlers following in the wake of logging operations it has not been an unmixed blessing. Measured by ordinary standards the stumps are enormous. Diameters of 4 to 5 feet are common, and occasional stumps 8 feet or larger are encountered. Little imagination is needed to picture the back-breaking labor required to clear a few acres of this cut-over land without the aid of machinery. Blasting, stump-pullers, donkey engines, and special methods of burning have reduced the labor and cost of preparing the land for agriculture, but until recently it remained an expensive and laborious undertaking.

About 10 years ago the bulldozer was developed for trail and road building. A bulldozer is a steel blade 7 to 10 feet long, mounted in front of a tractor in such fashion that it can be raised or lowered by the operator. It is an efficient instrument for shallow digging in loose soil, leveling ground, and similar operations. This device came into use for land clearing only a few years ago, and has effected an astonishing reduction in costs.

1/ Mr. Troxell was formerly an Industrial Economist and Mr. Voth, Senior Statistical Clerk, Bureau of Agricultural Economics.

MACHINES AND METHODS

Tractors used in this work are of the track type with Diesel or "controlled ignition" oil engines. In size they vary from about 36 to 96 horsepower at the drawbar and from about 11,000 to 33,000 pounds in weight. These jobs have been grouped into four classes according to the difficulty of the work. The classification was based on consideration of the machine time and powder used, the reported number and size of stumps and the quantity of other cover. Costs given in the table represent cash costs to the landowner, and cover powder, shooting labor, bulldozer work, and hired labor for picking up. Burning cost is excluded and no allowances have been made for the farmer's own time, except where he did the blasting. All three types of contract are represented.

Two-thirds of the jobs were in the B and C (easy and medium work) classes, in which the total cost to the landowner, excluding burning, ranged from \$30 to \$75 an acre. Eighteen jobs, or 42 percent of the total, were in the range from \$35 to \$60. The more difficult work (class D) was represented by six jobs, the maximum total cost, excluding burning, being \$105 per acre. Costs exceeding this amount are rarely encountered. Possibly considerable land in the Northwest would cost more than \$105 to clear by the bulldozer method, but owners of such land are seldom willing to pay for the work. Clearing similar to the most difficult of the jobs listed in table 1 is reported to have cost \$200 to \$250 or more by order methods.

Bulldozer work represents about 60 percent of total cost of the more difficult work, on the average, and about 75 percent of the lighter work.

Where many large stumps remain, the cost of blasting is a major item. The quantity of powder that must be used varies according to the species, size, and condition of the stump, and the condition of the soil. It takes experience and good judgment to fix the proper size and placing of the charge to do the work most economically. Too much powder runs the blasting cost too high, while too little may require excessive bulldozer time.

The labor for picking up is a relatively small item in the total cost.

The descriptions of the type of cover given in the table are intended as a generalized picture only. Every job differs from every other to some extent. Any given tract of land may have special features which affect the difficulty and cost of the work. Green oak stumps and vine maple are very difficult to remove. A stratum of hardpan penetrated by roots, or soft ground which provides poor traction, adds to the cost. More powder is required if the soil is

loose and sandy than if it is a tight clay. The cost of the tractor and bulldozer ranges from about \$5,500 to \$12,000, depending on size and accessories used.

Bulldozers are of varying design. The ordinary type of curved blade, which was designed for moving earth, is sometimes used. Special land-clearing blades are equipped with heavy teeth which extend about 18 inches below the blade. These teeth are in some cases removable and adjustable for depth. Some bulldozers have a wedge mounted at one side and extending forward beyond the blade for splitting stumps. The bulldozer lift may be operated by cable or by hydraulic mechanism. Winches are sometimes mounted on the rear of the tractor for pulling stumps with a cable or for pulling the tractor itself out of holes or soft spots where it may be bogged down.

The usual procedure in clearing is first to blast the large stumps, using just enough powder to crack them and loosen the roots without throwing the stumps out of the ground. Many old stumps are rotten enough so that no shooting is required. Smaller stumps, say 24 inches or less, if not green, can readily be removed by a large bulldozer without cracking.

After a stump has been cracked the bulldozer pries the pieces loose, digs around it where necessary to cut off and remove lateral roots, then pushes the pieces of stump out of the ground. The machine shoves the fragments of stump, roots, and other debris into a pile or windrow in a part of the field previously cleared, backfills the hole, and is then ready for the next stump. After the stumps have been removed the land can be smoothed by the machine, if desired. The bulldozer with teeth can be used for combing and smoothing in one operation, thus removing nearly all of the roots and leaving the land ready for planting without plowing. The field can also be quickly smoothed by towing one or two large logs behind the tractor.

