

DOMINION OF CANADA—DEPARTMENT OF AGRICULTURE

LAND CLEARING

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DIVISION OF FIELD HUSBANDRY

DOMINION EXPERIMENTAL FARMS SERVICE



General View of Stump Land

ished by authority of the HON. JAMES G. GARDINER, Minister of Agriculture,
Ottawa, Canada.

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- Memorandum by A. Courey, Macamic, Que.
- Correspondence from Leo Brown, Deputy Minister of Colonization, Que.
- Photographs and data on Cultivators, Courtesy of the Ford Motor Co.
- Cuts of Stump Piler and Root Hook, Courtesy of G. R. Boyd, U.S.D.A.

CONTENTS

	PAGE
INTRODUCTION.....	5
Need for Land Clearing.....	7
Types of Land Clearing.....	7
CLEARING OFF TIMBER AND BRUSH.....	7
The Time to Start Clearing Operations.....	8
Tools for Removing Timber and Brush.....	8
Roads.....	10
Skidways.....	10
Bush Work.....	10
Pulpwood and Cordwood.....	11
Handling of Heavier Timber.....	11
Hauling.....	12
Brushing.....	12
Piling Brush and Logs.....	13
Burning.....	13
Repiling and Cleaning Up Operations.....	14
STUMP REMOVAL.....	14
Methods of Stump Removal.....	15
Pulling Equipment.....	18
DISPOSAL OF STUMPS.....	19
Collecting Stumps.....	20
Removal of Earth and Splitting of Stumps.....	20
Piling Stumps.....	21
Windrowing Stumps.....	22
Filling Stump Holes.....	22
POWER MACHINERY FOR LAND CLEARING.....	22
Brush Cutters.....	24
Power Grubbers, Sweeps and Tree-dozers.....	26
Bulldozers for Stump Removal.....	26
Operating Costs of Power Equipment.....	28
BLASTING.....	29
Uses for Explosives.....	29
Explosives and Blasting Supplies.....	29
Tools for Blasting.....	30
Making a Primer Cartridge.....	31
Blasting of Stumps.....	32
Amount of Stumping Dynamite Required.....	32
Blasting Boulders.....	33
Cost of Explosives.....	34
STONE REMOVAL.....	34
Disposal of Field Stones.....	34
Removing Boulder Stones with Cultivators.....	35
Pulling Boulders with a Rolling Hitch.....	36
Explosives in Stone Removal.....	36
Ploughing Stony Land.....	37
The Cost of Stone Removal.....	37
REMOVAL OF HUMMOCKS.....	37
PREPARING CLEARED LAND FOR THE PRODUCTION OF FIELD CROPS.....	40
Drainage.....	40
Topography.....	41
Ploughing, Disking or Cultivating.....	41
Fertilizing and Cropping.....	43
COST OF CLEARING LAND.....	43

INTRODUCTION

One of the first problems confronting agriculture in its beginning was that of clearing the land, and making it ready for cultivation and crop production. Land clearing continues to be a matter of major importance, particularly in a relatively young and thinly populated country with such a large total land area as that of the Dominion of Canada. Not only are there large areas of virgin forest land which might be cleared advantageously, but many areas which were formerly under cultivation have been abandoned and have reverted to forest or brush growth.

The classification of land areas in table 1 gives some indication of the potential agricultural land which awaits only the clearing tools and the plough to convert it into productive crop land.

The total land area in Canada is 2,218,595,840 acres. Only 351,708,000 acres of this huge area, according to the Dominion Bureau of Statistics, can be classed as present and potential agricultural land. Of the occupied agricultural land almost 86 million acres is improved and approximately 29 million acres is still in forest. This forested area includes numerous sugar bushes, woodlots, reforestation projects, etc., which will, no doubt, be maintained in forest for an indefinite period. It is probable that the clearing of any appreciable area of this forested land on occupied farms would be of doubtful economy, but certainly much of it could be cleaned up and made more productive.

Of the unoccupied agricultural land, more than 54 million acres is in grass, brush, etc., and almost 134 million acres is in forest. Much of this area is too rough, rocky, hilly or wet to clear and till as cultivated crop land, but may provide a certain amount of pasture, and is thus classified as agricultural land. According to estimates of the various soil surveyors throughout Canada, the area of potential agricultural land which is tillable is approximately 50 million acres. Thus the area of land in Canada on which land clearing may be economical, ranges from approximately 50 million acres adaptable for thorough clearing and cultivation, to 188 million acres on which clearing may be profitable to a greater or lesser degree.

Land clearing is probably the most important problem which must be faced in relation to any extensive agricultural expansion or land settlement policy which may be adopted in the Dominion of Canada.

TABLE 1.—CLASSIFICATION OF LAND AREAS IN CANADA

(Canada Year Book, 1941)

Classification	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat- chewan	Alberta	British Columbia	Canada
Total Land Area.....	1,397,760	13,274,520	17,582,720	335,061,760	232,500,480	140,622,720	152,304,000	159,232,000	229,938,560	2,218,595,840
Total Agricultural Land.....	1,258,240	8,092,160	10,718,080	43,745,280	65,836,800	32,380,160	80,074,240	87,440,240	13,248,000	351,708,000
Occupied Agricultural Land—										
Improved.....	765,000	845,000	1,330,000	8,994,000	13,273,000	8,522,000	33,549,000	17,749,000	705,000	85,733,00
Forested.....	339,200	2,503,040	2,433,280	8,012,800	4,702,080	2,019,260	3,507,840	3,893,760	1,212,160	28,625,280
Unoccupied Agricultural Land.—										
Grass, Brush, Etc.....	16,000	1,870,080	485,760	840,960	4,595,840	7,008,000	9,681,289	19,673,600	3,686,400	54,298,240
Forested.....	51,200	1,920,000	6,080,000	23,622,400	39,680,000	10,240,000	14,720,000	28,800,000	6,019,840	133,693,440
Unoccupied Agricultural Land—										
Total.....	67,200	3,790,080	6,565,760	24,463,360	44,275,840	17,248,000	23,401,289	48,473,600	9,706,240	187,991,680

Areas stated in acres.

Dominion Census, 1931.

LAND CLEARING

By

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Need for Land Clearing

In a comparatively new country with large areas of forested lands, it follows that, as the population increases either by normal birth rate or by immigration, more and more land is required for the production of agricultural commodities as these become more essential than forest products. Furthermore, on many occupied farms there is insufficient cultivated land to maintain a reasonable standard of living for the farmer and his family. The remaining areas on such farms must be cleared before farming them can be made profitable. Since land clearing can be done at odd times when other farm work is not pressing, it provides employment for labour which might otherwise be lost. The additional revenue which may be obtained from the tillable area added to a farm in this way may result in a sufficiently increased revenue to change an otherwise unprofitable venture into a successful farm enterprise.

Types of Land Clearing

In clearing land, consideration must be given to a number of factors which may have an important bearing upon the methods adopted and the purpose for which the land is to be used. Some of these factors may be listed as follows: (1) Kind of vegetation, i.e., large timber, pulpwood and similar small tree growth and brush or marsh land; each require different methods of handling. (2) Type of soil; it is more difficult to remove stumps from heavy clay soil than from sandy soil; the type of tree growth is usually more massive and difficult to remove on clay soils than on sandy soils; some farm crops will grow well on clay soils and some will do better on sandy soils. On muck soils great care must be exercised when burning brush or tree refuse in order to prevent the fire getting into the muck itself and burning off the accumulated organic matter. (3) Topography; some areas are too rough, rocky and hilly to be suitable for cultivation and in many cases such areas are more profitable if retained for tree production than they will be for the production of field crops. (4) Drainage; natural drainage, or the possibility of artificial drainage should be carefully considered before land clearing is commenced. These and other factors will be discussed in detail in subsequent sections of this bulletin. It must be remembered at the outset that there is no royal road to land clearing. It requires a great deal of hard work under any circumstances, and usually involves the expenditure of a considerable amount of money.

Although the methods of clearing land which are discussed in this bulletin are more directly concerned with the type of land to be cleared in Eastern Canada, many of the methods suggested may be applied to other parts of the country.

CLEARING OFF TIMBER AND BRUSH

In removing timber and brush from land the procedure followed must be varied according to the forest growth on the land, the size of the clearing project, the equipment available and many other factors. Although the methods

of clearing herein described have been effectively employed in land clearing operations, it will be necessary to adjust the methods to suit local conditions. In order to present information on various types of clearing, the subject will be discussed on the basis of the removal of lumber logs, pulpwood, cordwood and brush. Specific operations in land clearing, such as stump removal, blasting, stone removal and ploughing will be described for the information of persons who are interested in the details of these phases of land clearing. Some of the methods discussed may be more directly useable for the clearing of small woodlots on partially cleared farms; some by individual settlers having whole farms to clear, and some as a larger community project, involving investment in relatively expensive equipment.

The Time to Start Clearing Operations

In Eastern Canada land clearing work is usually started during the winter when the frozen ground and subsequent fall of snow provide the best conditions for timbering operations. The clearing should be started as early in the fall as possible so that all the saleable material can be removed from the land while sleighs can be used for hauling. Hauling should be done, if possible, early in the winter before the snow gets deep. The clearing operations may be completed in the spring when the unsaleable logs, brush and trash can be collected, piled and burned. Although land clearing is usually commenced in the fall, a settler should not plan to take up new land at this time, as it is usually necessary to build a house and stable on the farm during the summer before the clearing operations are started.

In land clearing the different operations should be done systematically and each phase of the work undertaken at the most suitable season. If each phase of the clearing is done thoroughly, time and labour will be saved in the operations which follow. An attempt should be made to cut off only as large an area as can be thoroughly cleared and broken during the year. In some areas the settlers plan to remove the timber and burn the brush on about five acres of land per year.

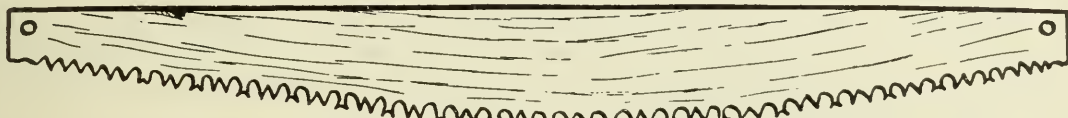
Tools for Removing Timber and Brush

The tools commonly used for removing timber and brush in land clearing are not expensive and can be obtained readily. An axe and a saw are essential and a cant-hook and lodging chains are required if lumber logs and pulpwood are being handled.

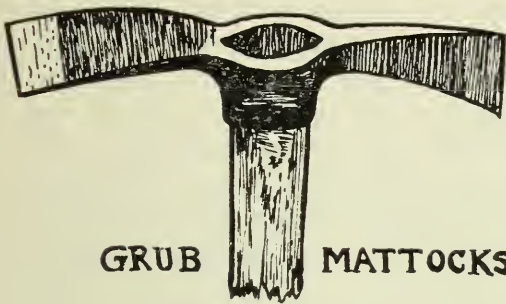
A steel bow or Swedish saw having a steel tube frame and a 4-foot blade is widely used for cutting down moderate sized timber, pulpwood and cordwood. This saw can be handled by one man and the 4-foot blade can be used as a measuring rod when sawing cordwood. A long cross-cut saw requires two men on the handles and can only be used to advantage in cutting heavy logs.

A double-bitted or two bladed axe is commonly used by bushmen, but a single-bitted axe is recommended for those who are not experienced in bush work. An axe head weighing $3\frac{1}{2}$ to 4 pounds is suitable for general bush work, while a lighter axe is to be preferred when cutting out light brush.

One or two logging chains having a link of $\frac{3}{8}$ -inch metal and a length of 12 to 14 feet are commonly used for skidding logs and cordwood poles out of the bush to the roadways. A cant-hook which costs about \$4 is a very useful tool for rolling logs on the skidways and can be considered essential if a large number of logs are being hauled out. Occasionally a 50-foot chain is used with a horse in piling logs on a skidway. The ends of the chain are hooked under auxiliary skidway poles. The centre of the chain is passed under the log being piled, and then over the top of this log to a horse on the road side of the skidway. When the horse pulls on the chain, the log being handled is rolled up the skidway poles onto the pile.

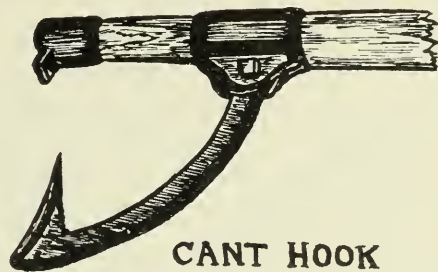


CROSS CUT SAW

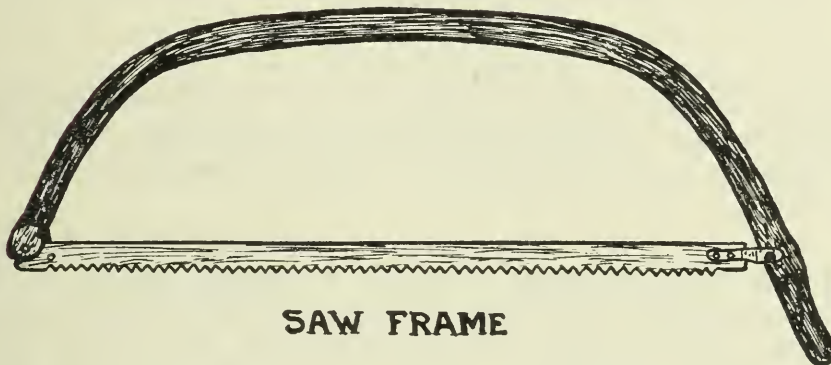


GRUB

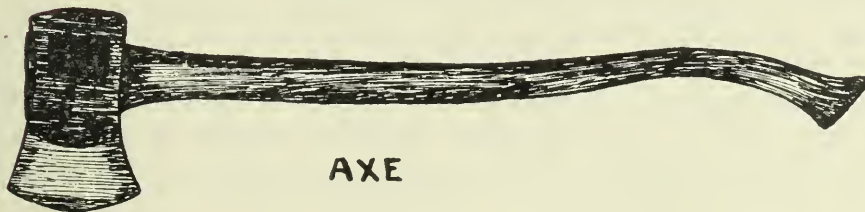
MATTOCKS



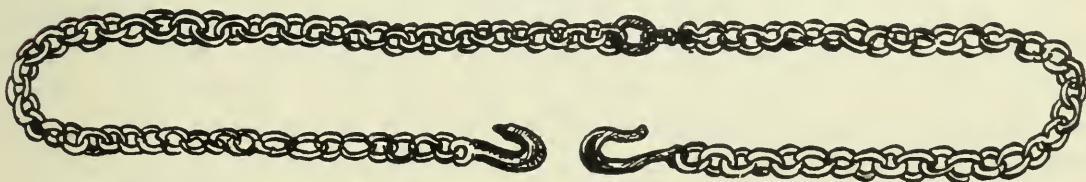
CANT HOOK



SAW FRAME



AXE



LOG CHAIN

FIG. 1.—Tools used in clearing land of timber and brush.