If care is not exercised to locate and remove all roots above plow depth the farmer will encounter them in his plowing and will have to take them out himself. Considerable hand labor is required in picking up small pieces of wood and roots and placing them in piles. This work is best performed by two or three men while the machine is at work, thus preventing the small pieces from being buried by the tractor. The pick-up men can also locate roots overlooked by the operator and call his attention to them.

The final operation is burning the debris and smoothing the ground that has been occupied by the piles. This is usually done by the farmer at his convenience after the machine work is finished. The windrows or piles do not cover much ground, so it is possible to grow a crop on two-thirds or more of the field while waiting for a favorable time to burn the debris. If the bulldozer is available after the first

firing it can be used to bunch the unburned material, or this may be done by the farmer himself with the aid of a team or tractor.

Where the land is covered with brush or second-growth trees, it is the practice in some areas for the farmer himself to slash and remove the trees and brush, leaving only the stumps to be taken care of by the machine. This has the advantage of keeping the bulldozer cost to a minimum, especially if a deferred system of clearing is used. In this system the slashing may be done in slack periods and the land used for pasture while the small roots are decaying. In this way it is possible to do a more satisfactory and less costly job of clearing. In case the land is to be cleared immediately, the labor involved in slashing is not justified. The bulldozer can readily clear out brush and small trees as a part of the stump-removal operation and do it more cheaply than can be done by hired labor.

While the bulldozer has clearly established itself as the best type of equipment for land clearing, it is still in the stage of development and controversy with respect to details. Argument rages as to the best size of tractor, the hydraulic versus the cable lift, and the merits and demerits of teeth and splitting wedges. For example, advocates of the teeth claim that a machine so equipped can reach and cut off lateral roots without pushing a big pile of dirt around, operates with less disturbance of the ground, and leaves the land in condition for planting without plowing. On the other hand, opponents argue that roots frequently slip between the teeth and are left behind, that the teeth are no good for levelling, and that they are heavy, expensive, and require frequent repairs. Further experience will probably settle most of these controversies and lead to improvement in equipment and technique. New ideas are being tried constantly and if successful are widely adopted. As an example of a recent development, the special A-frame which permits higher lift of the dozer may be cited. This rig can build higher piles and is more efficient in trees and heavy brush.

TYPES OF CONTRACT

As the equipment is too costly for farmers to own individually, practically all of the clearing work is being done by contractors, or by cooperative associations such as the Agnew Land Clearing Service of Clallam County, Wash., which was sponsored and financed by the Farm Security Administration. Many of the contractors have been road builders or loggers who have started in the land-clearing business as a means of keeping their equipment working in slack times of their regular business. Some have gone into it as a full-time proposition.

Contracts are of three kinds, (1) lump sum, (2) a stipulated amount per acre, or (3) an hourly charge for the machine and operator. Lump sum or per acre contracts may cover machine work only, machine work plus shooting, or a complete job, including burning. Hourly rate contracts cover only the machine work, usually including the wages of the operator and sometimes a foreman who acts as powderman also. Under the usual hourly rate contract the owner is responsible for the shooting, burning, and miscellaneous labor. The latter arrangement exclusively is used by the Clallam County cooperative. Hourly rates range from the \$3.50 an hour charged by the Clallam cooperative for a 45 H. P. tractor, up to \$7 or \$8 an hour charged by others for more powerful machines. These rates include the driver's wages.

Like all contracting businesses where costs are largely determined by underground conditions that cannot be fully appraised beforehand, land clearing contains a considerable element of gambling. Lump sum and per acre contracts place all of the risk on the contractor, who naturally tries to get the price high enough to cover all hazards. With the hourly charge, the risk is divided, the uncertainty as to the time required falls on the landowner, and the risk of breakdown and other machine hazards are borne by the contractor. Hourly rate contracts are more flexible and more equitable than other forms, but many farmers hesitate to go into a clearing venture without knowing in advance exactly what the total cost will be.

COSTS

Cost of clearing depends upon the resultant effect of many variable factors acting in combination. The machine time and the quantity of explosive required depend on the number, species, size and condition of the stumps; the quantity of second-growth timber and brush; the quantity of down timber; the kind and condition of the soil; the equipment used; the judgment and skill of the powderman; and especially the skill of the bulldozer operator. The contractor must set his price high enough to cover the cost of moving the machine, a highly variable item that depends on the weight of the equipment and distances to be moved, as well as compensation for his own time and effort and other overhead costs. It is not possible to present definite figures of cost for any given set of conditions, but the data presented below indicate about what it costs to clear land under fairly typical conditions in the Douglas fir region.

Table 1 gives an analysis of data obtained during the summer of 1939 from 45 contract jobs, aggregating about 550 acres, on farms

Table 1. - Summary of cost data per acre for land clearing in Western Washington, by classes

Table 1. - Summary of cost data per acre for land clearing in Western Washington, by classes (Continued)

Items	Class C - Medium Work	Class D - Difficult Work
	14 jobs	6 jobs
Total cost <i>a/</i> excluding burning	Average: \$57 Range: \$47 to \$75 7 jobs, \$50 to \$60	Average: \$80 Range: \$68 to \$105
Cost of bulldozer work	Average: \$34 Range: \$23 to \$49 9 jobs, \$30 to \$40	Average: \$52 Range: \$44 to \$58 4 jobs, \$50 to \$55
Bulldozer time (Hours)	Minimum of 4.5 hours for a 96 H. P. machine to a maximum of 12 hours for a 45 H. P. machine	Minimum of 6.5 hours for a 96 H. P. machine to a maximum of 11 hours for a 55 H. P. machine
Blasting cost including labor	Average: \$17 8 jobs, \$10 to \$20	Average: \$24
Explosives Pounds	Average: 98 lb. 8 jobs, 50 to 130 lb.	Average: 131 lb.
Physical Description: Stumps, trees, brush	About 10 large to 25 relatively small stumps of blasting size, and some additional smaller stumps with some trees and brush.	About 20 large to 50 relatively small stumps of blasting size, or perhaps fewer, if unusually large. Other cover quite variable. May be light if combined with a large number of big stumps. Dense cover of second-growth stumps or trees, with a few large stumps, would also be in this class.

a/ Costs include explosives, blasting labor, bulldozer work, and hired labor for picking up small pieces while bulldozer was in operation. Cost of labor for burning or otherwise disposing of debris after bulldozer was finished is not included. No allowance has been made for any labor the farmer himself may have performed while bulldozer was operating; in most cases this was not significant. In the few cases where the farmer did his own blasting, an allowance has been made for his labor at the rate of \$2.00 a day.

in Skamania, Lewis, Thurston, Pierce, and King Counties in Washington. 2/

HOURLY OPERATING COST OF BULLDOZER EQUIPMENT

The principal items of cost incident to the operation of the bulldozer equipment may be classified as follows:

- (1) Machine cost; depreciation, maintenance, fuel, lubrication, interest, taxes, insurance, and miscellaneous.
- (2) Operator's wages.
- (3) Moving.
- (4) Management and other overhead; manager's compensation, automobile expense, office expense, compensation for risks (or profit).

The machine costs are a function of size. The largest items are depreciation and maintenance, and these are also the most uncertain. As the bulldozer has come into general use for land clearing only within the last few years, experience has not covered a long enough time to permit probable useful life and cost of maintenance to be closely estimated. Representatives of some of the manufacturers of tractors say that 10,000 hours useful life is a safe basis for estimating depreciation. Land clearing is grueling work, and maintenance costs will probably average higher than for the usual kinds of service.

For purposes of comparison, estimated hourly operating costs for four machines are shown in table 2. The basis for these figures is as follows:

Operating life: 10,000 hours. No salvage.

Maintenance: average figures quoted by manufacturer, plus 20 percent.

Interest, taxes, insurance = $0.10 \times \text{average value} \div 2,000 \text{ hrs. per yr.}$, where average value = $0.6 \times \text{initial cost.}$

Fuel: based on several months' experience with two of the machines, fuel consumption was estimated at 0.055 gal. per hour per rated horsepower. The fuel is Diesel oil costing about 7 cents a gallon.

2/ Data were also collected from 25 jobs in Yamhill and Washington Counties, Oreg. This work was under slightly different conditions, but costs were similar to those of the Washington jobs. Additional information was obtained from contractors and farmers in Snohomish and Whatcom Counties, from representatives of equipment manufacturers, and from the Farm Security Administration.

Lubrication: manufacturer's estimates.

Table 2. - Estimated hourly machine operating costs 1/

Item	Tractor Drawbar H.P.			
	45 h.p.	62 h.p.	81 h.p.	96 h.p.
	Dollars	Dollars	Dollars	Dollars
Approximate initial cost 2/	6,800	9,000	10,500	12,000
Hourly operating cost:				
Depreciation	0.68	0.90	1.05	1.20
Maintenance	0.65	0.88	1.00	1.10
Interest, taxes, insurance	0.20	0.27	0.32	0.36
Fuel	0.18	0.24	0.31	0.35
Lubrication	0.12	0.16	0.23	0.28
Miscellaneous supplies	0.05	0.05	0.05	0.05
Total machine cost per hour	1.88	2.50	2.96	3.34

1/ Costs to the contractor. Hourly charges for land clearing must cover driver's wages, moving and other overheads in addition to the costs given in this table.