Roads

If land clearing is being done either on virgin forest or on cut-over timber land, the cutting of roadways for hauling out saleable material is usually the first step. By using roadways which are laid out systematically, the timber can be moved out of the bush most efficiently. Depending on the size of the sleighs used and on the amount of material to haul out, roads should be cut 12 to 18 feet wide and spaced from 60 to 150 feet apart. The roads should be cut straight whenever possible.

In clearing the roadways all material should be cut off at the ground surface. The brush is usually cut first and piled at the side of the road to make room for felling the heavier trees. All trees larger than five inches as the base may be cut with a saw, while an axe may be used for cutting the brush and for trimming off tree branches. Material which is suitable for pulpwood or cordwood may be cut down, topped, the branches trimmed, and the wood piled at the side of the road. Pulpwood may be left in pole lengths or cut into 4- or 8-foot lengths, depending on how it is sold in the district. Since cordwood is commonly sold in 4-foot lengths it should be cut accordingly, and piled between stakes ready for hauling. Material suitable for lumber may be cut down with a saw, topped, trimmed, cut into suitable lengths and moved to the side of the roadway. Other heavy material which is unsuitable for sale is handled in a similar fashion but piled separately. All tree tops, trimmings and brush should be neatly piled at the side of the road to eliminate rehandling in the spring.

Skidways

When there are a large number of logs suitable for lumber, skidways should be built at intervals along the main roads for piling the logs. Skidways should be placed where the timber is the thickest in order to keep the haul to the piles as short as possible.

A skidway consists of two logs about 20 feet long which are blocked up at one end and spaced 8 feet apart to form a two-log ramp. A supporting log or block is placed at the edge of the roadway and parallel to it, and one end of each of the ramp logs is placed on the supporting log and at right angles to it. If one supporting log does not make the skidway as high as the bunk of the hauling sleighs, a second log may be laid on top of the ramp logs and an additional pair of ramp logs placed on the top.

Logs should be piled two or three layers high on the skidway so they can be easily rolled onto the sleighs. Piling in this way also protects many of the logs from the snow and makes them easier to clean when loading. Auxiliary ramp logs may be used to roll up logs when forming a second and third layer in building a pile on the skidway. In handling the logs, a cant-hook will prove to be a very useful implement.

Bush Work

In clearing out the timber in the bush the material may be handled in a manner similar to that described in the clearing of the roads. As in other clearing operations, the bush work should be done systematically in order to save labour, to recover as much saleable wood as possible and to make the work in the spring easier. Pulpwood, cordwood and waste wood should be carefully sorted and set aside for sale. The money obtained from the sale of this material may pay for much of the equipment and labour required for clearing the land.

In bush work the underbrush is sometimes cut before cutting the large timber. This method will facilitate removal of the timber, and in many cases

eliminates the necessity of cutting trails to the skidways. If the brush in the bush is relatively thin, however, the cutting of the shrubbery is usually left until spring. All material in the bush which is larger than 5 inches in diameter should be cut with a saw about three feet above the ground. Although more wood or lumber can be obtained by cutting a tree lower, the stumps should be cut high to make pulling easier when removing the stumps.

When the timber is being removed the pulpwood and cordwood should be cut first to make room for the felling of the larger trees. Although different methods are used, many settlers prefer to start the clearing at the furthest point from the skidways and work towards the road so that the piled brush and branches do not interfere with the skidding of the logs.

Pulpwood and Cordwood

Spruce trees which are too small for lumber logs are suitable for pulpwood, if they measure at least 3 inches in diameter at the small end. In most districts mills allow 10 per cent of balsam mixed with the spruce. Poplar and various other types of wood can be sold as fuel in almost any part of the country.

After cutting, the pulpwood and cordwood may be trimmed, topped, and hauled to the roadways in pole lengths. The trimming of branches is usually done with an axe, but small, frozen branches near the top of the trees can be removed by knocking them off with a wooden shaft about $2\frac{1}{2}$ inches in diameter and 4 feet long. For skidding to the roadways, a chain can be wrapped around several pieces and one horse can be used to haul them out.

Pulpwood is usually sold in 16-foot lengths when laid down on the bank of the river, or in 4-foot lengths when placed at the edge of a main road for truck hauling in the summer. Cordwood for fuel is usually cut in 4-foot lengths and placed between stakes at the side of the roadway in piles which are 4 or 8 feet high, so that it can be readily measured into cords of 128 cubic feet.

Handling of Heavier Timber

Heavier trees are handled in much the same way as pulpwood. Material cut for lumber such as pine and spruce should be reasonably straight, at least 10 feet long, and not less than 6 inches in diameter at the small end. When difficulties are experienced in pulling out heavy logs with a horse or team, a sled can be made to carry the front end of the log. Runners for the sled can be made from two pieces of 5-inch material which have a natural bend at one end for the front of the runner. Two cross bunks may be fastened to the runners with bolts to make a sled about 3 feet wide and 5 feet long. By placing a ring at each end of the back cross bunk a chain can be hooked into one ring, laid over the log, run through the other ring, and passed through a loop on the centre of the front bunk to hold the log and draw the sled.

Large trees which are not suitable for sale may be cut down, trimmed, topped, and sawed into convenient lengths for piling and burning. The amount of material that is prepared for burning depends on the time available for this work during the winter. All tree tops and branches should be piled, however, when cut, to eliminate rehandling in the cleaning-up operations in the spring.

On cut-over land in northern Ontario settlers remove the timber and clear off the brush on about 5 acres of land per year. The timber is about half and half jack pine and spruce, ranging up to 30 inches in diameter, with the majority 8 to 18 inches in diameter.

On new land the stand may range from 5 to 50 cords of pulpwood per acre with an average of possibly 8 cords per acre. In 1941 pulpwood was selling \$5 to \$6 per cord, poplar cordwood for about \$4 per cord, and timber suitable for lumber at about \$10 per 1,000 feet. In 1945 pulpwood was selling for \$7

to \$8 per cord when placed on railway cars, poplar was selling for \$5 per cord and timber for lumber ranged from \$15 to \$20 per 1,000 feet.

Hauling

If possible the hauling of logs and pulpwood should be done before the snow gets too deep. To haul logs or poles, sleighs are fitted with 8" x 8" cross bunks which are 4 to 7 feet long. The length of the sleigh can be increased if desired by coupling the front and rear sections with two crossed chains. When hauling 4-foot material, sleighs may be fitted with two 12-foot stringers with end stakes to hold the wood which is piled crossways on the sleigh. One or more logging chains are used to hold the load on the sleigh.



FIG. 2.—Hauling Pulpwood. This photograph was taken when clearing the Dominion Experimental Station at Kapuskasing, Ontario. The sale of pulpwood in some areas will defray part of the cost of land clearing.

Brushing

In the spring brushing and piling operations may be started. In northern Ontario where most of the new land is covered with timber and brush, this work is usually started in the latter part of April or in the first days of May. On land which has a heavy growth of brush and few trees, brushing may be started in the fall and finished in the spring.

All of the brush and small trees should be cut at or below the surface of the ground. By cutting the brush in this way horses can be used on the land with less danger of damage to their feet, and cattle will browse more freely when the land is sown to pasture. In general, all material which is less than 3 inches in diameter is cut off at the surface and placed in piles or windrows. If heavy tractors and brush breaker ploughs are to be used for ploughing, however, larger trees may be cut off at the surface, because this equipment will cope with larger roots.

On land where a running fire cannot be used to clean up the slash due to fire regulations or because of fire damage to the top soil, it is necessary to cut all of the brush and place it in windrows. Where an open fire can be run, however, the fire will consume the fine slash on the ground, thus saving much labour in piling.

A light single or double-bitted axe is the implement used in brushing operations, when the brushing is done by hand. Power equipment for the removal of brush will be described in the section entitled "Power Machinery for Land

Clearing.” In clearing land in northern Ontario, two men might be expected to brush and clean half to one acre of land in one or two weeks, according to the amount of brush on the land.

Piling Brush and Logs

In order to dispose of scrap wood by burning, it is necessary to place the brush, trash, or unsaleable logs in compact piles. If piles are not carefully made the fire will burn only a small part of each pile and it will be necessary to rebuild the piles several times before all of the material is destroyed.

Unsaleable logs which are left on the land should be trimmed and cut into lengths which are readily piled. In the piles the logs must be in close contact as the fire will often fail to cross a gap which is broader than two inches. Piles containing logs should be built so that the material falls in as the fire consumes the wood. To obtain this action the logs are laid parallel and the built up piles have a triangular shape when viewed from the end.

Burning

There are two methods of using fire to dispose of waste material, namely, pile burning, and running fire burning in conjunction with pile burning. In sections where the top soil is likely to be damaged by an open running fire, all material is burnt in piles.

For the most part the soils that are damaged by fire are those of the podsol and muck types where large quantities of organic matter are present at the surface of the land. Since the first two or three crops following the clearing are not seriously affected by the surface fire, farmers often do not realize the seriousness of damage caused by fire on these types of soil. In sections where an open fire can be used, much labour is saved by cleaning off slash by this method.



FIG. 3.—Stump land after brushing—A surface fire was used to destroy the trash on the land shown in the left foreground of this photograph.

Before fire is used in any land-clearing operation in the late spring, summer or early fall, a settler in timber areas must obtain a permit from the local forestry office. Permits carry regulations regarding the burning of bush and state the months of the year when fire can be used in land clearing. Remember that “fire makes a good servant but a poor master”.

If a surface fire is to be run across a section of land, all trash should be cleared off a strip 50 feet wide along the sides of the area to be burned, to protect the adjoining timber. Where this method of protection is not used, small back fires can be used to clear off the land at the edges. Particular care should be taken when burning over areas adjoining timber land which has a heavy growth of evergreen and resinous woods. The proper time to start a surface fire will depend on the dryness of the slash and the density of this material on the ground. Some people prefer to run a fire against the wind, claiming that it moves more slowly and consumes more brush, while others prefer to run the fire with the wind to get a more rapid burn.

For control of surface fires, water is of little value alone, unless available in large quantities. Earth is a good material for checking fires and can be shovelled on to a surface fire to smother it. Surface fires can also be checked by beating out the flames with a sack dipped intermittently into a pail of water.

Repiling and Cleaning Up Operations

Probably the best time for repiling is immediately after the fire of the first burning operation has subsided. In this job the unburned ends of logs and unburned sticks lying on the land should be collected and piled. Piling should be done carefully with the idea of making the second burning complete the clearing operation. Where the stumps are not being removed immediately, the land should be seeded down as soon as possible after burning to obtain pasture for animals so that they will check the growth of shoots from the green roots.

STUMP REMOVAL

Stump removal methods may be considered for three different classes of stumps, namely, green stumps, dead stumps and decayed stumps. The method selected will depend on the nature of the clearing project. If the land is required immediately, stumps are normally removed in the summer, following timbering operations. This is the most expensive procedure and will involve the use of heavy equipment if the work is to be done quickly. Where the amount of land under cultivation is being only gradually extended, the usual procedure is to seed down the stump land and pasture it for a few years to kill off stump shoots and allow the stumps to die. Dead stumps can be more easily removed than green ones. Where time is not a factor, stumps may be allowed to decay. In this condition they can be readily removed with a minimum of labour and equipment.

Green Stumps.—The work and expense involved in removing green stumps should not be underestimated. The method selected will, of course, depend on the size of the stumps, the acreage to be cleared and the time, labour and equipment available. Hand grubbing of green stumps is most laborious but can be done if only a few stumps are to be removed. A team cannot pull more than about a 4-inch jack pine or spruce stump on a straight draw. Where the acreage to be cleared is small, heavy charges of dynamite can be used economically in removing scattered green stumps. On larger acreages stump pullers may be used to advantage, in conjunction with blasting of larger stumps to save time and breakage of equipment. On extensive land-clearing projects tractor bulldozer units can be used to remove relatively large green stumps. This equipment permits rapid clearing and eliminates much of the heavy work normally required, but owing to the high initial cost it must be operated on large acreages to be economical.

Seeding Stump Land.—Where stumps are to be left in the soil for more than one year it is recommended that the area be seeded down for pasture in

order to utilize the land. Animals in the pasture will check the growth of shoots from the stumps and tramp down the soil, exposing many of the heavy roots. Following the disposal of slash and other material, except stumps, the land may be cultivated with a heavy triangular wooden-framed harrow. Seeding may be done with a hand broadcast seeder, using a mixture of 8 pounds of red clover, 2 pounds of alsike and 10 pounds of timothy per acre.

Dead Stumps.—When stumps are allowed to remain in the soil for two to five years, the top of the stump usually remains solid, but the roots lose much of their grip on the soil. In this condition they can be handled less laboriously and at about half the cost of removing green stumps. Moreover, the roots of dead stumps when pulled will carry less earth than green stumps. In any case, it is advisable to leave the turned up stumps on the land over winter to allow frost action to remove as much of the earth as possible before attempting to pile them. Dead stumps are drier and weigh less than green stumps, thus hauling and piling is easier and burning is facilitated. A variety of methods may be used for the removal of firm dead stumps from the soil, ranging from grubbing and pulling, to bulldozing with tractors, or to the use of dynamite.

Decayed Stumps.—The roots of stumps left in the soil for seven to twelve years will be well decayed and the tops can be removed by hand or by pulling with a team. A stone-boat or small sled is usually used in removing stumps from the field for burning. Well decayed stumps are not difficult to burn, even when placed in small piles. With this deferred method of stumping the levelling of land is usually not a serious problem, since the hole left when the stump is removed is shallow. Where the roots of stumps have been well rotted, the land can be ploughed with a walking plough and the work of picking roots is relatively light.

Methods of Stump Removal

Open Burning.—Stump burning is practised chiefly where the stumps are very large and numerous. Where it is possible to burn the stump and its roots to a depth of about 18 inches this method eliminates pulling, piling and subsequent burning. In addition, the ground is left fairly level. The difficulty is to burn out the stump roots. A depth of 18 inches is usually required as there may be considerable settling of the ground after the stump is burned and the land cultivated. Burning methods are best adapted to the heavier soils as a more satisfactory burning of the roots is secured under these conditions. Both stumps and ground must be dry to obtain good results from open burning and the heat must be directed to the stump roots.

One method of accomplishing this is to saw the stump off just above the ground and raise the sawed off top section 2 to 4 inches by placing several small stones between the crown of the stump and the top section. A fire is then started under the top and in the centre of the stump. As the fire continues to burn the heat is reflected from the more inflammable top down towards the roots.

Another method of getting the fire into the centre of resinous stumps, such as pine, is to bore a 2-inch auger hole through the stump. This hole is bored diagonally through the base of the stump from the surface of the soil on one side, to a pit 18 inches deep and about a foot wide on the opposite side.

A fire is built in the pit and the auger hole serves as a flue to heat the centre of the stump to ignition temperature. On very large stumps two or three holes may be bored. One hole may be made down the centre of the stump to a depth of about one foot below the surface of the ground. A second hole, started at ground level, is bored diagonally so as to intersect the first hole near its lower end. A fire is started at the junction of the two holes with a hot iron, a glowing coal or a blow torch. A hand bellows will help in starting the

fire. It may take from 24 to 36 hours to burn out a dry stump. One man can keep about 75 stumps burning if they are not too far apart.

A boring apparatus may be made by welding a 2-inch auger to one end of a piece of $\frac{3}{4}$ -inch shaft, about 4 to 6 feet long. The labour of boring may be reduced by placing the auger shaft in a frame with a cross shaft carrying a flywheel and hand crank so as to drive the auger through a set of bevel gears. The boring unit may be mounted on wheels so that the frame will slide forward to allow the auger to bore through the stump. This type of outfit may also be operated by a small air cooled gas engine.

Enclosed Burning.—A system adapted to burning stumps of considerable size is the char-pit method. This consists of building a fire at the base of the stump and enclosing it with a layer of clay to limit the air admitted, and to retain as much heat as possible within the stump. This method is only adapted to clay soils, as light soils will not bake to form a satisfactory covering to concentrate the heat. It is possible to char-pit wet stumps, although the method works best on dry stumps. Resinous stumps with taproots are more easily handled by this method.

A layer of stove wood about 6 to 8 inches thick is placed around or part way round the base of the stump. A little straw is placed under the wood. A layer of clay or heavy soil 3 to 4 inches thick is piled against the stump to a height of about 18 inches. Fires may then be started at several places around the stump. After the fire is well started, it is entirely confined to a covering of clay and, as the top settles down in burning, the roots are burned out below the surface of the ground.

Considerable attention is required to keep the fires confined. If allowed to burn into an open blaze much heat is lost and the formation of charcoal ceases, due to excess air. A char-pit fire may burn from several days to a month or more, depending on the size of the stump. Stumps should be inspected two or three times a day to ensure that the fire does not break through the clay covering as it burns into the roots of the stump.



FIG. 4.—Pulling Decayed Stumps. When stumps are allowed to rot for several years, they can be removed easily. In pulling, a high rolling hitch is used on the stump to obtain leverage.

Grubbing and Pulling.—Where hand labour only is available, stumps may be removed by grubbing or digging around the stump and cutting off the larger roots so that the stump may be pried out with a pole. This method is only effective for small well-rotted stumps, in which case one man can tip over 74 or more stumps per day. It is not effective on green stumps where one man would have to work extremely hard to remove more than about fifteen 10- to 12-inch stumps per day. However, grubbing makes a clean job of root removal and is equally adapted to thick or scattered stumps, and the only tools required are an axe, mattock, crow-bar and shovel.

Where a horse or team is available a combination of grubbing and pulling is a more economical method. The simplest puller is a chain with a hook on each end. By hooking the chain to one of the main roots of the stump and pulling over the top of the stump some leverage may be secured. A high rolling hitch may also be secured by attaching the chain near the top of the stump on the opposite side to the draw so that the pull will be over the top of the stump. Green stumps up to about 6 inches in diameter may be removed by a direct draw with a team or, if sufficient grubbing and cutting of roots is done, even larger stumps may be removed. If the ground is not too wet, a farm tractor may be used and will remove larger stumps than can be pulled with a team.

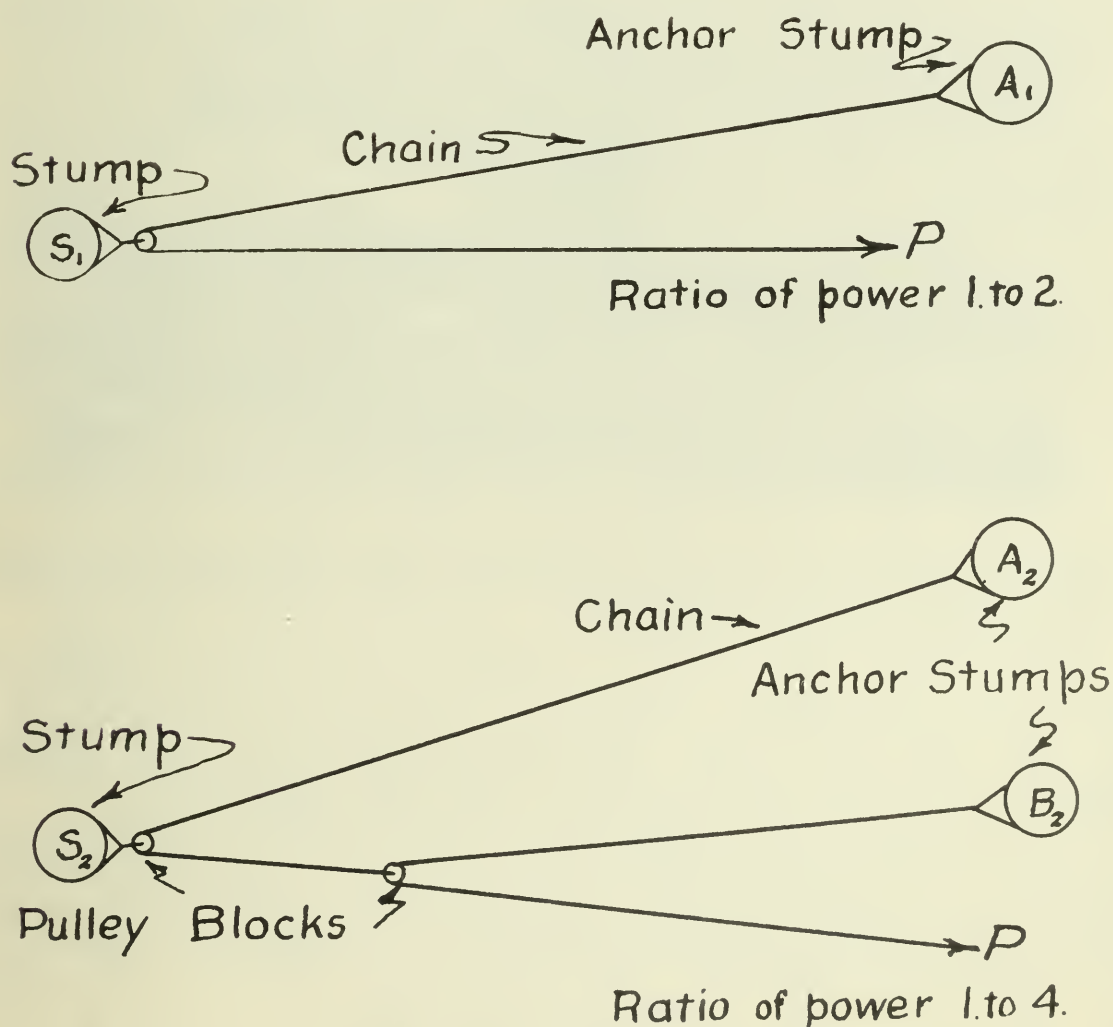


FIG. 5 (a).—Method of Pulling Stumps with Chain and Single Pulley Blocks. When one single pulley block is used, the pull applied to a stump is twice the pull supplied by a team or tractor that is coupled to the chain at the point P. Two single pulley blocks and two chains can be used to obtain a power ratio of one to four.

Pulling Equipment

As direct pulling of stumps is hard on either a team or a tractor, it is generally advisable to use some mechanical means to increase pulling power. Experience has shown, however, that the simplest design of stump puller is usually the cheapest and most satisfactory.

"A" Frame.—A direct pull may be applied to better advantage by using a frame about 6 feet high made from pieces of 6 x 6 inch pine in the shape of the letter A. The chain from the team or tractor is passed over the top of the frame and attached to one of the main roots so as to afford a lift as well as a pull. This works to advantage on a tap-rooted stump.

Twister.—A device known as a "twister" can be used to advantage on partially decayed stumps. A tough wood pole about 20 feet long is used as a lever. A logging chain is wrapped around the stump and hooked so as to leave a loop in which the large end of the pole is inserted. A team is hooked to the free end of the pole and driven around the stump, thus twisting it off. This device may give as much as 10 to 1 leverage and will handle 6- to 10-inch stumps.

Chain Blocks.—A set of chain blocks provides a flexible, low-cost stump puller. A 150- to 250-foot length of $\frac{3}{8}$ -inch cable or chain, with two or three single pulley blocks is a convenient outfit. Grooved pulleys about 8 inches in diameter are recommended for $\frac{3}{8}$ -inch chain. Pulleys will cost about \$10 each, and $\frac{3}{8}$ -inch chain about 25 cents per foot. (See Fig. 5a.)

With reasonable footing, a team will pull up to 2,000 pounds on a straight pull, and various combinations of pulleys may be used to increase the power of the team. A single movable pulley used on a stump will give a ratio of 2:1 or double the power of the team.

Two single pulleys may be used to form a compound pulley, giving a ratio of 4:1. In this case, one pulley is fastened to the stump to be pulled. One end of a chain is attached to an anchor stump, the other end is passed through the pulley and attached to a second pulley. A second chain has one end fastened to the same or, if convenient, another anchor stump. The other end is passed through pulley number two and thence to the source of power. A ring or grab hook on the eveners and one on each pulley will be found convenient.

Another combination is to use a single pulley and a double pulley block, or two single pulleys hooked together to secure a ratio of 3:1. With this arrangement, a team will pull green stumps up to 15 inches in diameter. Two men and a team may be expected to pull from 75 to 150 medium-sized green stumps per day with this equipment.

Capstan Pullers.—The capstan or windlass is one of the most widely used types of horse power pullers. The power of a team may be multiplied by 20 to 25 times, with a capstan, and this power may be doubled by introducing a single pulley in the line of pull. The pulling cable may be operated through the single power pulley which is chained to the stump being pulled.

A simple capstan puller consists of a cast base, bolted to two 6- or 7-inch pole skids about 8 feet long, a cable winding drum with toothed base and driving dog forming a ratchet, and a solid cast cap or sweep holder, which may be released from the drum to permit unwinding of the cable. A puller of this style, weighing about 560 pounds when equipped with 100 feet of $\frac{3}{4}$ -inch pulling cable and a 12-foot length of $\frac{3}{4}$ -inch anchor wire rope, will cost approximately \$100. This size of puller is recommended for stumps up to about 2 feet in diameter. A similar light puller with only 50 feet of $\frac{3}{4}$ -inch cable can be secured for about \$60. This size is recommended for stumps up to 12 inches in diameter. In most cases the longer cable is advisable as it will reach a larger number of stumps from one position. The capstan bar or sweep used with these pullers is usually 10 to 12 feet long.

In operation, the puller is placed alongside a heavy stump which serves as an anchor. This stump is cut off short to allow the sweep to pass over it as the cable is wound up. If possible, secure anchor stumps should be selected on slight rises in the ground where the footing is good for the team and where a large number of stumps can be pulled from one position. Time may be saved by fully extending the cable and working towards the puller. The pull cable may be hooked directly to or chained to stumps with solid tops. Stumps with decayed tops can be gripped with a root hook. A single-prong root hook weighing 45 pounds can be secured for about \$10.

Three men form a satisfactory crew for a puller. With one man driving the team, two men are available to handle the pulling line. Pulling is stopped just as a stump is turning over, when the earth can be knocked off the roots so as to fall back into the hole. While the number of stumps pulled per day will vary with the type of soil and the size, condition and stand of stumps, a three-man crew may be expected to pull up to 100 twelve-inch stumps per day.

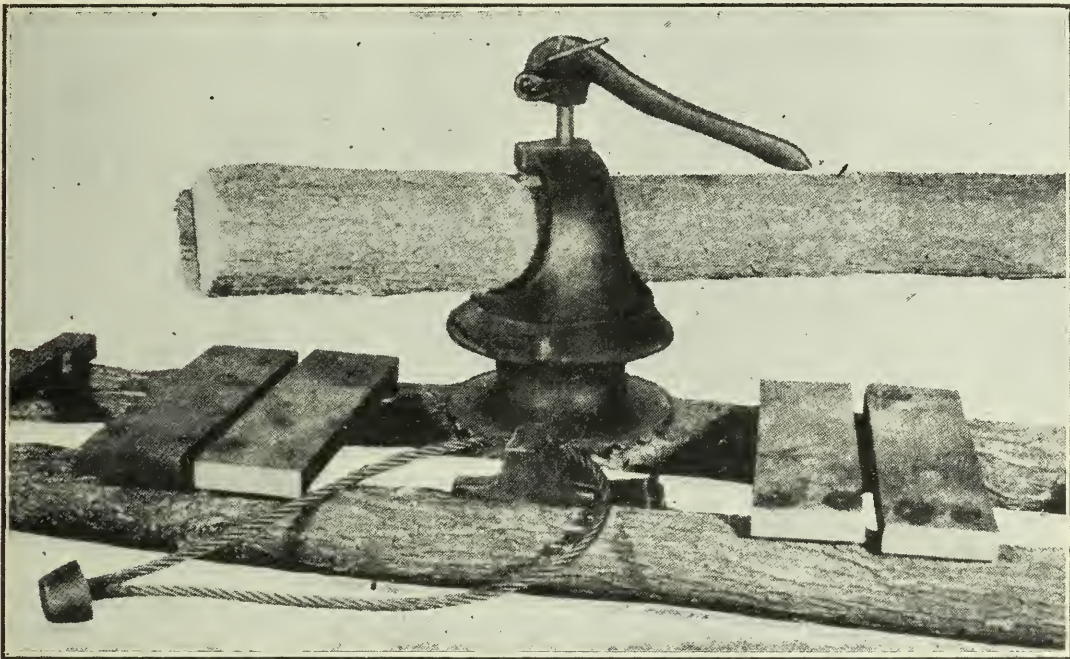


FIG. 5 (b).—Capstan Stump Puller—Capstan pullers are used extensively in land clearing operations. The short cable is placed around an anchor stump, a team is hitched to the sweep log, and a pulling cable winds onto the puller spool as a stump is being pulled. This type of puller is very satisfactory for removing moderate sized stumps.

Tractor Winches.—Power winch attachments are available for various makes of tractors. These consist of a gear reduction driving a horizontal drum, on which the cable is wound. This type of equipment has not proved very satisfactory for stump pulling. The initial cost usually approximates that of a small tractor, and when used on a light tractor anchorage must be found for the tractor. When used on large track-type tractors, difficulty is frequently experienced with rapid wear on the cable, due to improper guiding to the drum.

DISPOSAL OF STUMPS

Not the least of the problems in land clearing is the disposal of stumps after they are pulled out of the ground. The cost in time and money to remove and destroy the stumps is probably as great as that of pulling or blasting.