2/ All machines equipped with winch. Bulldozer on small machine without teeth; others with teeth.

The wages paid bulldozer operators by the contractors interviewed ranged from 70 cents to \$1.25 an hour. It is important that the machine operator be skillful and experienced. Hiring a less capable man to save a few cents an hour is poor economy, as the efficient operator can get much more work done in a given time. Where the contracts are on an hourly rental basis the value of a good operator is not always taken into account by the landowner, who is likely to consider only the hourly rate.

The cost of moving depends on the weight of the machine and the distance moved. The tractors can make short moves on unpaved roads under their own power, but the operation of tractors with cleated wheels or tracks on paved highways is prohibited. For the longer moves, or

moves along paved highways, it is necessary to load the machines on rubber-tired trucks. The Clallam County cooperative has its own truck, bought second-hand for \$500. Some contractors who operate light machines also use their own trucks. The equipment for moving the heavier tractors is too expensive for a land-clearing contractor to keep for his own purposes, so it is necessary to have the heavy tractors moved by hauling companies. One contractor stated that he had moved his machine, an 80 H. P. Allis-Chalmers, by truck eight times in $4\frac{1}{2}$ months of operation at an average cost of \$47 per move for the truck, and about 6 hours time of the bulldozer operator, or a total of \$54.50 per move. This meant an average moving cost of about 35 cents for each hour of machine operation. This does not include the cost of several short moves under the tractor's own power. The Clallam County cooperative's machine is moved frequently, because the farmers usually have cash available for only limited work at any one time. In the first 6 months of operation 50 moves were made, or about a move for each 2 days of work. The cost per move, however, is low.

A margin between the rental rate of the machines and the costs discussed above should be sufficient to cover the compensation of the contractor, or hired manager if there is one, the risks of the operation, automobile expense, and other overheads. The usual contractor operates one or two machines, and most of his time is taken up with running the enterprise. A great deal of his effort and time is devoted to selling. He seeks out prospects, makes estimates, and negotiates contracts. He must also plan the work, see that supplies are on hand when needed, keep accounts, and exercise general supervision. These men do not maintain offices, but work from their homes.

Overhead costs per hour will depend on how many hours of work are performed in a year. Time is lost between jobs, in moving, and in delays due to breakdowns, adverse weather conditions, etc. On some soils in western Washington and Oregon use of the bulldozer is undesirable during the winter rainy season because it results in puddling of the soil and excessive quantities of soil and mud in the debris piles. Two-shift operation is sometimes resorted to in order to get the maximum use of the equipment. Where there is no lack of work to be done, as much as 2,000 hours a year may be possible from single-shift operation.

From the foregoing discussion it can be seen that in establishing a basic hourly rental rate the margin included to cover overheads will depend on the contractor's estimate of the risks involved and the amount he considers he should, or can, get for his own time and effort. Competition should tend to keep the margin down. Where selling cost and much of the risk of idle time can be eliminated, as in the Clallam County cooperative, the rates should be correspondingly reduced.

Persons interested in land clearing in the Northwest have discussed a great deal the most economical size of machine for this work. In the absence of time studies on strictly comparable tracts of land

(if such could be found), no definite answer can be given. Unquestionably, the larger machine can root out big stumps much faster than can the small one. On the other hand, the heavy equipment costs considerably more to operate and move, and much of its power may be wasted on light work. It therefore seems probable that for tough clearing jobs where moves are infrequent the more powerful machine will do the work cheaper. For easy work where the land to be cleared is in small tracts necessitating frequent moves the small machine is perhaps more economical.

CLEARING LAND FOR SETTLERS

A great deal of cut-over land in the Northwest would be suitable for cultivation if cleared. But not all of it would be productive enough to justify the cost. Both earning power of the land and clearing costs vary enormously, so that only by a balancing of capitalized earning power, or value, against estimated clearing cost plus purchase price can any proposed undertaking be justified. With clearing costs below \$100 per acre it is feasible to bring into cultivation a considerable acreage if the purchase price is reasonable. Clearing of much of the poorer land, or land on which clearing is unusually difficult, would not be justified even if it could be acquired for nothing. Before any clearing project is inaugurated a careful appraisal of economic feasibility should be made for the specific tracts under consideration. ^{3/}