Collecting Stumps

After pulling, the stumps are usually piled and burned to clear the land for crop production. Pulled stumps are commonly dragged to piles with a team or tractor. When one layer of stumps has been collected to form the base of the pile, a long chain is thrown over the pile and hitched to the stumps so they can be rolled onto the top of the pile. Roots are thrown in with the stumps, and the pile is built up as high as possible. Sometimes a wooden sled about 4 feet wide and 8 feet long is used to draw the stumps and loose roots to the piles. In loading the sled the roots of the uprooted stumps are cut off on one side, the sled is pulled along this side, and the stump is then rolled onto the sled.



FIG. 6.—Collecting Old Stumps—Stone boats or sleds are commonly used to haul rotted stumps and roots off the land in land clearing operations.



FIG. 7.—Stump Piles.—In many districts stumps and roots are piled by hand in compact oblong piles for burning.

Where donkey engines or winches are used for stump pulling, this type of equipment may also be used in dragging stumps to piles. The machine is located where a pile of stumps is to be made and a cable is used to draw in the heavy stumps. Since the dragging of stumps along the ground is usually a relatively light job for this machine, light auxiliary cables may be attached to draw two or more stumps at one time. Bulldozers or tractor bulldozer rakes may also be used to sweep stumps or brush to piles or windrows on large land clearing projects. These machines are very effective and eliminate a tremendous amount of hand labour.

Occasionally stumps are disposed of by dragging them from the fields and dumping them into a deep ravine. When using this method of disposal, care should be taken to select a place where the stumps will not have to be moved later on.

Removing Earth and Splitting Stumps

Where large stumps have been pulled, they are generally split with explosives in order that they may be more easily moved to the piles. One of the best methods of splitting a stump is to bore a $1\frac{1}{2}$ -inch hole into the side, just above the crown, and inclined downward towards the centre, in such a fashion that a charge of dynamite may be placed in the heart of the stump. Some prefer to bore this hole in the centre of the top face of the stump and down towards the base. Where an auger is not available, a mud cap charge can

be placed in a notch cut between two heavy roots to split the stump. Earth can be removed from green stumps in a similar manner to facilitate their handling and burning.

Piling Stumps

Stumps should be piled as compactly as possible, in narrow or oblong piles which have considerable height. The size of the piles depends upon the piling equipment used and the number of stumps. For good burning, piles having two or more tiers are desirable. By building large piles more land can be cleared for other operations while the stumps dry out. It is important that as much earth as possible be removed from the stumps before piling as earth interferes to a marked extent with the burning. Stumps which can be utilized for firewood or other purposes should, of course, be saved instead of burnt.

Equipment for Piling Stumps.—In cases where the stumps are large and very numerous more elaborate equipment is required for piling. A stump piler can be made from heavy poles equipped with a cable and block for lifting stumps. The puller illustrated is inexpensive to construct, operates very satisfactorily and can be easily hauled from pile to pile. With any device for piling stumps, some kind of trip to release the stump when it hangs over the pile is desirable. The trip illustrated in Fig. 10 is very useful and can be made by a blacksmith. The link at the

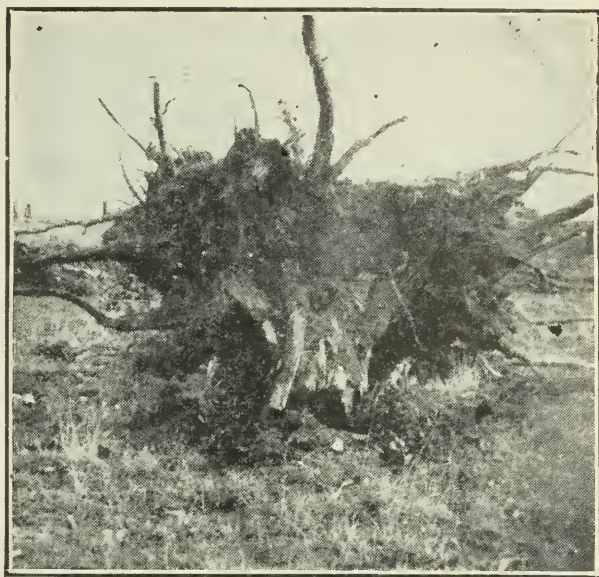


FIG. 8.—A Stump after Pulling—This five year old 16-inch stump must be disposed of before the land clearing is completed. If this stump is left in the field until spring and then pulled to a stump pile, most of the earth will fall off the roots.

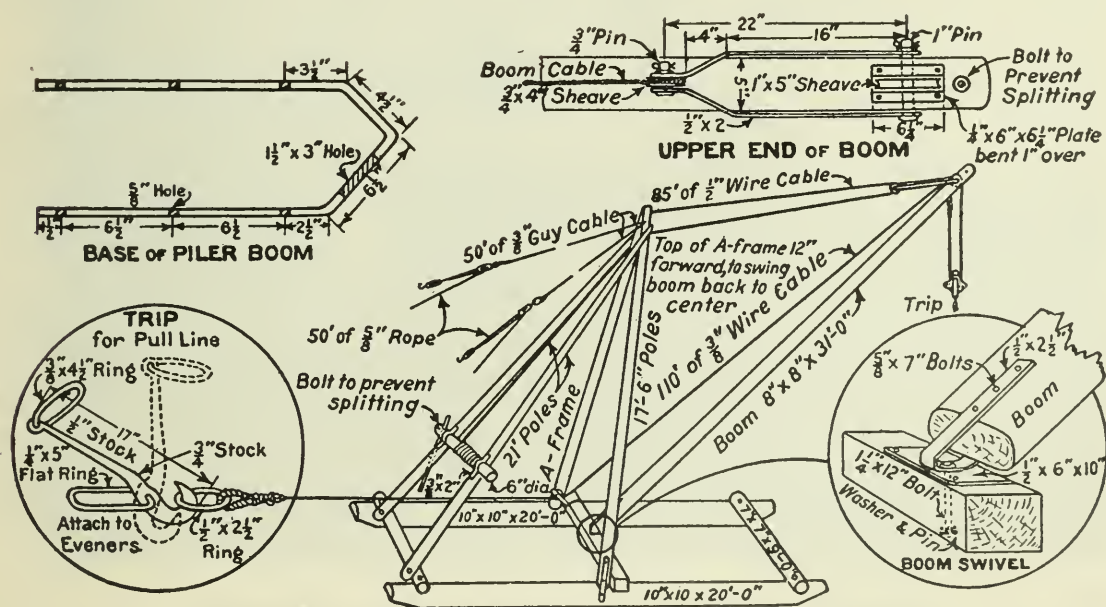


FIG. 9.—Conrath Stump Piler—A stump piler can be made from poles, similar to that illustrated, for use where a large number of heavy stumps are being piled for burning. (Courtesy of Bureau of Chemistry and Engineering, U.S.D.A.)

top is connected to the hoisting cable of the stump piler, the 20-foot length of chain is wrapped around the stump and slipped into the horseshoe hook, and the ring at the end of the chain is placed in the mouth of the trip dog. When the stump is over the pile, a trip rope is used to release the dog to drop the stump in the desired location.

Tree gin poles can also be used to pile stumps if a tree can be left standing in the field where stump piles are to be made. The tree is stripped of branches, topped at a height of about 25 feet, and a pulley block is attached to the top of the tree trunk. A cable or heavy rope is attached to the stump, passed through the pulley block and pulled by a team to drag the stumps into a conical pile around the tree. Stumps are dragged from the field to the pile and the piling is done in a second operation.

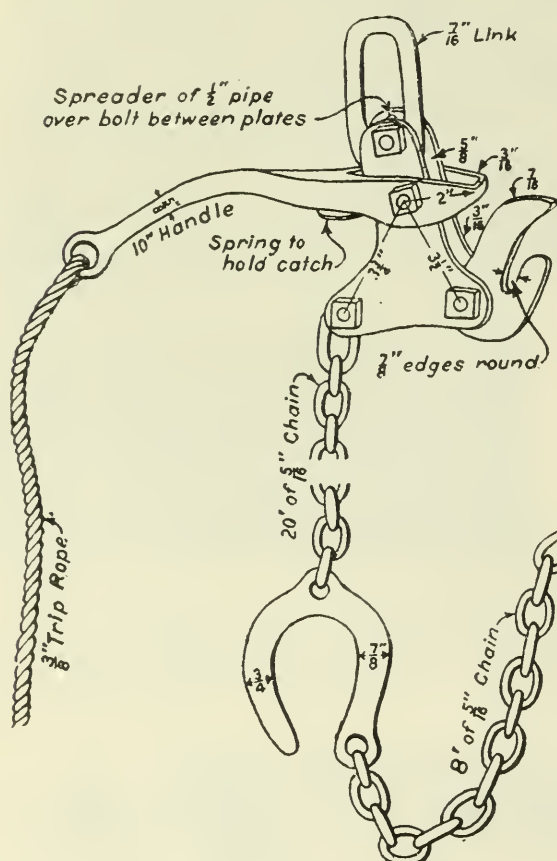


FIG. 10.—Trip Hook for a Stump Piler: Where a stump piler is used, a trip device is desirable so the stumps can be dropped on the pile after being hoisted by the piler. (Courtesy of the U.S.D.A.)

In cases where it is not desirable to leave trees in the field, an ordinary gin pole 25 feet long can be erected, braced with cables, and used in a similar manner to a tree gin pole for piling the stumps. Both of these methods have proved satisfactory and require little equipment.

Windrowing Stumps

Under some conditions it is desirable to clear off small pieces of land for crop production before all phases of the land clearing job can be completed. In such cases, stumps may be drawn into parallel windrows, about 150 feet apart, so that intervening land may be cultivated. This method has the advantage of aiding the stumps to dry and allows time for the frost to crumble the earth from the roots, but the stumps must be rehandled in piling, the windrows hamper field operations, and the clearing program is prolonged.

Filling Stump Holes

Whenever stumps are pulled, blasted or bulldozed out of the soil, it is necessary to fill the stump holes before the land can be ploughed. For this job, a home made drag, a scraper or a bulldozer may be employed. Home made drags are made in three styles for moving the earth into the holes. Some farmers use two heavy planks to make a V-shaped snow plough style of drag, while others make a drag similar to a two-blade road drag. A wedge-shaped drag with one guide plank running parallel to the movement of the drag and an angled side wing may also be used. This unit is similar to a martin ditcher and requires a metal tail fin on the rear end of the guide plank. Where stump holes are large, a plough may be used to turn the earth into the hole.

POWER MACHINERY FOR LAND CLEARING

During the last five years there has been a remarkable increase in the use of tractor-powered equipment for land clearing in the United States, and in the land settlement districts of Eastern Canada. During the year 1940



FIG. 11.—Power Equipment for Cutting Brush. Tractor mounted brush cutters can be used to eliminate tedious hand labour in cutting brush. These machines are best adapted to brush land which has very few large trees. Brush cutters will swath 6 to 12-inch trees which might be encountered amongst the brush. It is reported that the cutter illustrated above will do the work of 75 men in cutting brush. (Photo courtesy LaPlante-Choate Manufacturing Co., Cedar Rapids, Iowa.)

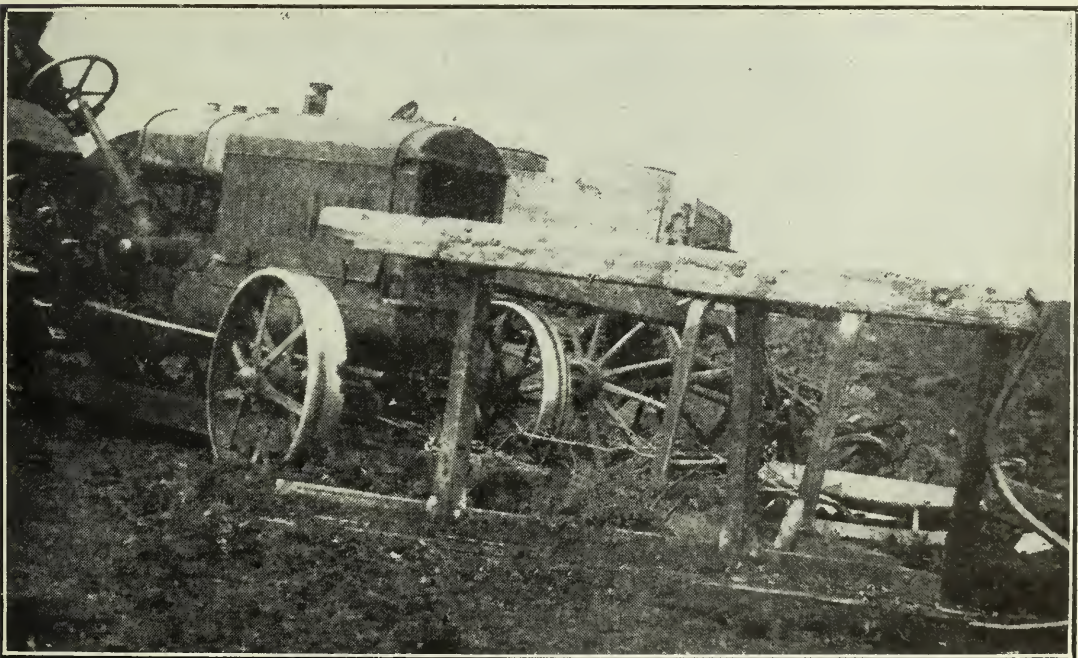
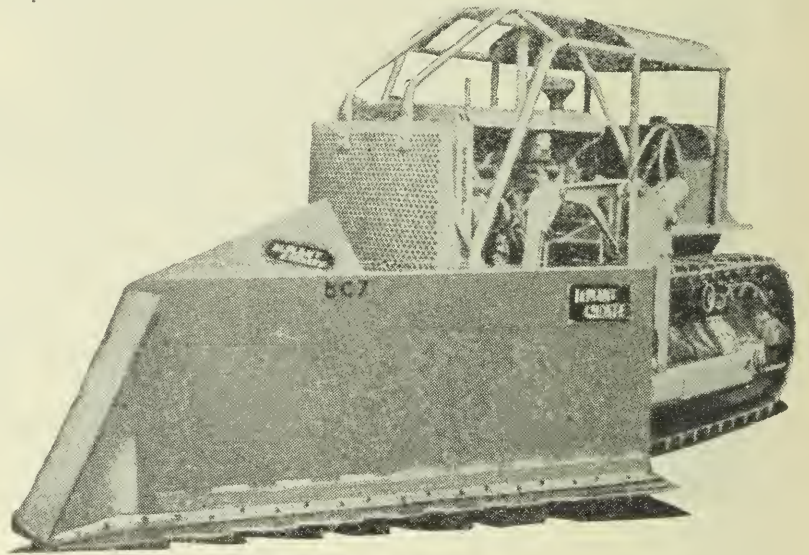


FIG. 11 (b).—Home-made Tractor Brush Cutter—Light brush cutters can be built and mounted on the front, side or rear of a tractor. This type of machine will cut 3-inch to 5-inch poplar brush, but is not sturdy enough for hardwood trees and is not entirely satisfactory for cutting heavy willows. (Courtesy of the University of Saskatchewan.)

tractor bulldozers were used to stump about 2,000 acres of land in the colonization areas of the Province of Quebec. Highway equipment has been used for custom work ploughing and land clearing projects in other parts of Canada.

In cases where time is an important factor in the clearing of land for crop production, power equipment can be used to advantage. On large projects, and where the cost of labour is relatively high, tractor equipment can be employed to reduce the cost of clearing land. Tractor bulldozers have proved very satisfactory for the removal of stumps in land clearing in Eastern Canada, and it is likely that they will come into more general use.

FIG. 11 (c).—Commercial Brush Cutter—A heavy duty brush cutter on a 40 to 60 h.p. tractor may be expected to cut poplar brush and light spruce at a rate of 10 to 20 acres of scrub poplar brush per day or 5 to 10 acres of poplar cover measuring up to 10 inches in diameter. The rate of operation varies considerably, however, depending on the tractor power and conditions of operation. Custom rates for machine, operator and fuel usually range from \$2 to \$10 per acre, depending on the brush cover.



Brush Cutters

Where land is covered with scrub brush or softwood trees having a diameter of approximately 12 inches or less, power brush cutters are now used in clearing operations. Brush cutter attachments closely resemble V-type snow ploughs, except that they carry two heavy sharp blades which are given a longer slope than the blades of a snow plough. The cutters are usually mounted on track-laying tractors having a draw bar rating of 50 to 75 horse power when they are to be used in heavy brush but small cutters are also being used on wheel tractors when the brush cover is light.

Brush cutters are best adapted to brush land which has very few large trees amongst the brush. Although heavy cutters can cut 4- to 8-inch trees in a single cut and 12- to 14-inch softwood trees in two cuts, a large number of heavier trees interfere with brushing operations unless removed previous to brushing operations. When operating under favourable conditions, a heavy cutter might be expected to swath from $\frac{1}{2}$ to 3 acres per hour depending on the density of the cover. It is estimated that a cutter working in favourable conditions will do the work of 50 to 100 men. In softwood brush, customs rates might range from \$6 to \$13 per hour for operator, tractor and operator.

Commercial brush cutters are sturdy machines and very effective in heavy clearing but because of their cost they are usually owned by custom operators or public agencies. In areas with softwood brush which is relatively light, home-made cutters have been made in various forms depending on the materials at hand and according to the power unit involved. Home-made units resemble commercial cutters and consist of V-blade units ranging from 6 to 10 feet in width. On cutters which are 8 ft. wide, each blade is about 6 to 7 feet long. The cutter is usually connected to the tractor by two heavy beams slung under the tractor or on each side of the tractor. The rear ends of the beams are attached to the draw bar and the front ends are attached to the cutter. When the beams are slung under the front axle of the tractor, the cutter is usually



FIG. 12.—Power Brush Rakes. Bulldozers with grubber teeth or brush rakes can be used to grub out brush or sweep brush and scrap wood into piles. (Photo courtesy LaPlante-Choate Manufacturing Co., Cedar Rapids, Iowa.)

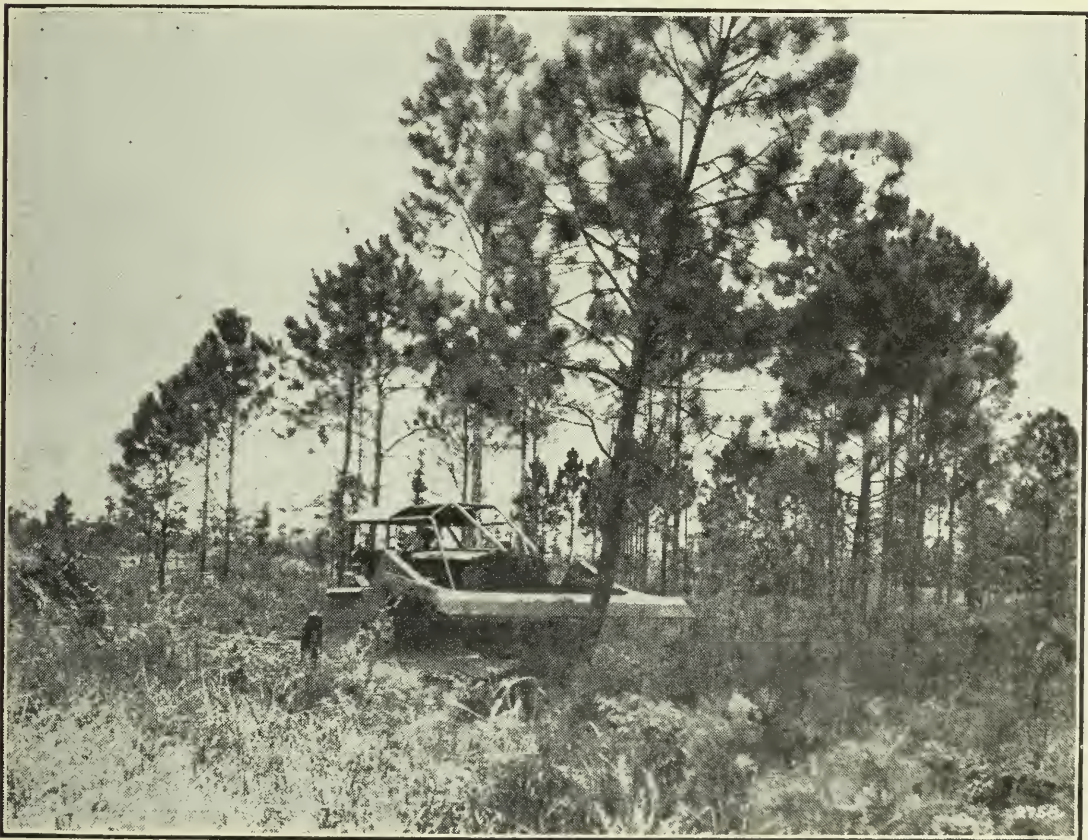


FIG. 13.—A Tractor with Tree-dozer Attachment. In large land-clearing projects tree-dozer are sometimes used to speed up the clearing operations. (Courtesy LaPlante-Choate Manufacturing Co.)

hinged to the beams so that the nose of the cutter can be raised or lowered. The nose of some cutters rides on broad flat shoes, while the nose of other cutters is supported from a frame on the tractor with a chain block so that the nose can be raised or lowered. The cutting blades are made of high quality steel and are bolted to heavy supports. Some cutters are built to mount on bulldozer frames. In some instances angle dozer blades have been sharpened and used as cutters and occasionally horizontal cutter blades have been fastened to the bottom of angle dozers for swathing brush.

Power Grubbers, Sweeps and Tree-dozers

Bulldozer blades when fitted with a set of chisel shaped teeth can be used as a power rake for collecting brush or as a grubber to remove roots. This type of equipment has been used in Eastern Canada and appears to have good possibilities for brushing and grubbing in alder brush land. As yet there is no information available on the burning of roots and brush collected in this manner and although the teeth of the grubber are designed to collect a minimum of soil, it is evident that the mixing of too much soil with the brush would interfere with burning operations.

Push sweeps or pilers are used for the collection of brush and usually consist of a unit with a few heavy horizontal stub teeth and a vertical tractor shield or push plate. Piling with power sweeps usually costs from \$1.50 to \$4.50 per acre depending on the cover and on conditions of operation.

When brush is cut with power units, piled, burned and the land broken in one year, the cost of these operations is much more costly than when some time is allowed between operations. By swathing down the brush the first year and then burning the brush and subsequent growth of grass the second year, piling of the brush is eliminated.

Tree-dozers are being used by contractors in large land-clearing projects in the United States. This type of equipment will remove trees from the soil under a wide range of conditions with a minimum of labour, and at a low cost per acre. Tree-dozer units are probably most suited to districts where the timber is of little commercial value, but do not appear to offer much assistance in land clearing operations where it is desirable to recover lumber logs and pulpwood.

Bulldozers for Stump Removal

A bulldozer consists of an adjustable steel blade about 10 feet long, mounted on the front end of a tractor. This equipment is not new as it has been used extensively for moving earth and stone in the construction of roads. Tractor bulldozers are more widely used than any other type of power equipment and have proved very satisfactory for removing stumps.

The method of operating a bulldozer is very simple, being no more involved than operating any track-type tractor. Moderate sized stumps are removed in two operations. First, the blade is hoisted to catch the top of the stump to push it over. The tractor is then moved back and the blade is lowered while the machine moves forward to catch the stump below the roots, and hoist it completely out of the ground. The above mentioned operation requires about 60 seconds when 5-year-old jack pine stumps 12 inches in diameter are being removed. Old stumps can be lifted out in one operation by engaging the stump at the base with one corner of the blade.

Windrows of stumps can be built up if desired by simply pushing the uprooted stumps into rows with the bulldozer. The use of a bulldozer for carrying stumps from a field will be governed by the cost per hour of the machine, the amount of land to be cleared, and the speed with which the clearing operations must be carried out. Although the bulldozer eliminates heavy work in removing the stumps, the economy of windrowing may be questionable, as it is possible for the settler to haul the stumps from the field with a sled and team.

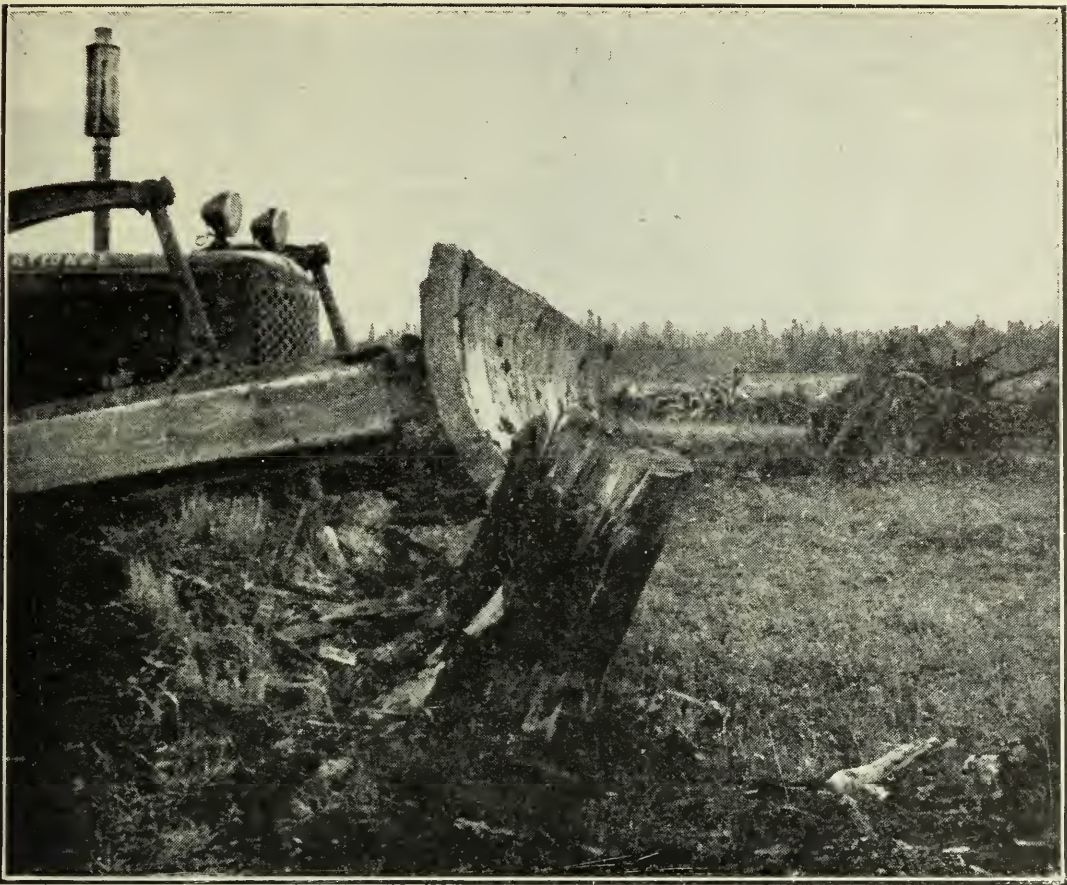


FIG. 14.—Removing Stumps with a Bulldozer.—To loosen the stump the blade is first used against the top of the stump. The stump illustrated is 19 inches in diameter and 3 to 5 years old.



FIG. 15.—Lifting Out a Stump with a Tractor Bulldozer.—After loosening the stump, the blade of the bulldozer is lowered to catch the base of the stump. The blade is raised as the stump is hoisted out. The stump in this photo was removed in 60 seconds.

Large stumps can be handled by the bulldozer in several different ways. If the tractor cannot push the stump over with one or two bunts, the corner of the blade can be lowered and used to cut the large roots by several strokes along the sides of the stump. If desired, a stump splitting arm can be employed to divide the stump, in order to remove it in two sections. Blasting has also proved to be an economical supplement to bulldozing work in handling large stumps. A small charge of explosives in any stump which appears to be too heavy for the machine will split the stump so that a bulldozer can handle it easily. Splitting of large stumps also makes them easier to remove from the field on a sled. Farmers who hire bulldozers for removing stumps have found that money can be saved by the use of explosives. It was found, in observing land-clearing operations, that 45 horsepower bulldozers removed satisfactorily 5-year-old jack pine stumps 12 to 18 inches in diameter. Bulldozers with 65 horsepower were suitable for 18-inch to 25-inch stumps in the same conditions.

Green stump removal with bulldozers is, of course, more costly than the removal of old stumps. When lifted, a green stump carries with it much soil, making it necessary to back fill the stump hole. Where the land clearing must progress rapidly the bulldozers can be used to bunt the stumps in order to remove the dirt before they are swept into windrows. Small charges of dynamite may also be placed in the stumps to remove the dirt from the roots. If time is not pressing, however, the stumps can be left in the field over the winter to let the frost action remove the soil.

Bulldozers appear to accomplish the most work per dollar if used on stumps which are about 3 years old, but when balancing the cost of removing green stumps against the loss of crops while the stumps are allowed to age in the field, the removal of green versus old stumps may be a debatable subject.

Boulder stones have been removed from land by bulldozers in some sections of the country. A 45-horsepower machine can roll stones 5 feet in diameter if the land is reasonably firm. Stone removal, however, takes considerable time and this practice of handling boulders is only feasible in special cases.

Operating Costs for Power Equipment*

Due to the wide variety of conditions in land clearing work, equipment costs are usually calculated on an hourly basis. As with other equipment, the cost of operation will depend on the number of hours of operation per year and on the type of work involved.