When allowance is made for all the costs involved, including a reasonable compensation for the farmer's own labor, the bulldozer method is in most cases much cheaper than others ^{4/}, far more rapid and adapted to use under all conditions except where the ground is too soft to support the machine. But this method has the disadvantage that it requires an immediate cash outlay of considerable amount. Burning stumps in place by blower or charpitting requires little or no cash, but takes a great deal of patience, skill, and labor. A farmer can utilize spare time in this fashion and thus clear additional land at little or no cash cost, but many are unwilling to put in so much labor for so small a return. The use of bulldozers is preferred by those who can raise the money. A settler must have at the start sufficient cleared acreage to provide a livelihood, or his family must be supported out of savings or from other sources until the farm yields the necessary income. Rapid clearing by machine of at least enough acres to produce the family's minimum requirements is the plan that appears best in developing new farms.

^{3/} See Report No. 5 in this series, "Cut-Over Lands of Northern Idaho." Report No. 6, "Settlement Experience and Opportunities on Cut-Over Lands of Western Washington" is to be issued soon by the Washington Agricultural Experiment Station.

^{4/} See page 13 for list of references describing other methods of clearing.

The farmer's cash outlay can be kept to a minimum and his labor utilized efficiently if he will do the blasting, picking-up, and burning. If he does his own blasting it should be under the advice of someone who is experienced in the work, in order that neither powder nor machine time will be wasted. If extra help is required at any stage of the operation, an arrangement to exchange labor with neighbors will do away with the necessity for hiring men. This leaves only the explosive and the machine work to be paid for.

Keeping the cost of the machine work down is a problem in organization and management. If the acreage to be cleared is large enough it may pay the owner or agency carrying out the project to buy the machinery. Most clearing will average probably 4 to 8 hours of machine time per acre. In a probable life of 10,000 hours this would mean the clearing of a total area of 1,200 to 2,500 acres per machine over a period of about 3 to 5 years. Selection of the proper equipment and the hiring of a qualified man to operate it are obviously important. Moving costs can be minimized by scheduling the work so that moves by truck will be infrequent. Operations even as small as 20 to 25 acres between truck moves will keep the cost of moving the usual type of equipment down to \$2 or \$3 an acre at most.

Where no private contractors are in the business or where contract charges are excessive, the formation of cooperative associations may be advisable. The Agnew Land Clearing Service in Clallam County is an example. This organization was sponsored by the Farm Security Administration, which advanced \$6,000 to buy the equipment. Five local farmers, known as the "master borrowers," signed personal notes to secure the loan. These master borrowers receive a small quantity of free bulldozer work as compensation for their risk. One of these men acts as manager and gets 50 cents an hour for the time he puts in and 5 cents a mile for the running expenses of his automobile. Before FSA loaned the money it required that the members of the association sign up in advance for 5,000 hours of operation. The time for this selling was donated by the local people interested in the venture and by Farm Security itself, as none of its own overhead expense is charged to the cooperative. Thus there is no selling cost to be met from revenues.

Cooperatives can effect savings through adding together many small jobs to form a project of sufficient size to gain the benefits of scheduling the work to reduce moving costs and idle time to a minimum. But overhead charges are not escaped. Efficient management is a basic requirement. The actual work of organizing the cooperative, and persuading the farmers to join must be contributed gratis by someone. It is not necessary in all cases for a cooperative to buy the machinery. The organization could make a contract on an hourly rental basis with someone who owns a machine. If the organization can guarantee the owner steady work for several months or a year, a low rate could probably be agreed upon as there would be no selling expense and the risk of idle time would be reduced. Where a number of competent land-clearing contractors are competing for business, the formation of a

cooperative to buy and operate a bulldozer would probably be inadvisable.

In the Northwest are many thousands of acres of State- and county-owned land and tax-delinquent land that would be suitable for cultivation if cleared. It has often been proposed that this land be cleared up and sold to settlers. The use of relief labor in the work has been advocated. This would accomplish three worthwhile results: (1) it would provide opportunity for more people to earn a living from farming, (2) it would increase the tax base and economic activity of the counties and State, (3) it would provide useful work for relief clients. Surveys would be required for selection of the land and determination of the best way to organize and finance these projects.

But to keep the settlers' financial burden and the subsidy contributed by the public (if any) to a minimum, the cheapest known method of clearing should be used. In nearly all cases this means machine work, which involves relatively little unskilled labor and is not suitable for relief projects that require a high ratio of labor to total cost. Land clearing is suitable for public works projects if no restrictions exist as to the proportion of the money that must go directly to labor. As much as possible of the unskilled labor should be done by the settlers themselves. When the clearing must be done before the settler moves in, the stump fragments, logs, and other debris can be left in piles or windrows to be burned after the new owner takes possession.

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