The total cost of operating a 70-horsepower tractor bulldozer when the unit is used for stumping throughout the summer season is about \$5.00 to \$7.00 per hour. This figure includes depreciation, fuel and the operator's wages. Tractor bulldozers having a draw bar rating of 45 horsepower may cost from \$4.00 to \$6.00 per hour.

Tractors of the 45 horsepower class have proved very satisfactory for removing moderate sized stumps which are 3 to 6 years of age, but tractors of the 70 horsepower class are preferred when removing green stumps. When working on land in northern Quebec, which had about fifty 3-year-old, 10- to 24-inch jack pine stumps per acre, or about 150 smaller size spruce stumps per acre, bulldozers cleared 4 to 8 acres per day. In the above-mentioned conditions the cost per acre for removing stumps varied from \$7.00 to \$25.00, with an average cost of \$8.50 per acre.

Reliable figures on the cost of operating other types of land-clearing equipment are not at present available, but the cost of these units may be based on the cost of operating bulldozers in stump removal. In the operating costs given above, the tractor cost is about 75 per cent of the total cost, and 10 per cent of the cost is operator's wages. The tractor costs include depreciation, fuel

*See also section on Land Clearing Costs.

and oil. The remaining 15 per cent may be considered the cost of the bulldozer attachment. When considering other equipment the cost of the attachments can be calculated according to the value of the unit involved.

Municipal, Co-operative and Custom Work.—Since tractor-powered equipment for land clearing requires a heavy capital investment, the equipment is usually owned by municipal or co-operative organizations. As the cost of the tractor, however, is the greater part of the equipment cost, individuals and contractors who own track laying tractors are now doing custom land clearing work for farmers in some areas.

The cost of tractors suitable for land clearing operations normally ranges from \$4,000 to \$8,000 in Canada. Bulldozer attachments for these units may cost from \$1,500 to \$3,000 each, while bulldozer rakes and brush cutters are priced at about \$2,500 and \$3,000 respectively.

BLASTING

Explosives can be used to advantage in removing both stumps and stones in land clearing operations. Although they are sometimes used exclusively for the removal of large stumps, it is usually more economical to combine the blasting with other methods, such as stump pullers or bulldozers. The amount of labour required for placing explosives is very small, the tools for handling them are inexpensive, and the explosives can be used on a few scattered stumps as well as on many stumps in large or small land-clearing projects. Blasting materials, however, require the outlay of cash and, while there is an element of danger connected with the use of explosives, experience has shown that they can be handled with safety.

Uses for Explosives

Where labour is expensive, or where it is not advisable to purchase stump-pulling equipment because there are only a few stumps to remove on a small area, explosives can be used to lift stumps completely out of the soil. In this method of blasting the cost of explosive per stump is naturally high and it is necessary to fill the stump holes before the land can be cultivated. Heavy charges of explosives are also used on stumps which are so scattered that anchorage cannot be obtained for stump pullers, and where the acreage will not justify the use of such equipment as bulldozers.

Explosives can probably be used to the best advantage for loosening or splitting heavy stumps which are being handled with various types of stumping equipment. When bulldozers, stump pullers, block and tackle, or tractors are being used in the clearing operation, heavy stumps are often encountered, which the machine cannot handle readily. Small charges of explosives under these stumps will loosen or split them so that the equipment may remove them easily. Stones that are too heavy to handle conveniently can also be broken with explosives so that the equipment on hand can remove them from the field.

If large green stumps are to be removed from the land immediately after they are pulled, a small charge of explosives can be used to blast the earth from the stump, or a charge may be used to split the stump in half so that one or two horses can pull the stump to piles for burning. (For further information on the splitting or removing earth from stumps, refer to the section entitled "Stump Removal".)

Explosives and Blasting Supplies

There are two types of explosives on the market which are suitable for land clearing operations, namely, slow acting or stumping explosives, and rapid acting explosives, which are used for stone blasting. Slow acting explosives for the

removal of stumps are usually put up with strengths of 20 to 60 per cent, and they are especially designed to give a slow heaving action which is particularly effective for stump blasting. Standard 20 per cent stumping explosives are recommended for inexperienced blasters since they are probably the least sensitive of any explosives on the market. Special water-resistant explosives can also be obtained if they are required. Quick acting explosives for boulder blasting are obtainable in 25 or 40 per cent strength, and these have a high shattering effect, which is desirable for stone breaking.

Explosives are sold in boxes containing from 125 to 150 sticks of powder, the sticks being 8 inches long and $1\frac{1}{4}$ inches in diameter. Safety fuse is sold in packages containing 100 feet of fuse which will burn at a rate of 30 to 40 seconds per foot, depending on the brand obtained. The burning speed of a fuse can be determined by lighting a 3-foot length of fuse and timing the burning rate. Sufficient fuse should always be used to allow time for the blaster to retreat a safe distance before the charge is ignited. All safety fuse is sensitive to heat, cold, and dampness and it must be handled with reasonable care and stored in a dry place. Dampness may slow down or stop the burning of the fuse, and kinking or twisting will break the powder line, causing hazardous failures in the blasting operations.

Caps for fuses are sold in small tin boxes containing 100 caps. Various strengths of caps can be obtained but No. 6 caps are recommended for use with stumping or boulder powder. If explosives are to be ignited by the electric method, electric caps with 4 to 6 feet of electric lead wire are required. Electric caps are obtainable in boxes of 50, No. 6 strength being commonly used. Remember that ignitor caps contain sensitive explosive materials and that they must be handled with care and must be kept entirely separate from blasting powder until the charge is laid. They should always be carried in a suitable box, kept under lock and key when stored, and must never be accessible to children as the caps can be ignited easily.

Electric blasting machines are small generators used for igniting one or more charges of explosives which are laid with electric caps and connected with electric wires. The electric method of igniting explosives is positive and, from the viewpoint of safety, is superior to the fuse method. Electric machines are, therefore, highly recommended where there is a large amount of blasting work to be done. These machines can be purchased from companies manufacturing explosives, or rented from explosive distributors. A blasting machine is not a storage battery, but a generator which functions only when the firing handle is turned. Six-volt dry batteries and No. 14 copper lead wire are sometimes used to ignite one or two electric caps, but they are not ordinarily recommended because someone may neglect to disconnect the wires from the battery when inspecting a charge of explosives. Blasters who use a battery carry the battery on their person at all times so that there is no danger of the wires being connected to the battery except at the moment when the charge is to be fired.

Tools for Blasting

Blaster's pliers or crimpers are inexpensive yet will prove very useful for properly cutting fuse, crimping caps to the fuse, and for punching a hole in the primer cartridge when placing the cap.

The other tools needed for agricultural blasting are a shovel, a crowbar, a soil auger and a wooden tamping stick. In soft soil the crowbar can be used to punch a hole under the stump, while a 2-inch auger is desirable for making holes in hard clay soil. A wooden tamping stick, such as a fork handle, should always be used for tamping the charge under the stump and for packing the soil on top of the charge.

Making a Primer Cartridge

In order to ignite the explosives in blasting it is necessary to make a primer cartridge which consists of a cap, a length of fuse, and a stick of dynamite. The cartridge is made as follows:—

Cutting the fuse.—With a sharp knife or cap pliers, cut off a length of fuse, making the cut square and clean. Inspect the length of fuse to see that it is in good condition.

Crimping the cap to the fuse.—Take one cap from the cap box and push the square end of the fuse firmly into the cap. While holding the cap firmly in place, crimp the skirt of the cap on to the fuse with the crimping pliers.

Punching a hole in the cartridge for the cap.—With the handle of the pliers, or with a round stick of wood, about three-eighths of an inch in diameter, punch a hole in a stick of dynamite. The hole should be made so that the cap will be located in the centre of the explosive material when the cap is inserted.

Tying the fuse and cap to the primer Cartridge.—Tie a piece of binder twine around the fuse near the cap, push the cap into the cartridge, and bind the fuse securely to the cartridge. It is very important that the cap should stay in the cartridge when the explosives are being placed under a stump or stone.

Lighting a fuse.—There is a knack in successfully lighting the end of the fuse, which is nothing more than getting the first flare of the match to start the powder train. Prepare the fuse by splitting it at the end to expose the powder. Hold a stone or small match box and the end of the fuse in the left hand, strike the match, and quickly push the head of the match into the end of the fuse. The spitting of the powder will indicate the burning of the fuse. If for any reason a charge of explosives does not explode, **never, never** inspect the misfire for at least 24 hours. Practically all accidents are caused by investigating misfires too early. The moral is, handle and place explosives so that there are no misfires.

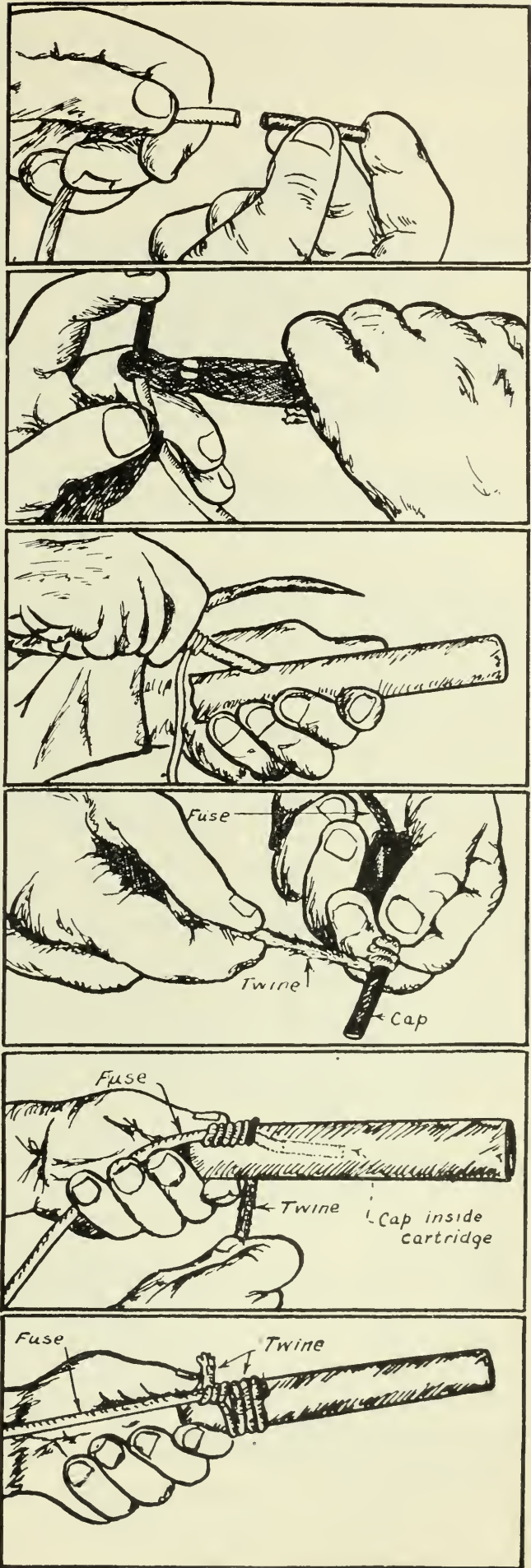


FIG. 16.—Preparing a Primer Cartridge.

Blasting Stumps

The efficient and effective use of explosives depends on the proper placing of the explosives, and on estimating the proper amount of explosives to use.

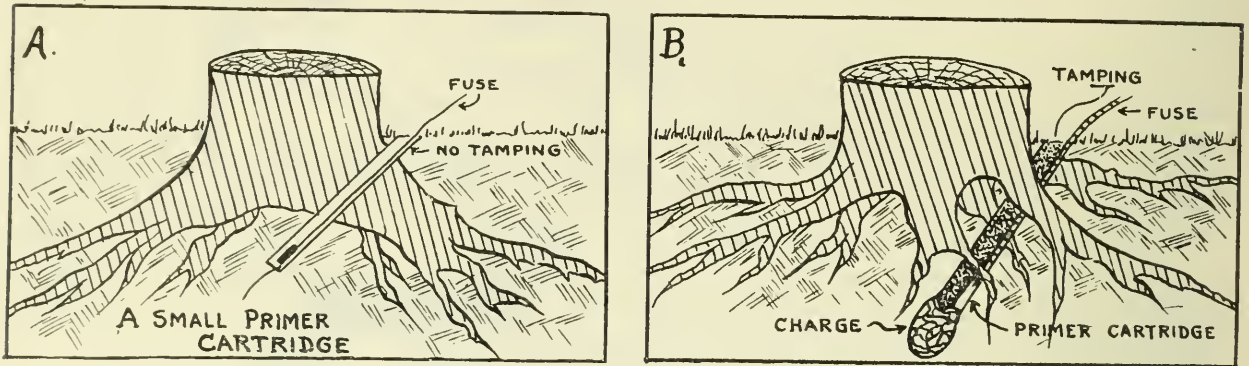


FIG. 17.—The Correct Placement of Explosives—A small charge of explosives can be placed under a stump (A) to blow the hole for a larger charge. Illustration (B) shows a complete charge in place.

Placing the charge.—Always study the root system of a stump by probing the soil with a crowbar to determine the arrangement and size of the roots. The charge should be located about 12 inches below the main body of the stump, or at this depth and slightly to one side, according to the root system.

A borehole can be made with an auger or a crowbar. If this hole is not large enough for a heavy charge, lower a primer cartridge into the hole, light the fuse, and blow the borehole to increase its size. Do not fill the hole above the cartridge when blowing a borehole, and wait 30 minutes to let the hole cool before setting the charge. After the borehole is made push the tamping rod down the hole to remove any obstruction. If the hole is relatively dry, slit the paper sides of the explosive sticks with a sharp knife, and slide them down the hole, pressing each stick into place with a wooden tamping rod. Next, slide the primer cartridge down the hole or gently push it into the hole with a tamping rod, without jarring the cap. Gradually fill the hole with moist earth, pressing the earth firmly into place, taking care not to damage the fuse. Hold the fuse cord in the left hand while filling the hole. Before firing the charge, be sure that no one is standing too close, and that the dynamite supply is at a safe distance. Light the fuse properly and retreat a distance of at least 300 feet from the charge.

In cases where the soil has some free water the cap must be protected from moisture. After crimping the cap to the fuse, smear the joint with soft soap or heavy hard oil to seal the fuse and cap. Take particular care in placing the primer and fire it immediately after it has been placed.

Amount of Stumping Dynamite Required

The amount of dynamite required for stumps depends on several factors—old stumps require less powder than green stumps, light, sandy soils need more powder than damp clay soils, the cracking of stumps requires less powder than complete stump removal, and fewer sticks of high-strength powder are required than low-strength powders. The following figures will act as a guide when using 20 per cent powder to lift out solid stumps.

Diameter of stump in inches.....	8-12-18-24-36
Number of sticks of dynamite.....	2- 3- 5- 9-14

Blasting Boulders

There are three common methods of blasing boulders. (1) Mud capping is used when the stone is on the surface of the ground; (2) ordinary snake holing is used to lift the boulder on to the surface of the ground; (3) contact snake holing is used for lifting the boulder and breaking it.

Mud Capping.—Boulders which are near the surface of the ground can be broken by placing a charge of dynamite on the top of the boulder. To get the best effect from the blast one side of the boulder should be lifted with a crowbar, and a small stone placed below it to leave a space between the boulder and the ground. Boulders, 2 feet thick and 3 feet across, require about 2 sticks of 40 per cent boulder dynamite for shattering.

To set a charge, scrape the earth off the top of the boulder, split the wrapper of all the dynamite sticks, except the primer, lay the charge and the primer in close contact, and cover with at least 8 inches of moist soil. On many stones the primer charge is all that is required. Never use less than 18 inches of fuse line for blasting boulders.

Ordinary Snake Holing.—Where a boulder is to be lifted out of the ground, place the charge in the soil about 6 inches below the boulder in a similar manner to the laying of a charge below a stump.

Contact Snake Holing.—In order to scatter and lift a boulder which is in the soil, it is necessary to dig a narrow trench below the boulder and place the charge in contact with the stone. Fill in earth under the charge to hold it against the boulder, and then fill the trench with earth, taking care not to damage the fuse. About 1 or 2 sticks of 40 per cent boulder dynamite and the primer are needed to lift and shatter a boulder that is approximately 3 feet in diameter.

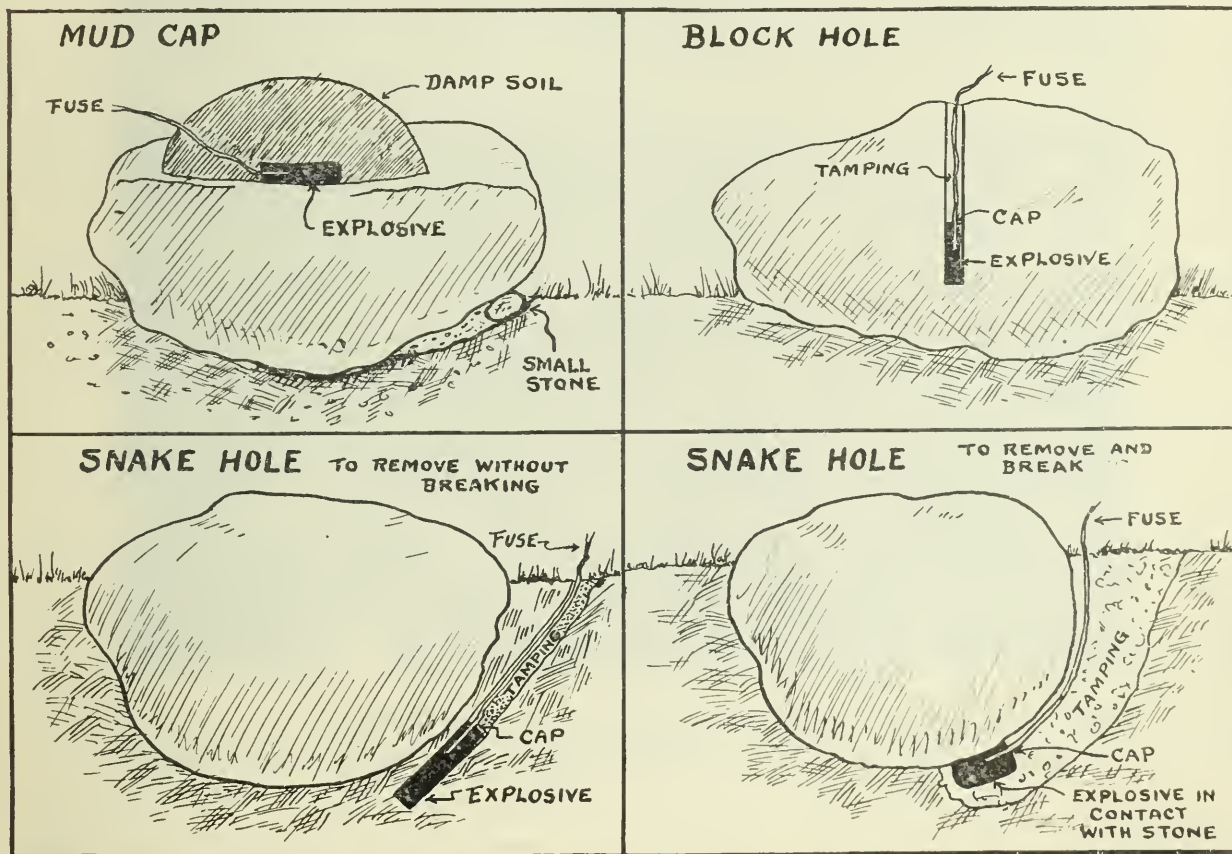


FIG. 18.—Methods of Blasting Boulders.

The Cost of Explosives

Due to the wide range of application of explosives in land-clearing operations, the cost of explosives cannot be figured on an acreage basis, but the cost of each charge may be estimated. A primer cartridge, that is, one stick of stumping explosive, a cap and 2 feet of fuse costs about 10 to 12 cents. Additional sticks of explosives for the charge will cost from 6 to 8 cents each, depending on the quantity purchased.

Stumping dynamite can be obtained in 50-pound boxes which carry the standard first class freight rates on railways. An electric blasting machine, if required, can be purchased for \$35 to \$55. Ordinarily any person can purchase explosives through local hardware stores, but in war time there are restrictions or regulations regarding the purchase of such materials. Dealers or manufacturers will gladly supply information on this topic at any time. At the time of writing, it is necessary to present an explosive permit signed by a police official when obtaining explosives.

STONE REMOVAL

Although land clearing is primarily a problem of stump and brush removal, the removal of stones from land is important in some districts. Unless the stones are removed, farm operations are hampered; good tillage is impossible; and the replacement cost of farm machinery becomes unnecessarily high.

Disposal of Field Stones

In cases where land contains stones which are relatively small, the removal of stone involves considerable hand work. As yet there appears to be nothing better than a stone boat or a low slung wagon for this job. A stone boat



FIG. 19.—Stony Land—Stone removal is part of the land clearing operations in many districts. The land illustrated was cleared of timber and ploughed with a single furrow tractor mounted plough. The stones will be removed by hand, using a stone boat or low wagon.

made from wood or a sheet of steel can be loaded easily and will carry about one-half ton of stone. Although this implement makes possible the removal of large rocks, it is often desirable to break the rocks with a sledge hammer

or with dynamite, to eliminate the lifting of heavy stones. At times it is possible to dig the stone boat down to load a heavy stone, or a chain and horse may be used to roll the stone on to the boat. Since a stone boat carries a relatively small load, it is only suitable for hauling short distances. As the length of the haul increases, the advantage of easy loading becomes relatively less significant and it is desirable to use a wagon to remove the stone efficiently.

Nothing better than a low slung, home-built wagon has yet been designed for hauling stone. The low wagon is made from the axles and wheels of an old wagon by suspending two logs 11 feet long below the axles and about 8 inches



FIG. 20.—Home-made Low Wagon for Stone Removal—Low wagons can be loaded easily and are more satisfactory for hauling stone than a stone boat when the hauling distance is over 150 to 200 feet. (Printed from University of Minnesota Bulletin No. 250.)

from the ground. At the front the logs are bolted together and suspended from the centre of the front axle with a chain. At the rear the logs are spread to the width of the rear axle and supported by two heavy pieces of strap iron which go over the top of the axle and attach to the logs at either side. Wooden blocks are then fitted between the logs and the rear axle. A plank floor is built on top of the logs. When loading heavy stones, a stout plank can be used for rolling the stones on to the floor, which is only about 14 inches above the ground.

The old practice of building many stone piles in the fields is obsolete, since by such a method the stones are only shifted and the stone problem is not solved. Numerous stone piles and stone fences, other than line fences, restrict the use of labour-saving farm machinery. Almost any farm has a ravine or depression where stones can be deposited and covered with earth if desired.

In stony land the picking of stones is not confined to one operation. During the crop rotation it appears best to pick exposed stones off the sod land before it is ploughed. If time is available after ploughing, stones turned up by the plough can be removed, or they may be picked after a crop such as corn or roots where the cultivation brings them to the surface. When small 2- or 3-inch stones are being handled, a manure fork sometimes proves useful in loading and unloading the wagon.

Removing Boulder Stones with Cultivators

Many rough pastures in Eastern Canada are filled with boulder stones weighing from 100 to 400 pounds, which are embedded in the soil. Ordinarily

these stones must be pried or blasted out of the ground before the land can be satisfactorily ploughed, and this requires much hand labour. Power-lift, tractor-mounted, stiff-tooth cultivators may be used very effectively in dislodging these stones. To remove a boulder which is protruding slightly above the ground, the cultivator is lowered as the tractor straddles the stone. When the cultivator teeth catch the stone, and the tractor moves forward, the cultivator is hoisted to lift and roll the stone on to the surface. By this method, flat stones measuring about 10 inches by 16 inches by 20 inches, can be easily rolled on to the top of the ground.

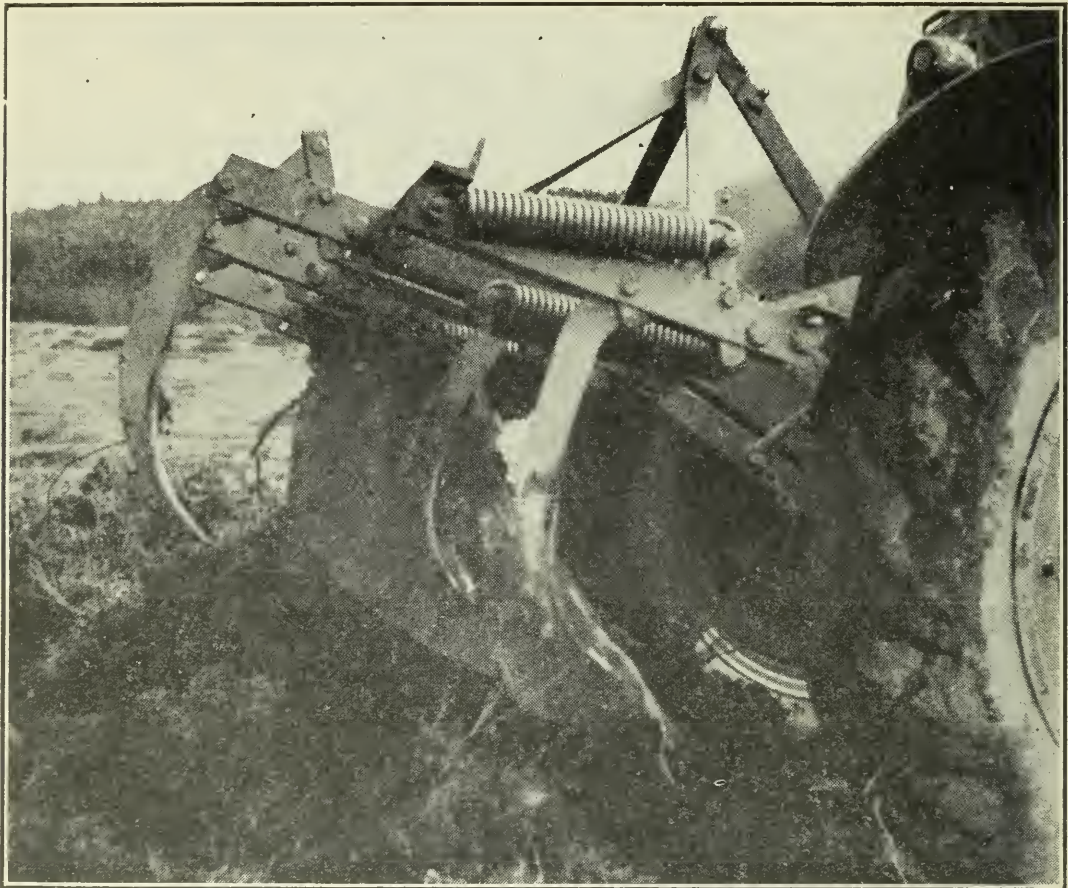


FIG. 21.—Pulling Surface Stone with a Tractor Cultivator—Tractor-mounted power-lift cultivators can be used to roll out flat stones which lie under moss knolls at the surface of the ground. The stone illustrated was about nine-tenths below the ground surface and weighed about 400 pounds.

Pulling Boulders with a Rolling Hitch

Large boulders which are imbedded in the soil near the surface can be rolled out with horses or a tractor by applying a rolling hitch to the stone. After digging the earth from around the boulder, a chain is placed around the stone and hooked together to form a loop so that the grab hook is located below the stone and close to one side. The draw end of the chain is then brought up over the end or side of the boulder, laid across the top, parallel to the loop of the chain, and the power is applied so that it is rolled upside down.

Bulldozers have also been employed to push or roll stones off the field where the stones are relatively numerous. Inasmuch as large boulders are only deposited in quantities in a few districts, this method of stone clearing is only feasible in special cases.

Explosives in Stone Removal

As with other land-clearing operations, explosives can be employed to assist in the handling of stones. Small charges of dynamite used on heavy stones

will break them and make it possible to handle the sections easily and economically.

Further directions for breaking and lifting boulders are given under the section entitled "Blasting".

Ploughing Stony Land

Light tractors equipped with tractor-mounted ploughs have proved useful in ploughing stony land, because the ploughs do not uncouple from the tractor when a stone is encountered. When a tractor-mounted plough has a power lift, stones of moderate size can be hoisted out of the ground during ploughing operations by lifting the stone with the point of the plough. After the stone has been hoisted the ploughing can be continued, leaving the stone exposed to be removed later.

The Cost of Stone Removal

Owing to the wide range of conditions and methods, cost figures on stone disposal can only be given for specific cases which have been recorded.

The cost of breaking boulders with explosives, hauling the pieces of stone off the field, and filling the hole left in the ground, averaged 4.3 cents per cubic foot of stone, according to Minnesota Agricultural College Bulletin No. 250. In this cost analysis the stones ranged from 21 to 100 cubic feet each, dynamite was valued at 8c. per stick, man labour at 30c. per hour, and horse labour at 15c. per hour. The labour required for removing stone was 1.6 man hours and 0.94 horse hours per cord (128 cubic feet) of stone removed.

In the removal of field stone and boulders where many stones were pried to the surface by hand, and where stones were picked up in three stages—before ploughing, after ploughing, and after disking—the following figures were obtained:—

Prying, 0.75 man hours; hauling (200 ft.) 3.8 man hours and 3.1 horse hours, and blasting, .17 man hours per cord of stone. The total for this field test, therefore, was 4.7 man hours and 3.1 horse hours per 128 cubic feet of stone. If an acre of land has 10 tons of stone, the stone removal may cost \$23 per acre.

When using a low wagon on sod land, two men and a team might be expected to load and haul off about 100 cubic feet of stone per hour, where the hauling distance is about 200 feet. With a stone boat, about 70 cubic feet might be removed under the same conditions. On broken land the volume moved may be reduced about 25 per cent. A low wagon will handle about 20 cubic feet of stone, and a stone boat about 10 cubic feet per load.

REMOVAL OF HUMMOCKS

In addition to roots, stumps and stones there are on many areas, particularly in Eastern Canada, fibrous hummocks which must be removed in order to allow for satisfactory cultivation. These mounds or hummocks are locally called by various names such as fairy knolls, moss hummocks, pasture warts or niggerheads. Very little information is available concerning their formation, and many and varied explanations have been given in regard to their origin. In some cases the hummocks are found built up around boulders protruding above the level of the soil surface. Ant hills have been found in the centre of some such mounds.

The most logical explanation seems to be that they are built up of the remains of plants, which start to grow on the organic remains of an old decayed stump or log, and growing in situ year after year deposit their remains at the base of their stalks. Certain mosses grow in this manner.

Each year as the growth is added the wind may blow silt and sand particles which become embedded in the moss and this provides the mineral matter found in the hummocks. Ferns are sometimes found growing on the mounds, as are also blueberry plants, lambkill, rhododendron, hard hack and huckleberry, and these may add to their quota of fibrous roots to the mass which goes to make up the hummock.

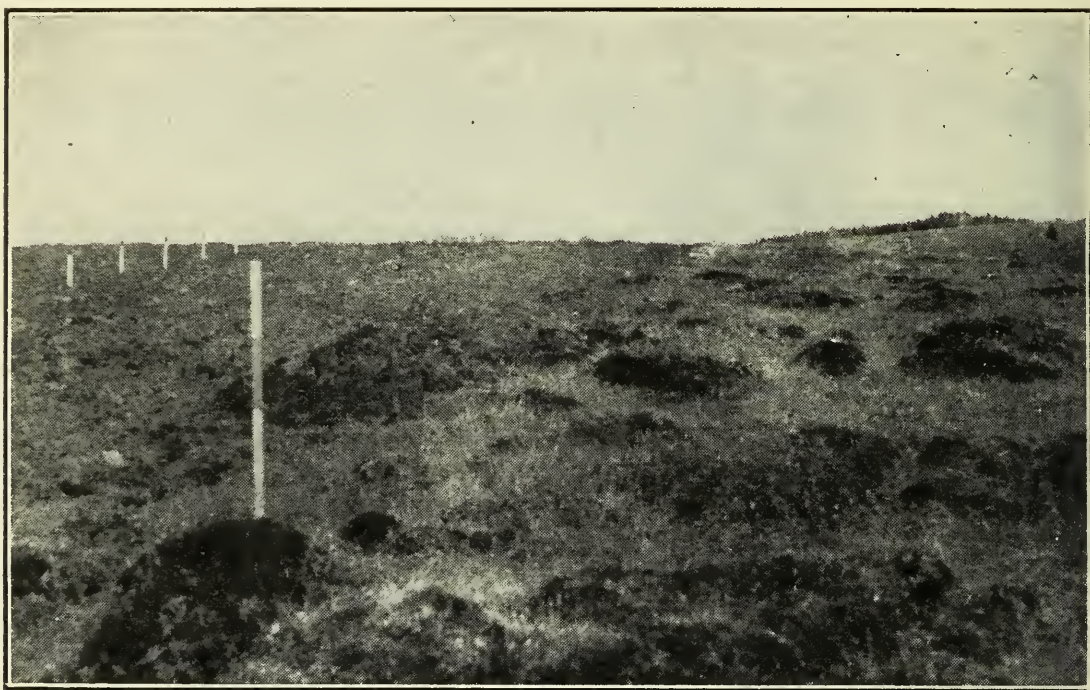


FIG. 22.—In addition to roots, stumps and stones, there are on many areas fibrous hummocks which must be removed in order to allow for satisfactory cultivation.

These hummocks are usually found in old pastures after they have been denuded of their forest growth. Once the hummocks have developed extensively the area becomes almost worthless as pasture land, and the hummocks must be removed to make the land productive.

Hummocks may vary in size from small round knobs 6 or 8 inches in diameter to large mounds 5 or 6 feet across and 1 to 2 feet deep. They are very heavy, fibrous and tough, and are difficult to break or cut into smaller pieces. The matted mass of roots and stems is confined largely above the ground level and the roots do not penetrate into the soil to any appreciable extent and therefore it is comparatively easy to detach the hummocks bodily from the soil. It is essential to tear out and remove the hummocks, since, as mentioned above, they are very fibrous and resist decomposition for a considerable period, and only become a nuisance if left on the land.

The smaller hummocks can be quite readily lifted or torn out by means of a mattock or a stiff-toothed fork, and loaded on a wagon to be drawn off the field. The larger mounds present more of a problem because of their heavy weight, and either horse or tractor power is necessary to tear them free. A very useful implement for use in this connection is a stone or root hook. This device is an arrangement with handles and a beam, similar to that of a plough, but in place of the plough point and moldboard two stout hooks are attached. These can be conveniently hooked into a relatively large mound and a sharp pull by a team of horses or a tractor will pull the hummock free. It can then be loaded on a stone boat and dragged off and piled in a convenient location near the field.

Another convenient means of lifting out these hummocks is by means of a tractor-mounted power-lift cultivator. The feet of the cultivator may be hooked slightly under one side of the hummock. The forward movement of the tractor acting at the same time as the power lift is set in motion, tears out the hummock by a combined lifting, rolling and folding action.

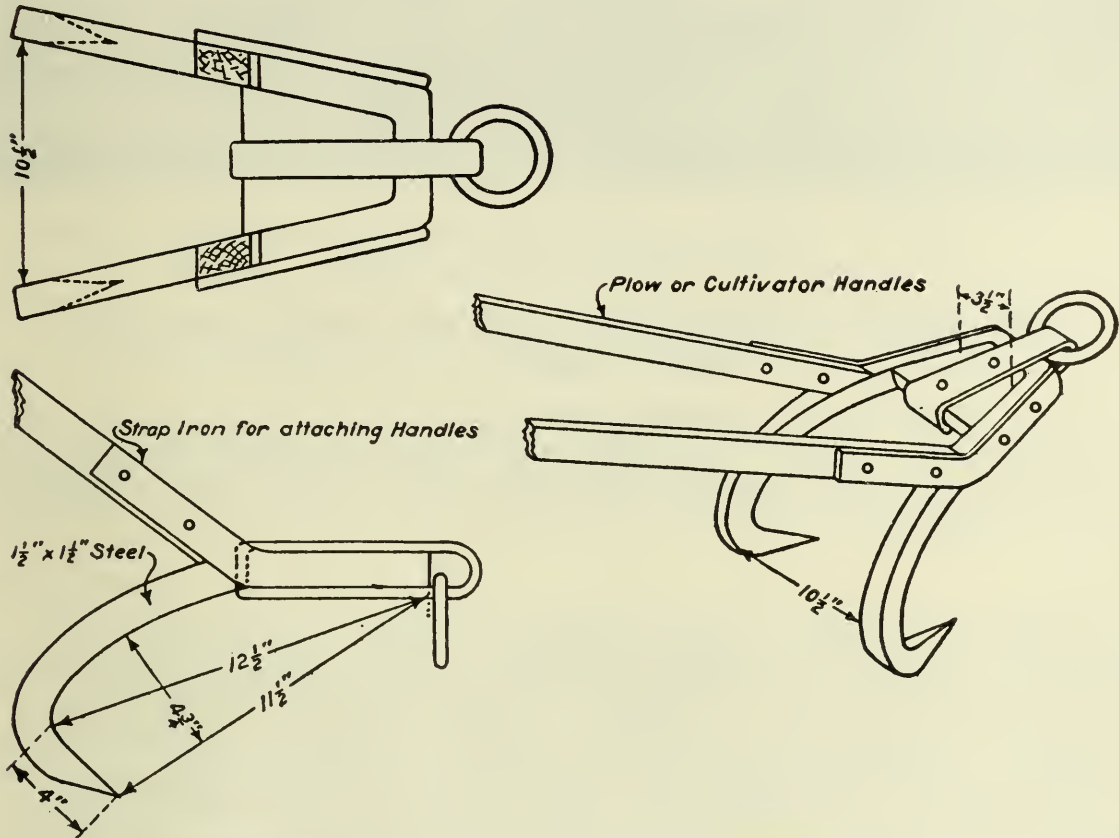


FIG. 23.—Root Hook—A hook of this style can be used for pulling roots or for removing moss hummocks.



FIG. 24.—Moss hummocks may be torn out with a root hook and drawn away on a stoneboat.



FIG. 25.—Another convenient means of lifting out moss hummocks is by means of a tractor-mounted power-lift cultivator.

PREPARING CLEARED LAND FOR THE PRODUCTION OF FIELD CROPS

If the job of clearing has been thoroughly done, the subsequent preparation of the land for field crop production is not materially different from that required on older cultivated land, since many of the same fundamental principles are involved.

Drainage

If field crop production is contemplated, before clearing operations are commenced, consideration should be given to the natural drainage in the area, or to the possibility of supplying artificial drainage with a minimum of expenditure. Land clearing at best is a costly undertaking and it is desirable if possible to avoid the necessity of installing an extensive drainage system which would add to the expense. If the land is too low, level and wet to permit of convenient drainage, it may be advisable to disregard it as poten-



FIG. 26.—If land is too low, level and wet to permit convenient drainage, it may be advisable to disregard it as potential field crop land.

tial field crop land and save the expense of clearing it by leaving it for whatever wood or timber growth it will produce; or by a small amount of ditching it may be used for pasture.

On many areas, however, the general drainage may be quite satisfactory, and only a few low spots or springy sections will require attention. It may be, if a suitable outlet can be found near at hand, that a short tile drain may be laid to drain such low spots. If there are several low spots it may be necessary to lay a short main drain and run laterals from it to the wet spots. If anything more extensive in the way of tile drainage is required it would be well to consult a competent drainage engineer.

If the cost of tile drainage prohibits its use, it is often possible to take care of the drainage by the use of surface drainage ditches. Such ditches should be located so as not to cut up the fields any more than is necessary. A relatively deep ditch may be located along a line where it is proposed to build a fence. This may serve as a main ditch and should be located at the lower end of the field with an outlet provided into some waterway at a still lower level. By ploughing fairly narrow lands down the grade to such a ditch, the dead furrows serve as drainage ways and will remove considerable of the surface water. Under some circumstances more extensive systems may be necessary and each cleared area may present its own problems in this regard, which would have to be solved as the necessity demanded.

Topography

The topography of the soil is closely related to drainage problems. Land may be too low, level and wet for ideal agricultural use. On the other hand if it is too rolling or hilly, clearing it of tree growth and attempting to cultivate it often results in such severe erosion that the soil is rendered useless for a considerable period thereafter. Very hilly land should be left in forest and only the fairly level or gently rolling land cleared and broken for crop production.

Ploughing and Disking, or Cultivating

All of the stumps, stones, brush and moss hummocks should be removed from the surface of the soil before ploughing is commenced. In Eastern Canada

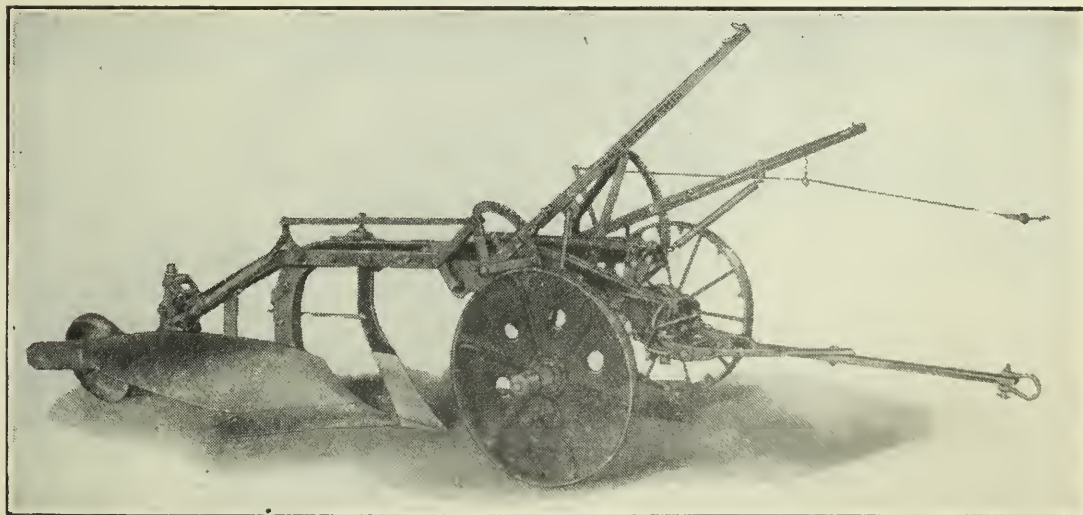


FIG. 27.—Tractor Breaking Plough—Heavy breaking ploughs with high throat clearance are desirable when breaking new land. These ploughs are built for 16-inch to 24-inch cuts for different sized tractors. The blade coulter illustrated is used on land which has small stumps and numerous heavy roots. A heavy breaking plough pulled by a tractor will split or turn a 5-inch to 7-inch jack pine stump which is three years old. Horse-drawn breaking ploughs are also available. (Photo courtesy Massey-Harris Co., Ltd., Toronto, Canada.)

breaking is usually done in the late summer or fall while land breaking in the early spring appears to be desirable for Western Canada. Few areas which are suitable for agricultural use are too rough to permit the use of a tractor when the surface has been properly cleared and prepared. Horse type breaker ploughs can be used for breaking land but the heavier high beam tractor ploughs are usually desirable for initial land breaking operations.

A tractor is the most satisfactory power for use in land breaking where relatively large acreages are involved. Possibly the tread type of tractor is more suitable but a wheel type may also be used with satisfaction. For use with the tractor a single-furrow plough with a fairly wide 16- to 24-inch bottom will do very satisfactory work. It is desirable also to have the plough equipped with a fairly long mouldboard to facilitate turning the furrow more completely. Where roots and stones are relatively thick a standard blade coulter is recommended. With smaller roots present or where there is a considerable moss cover a large rolling coulter is more serviceable. Such a coulter will cut the moss rather than tear it and will also cut the smaller roots. Where the land is stony or a considerable number of roots remain in the soil, it is very advantageous to have men following the plough to lift the stones and roots out of the furrow to the surface of the ground for removal later, and also to see that the furrow is completely turned where the plough has failed to do this. Custom charges for breaking which include tractor, plough, fuel and operator, usually range from \$4.00 to \$8.00 per acre.

After ploughing and removing any remaining stones, roots and parts of moss hummocks, the land may be disked. This may be accomplished with a disk harrow with as large diameter disk as possible. A 10-foot tandem disk is quite satisfactory for tractor use. An implement called a "bog disk" has been

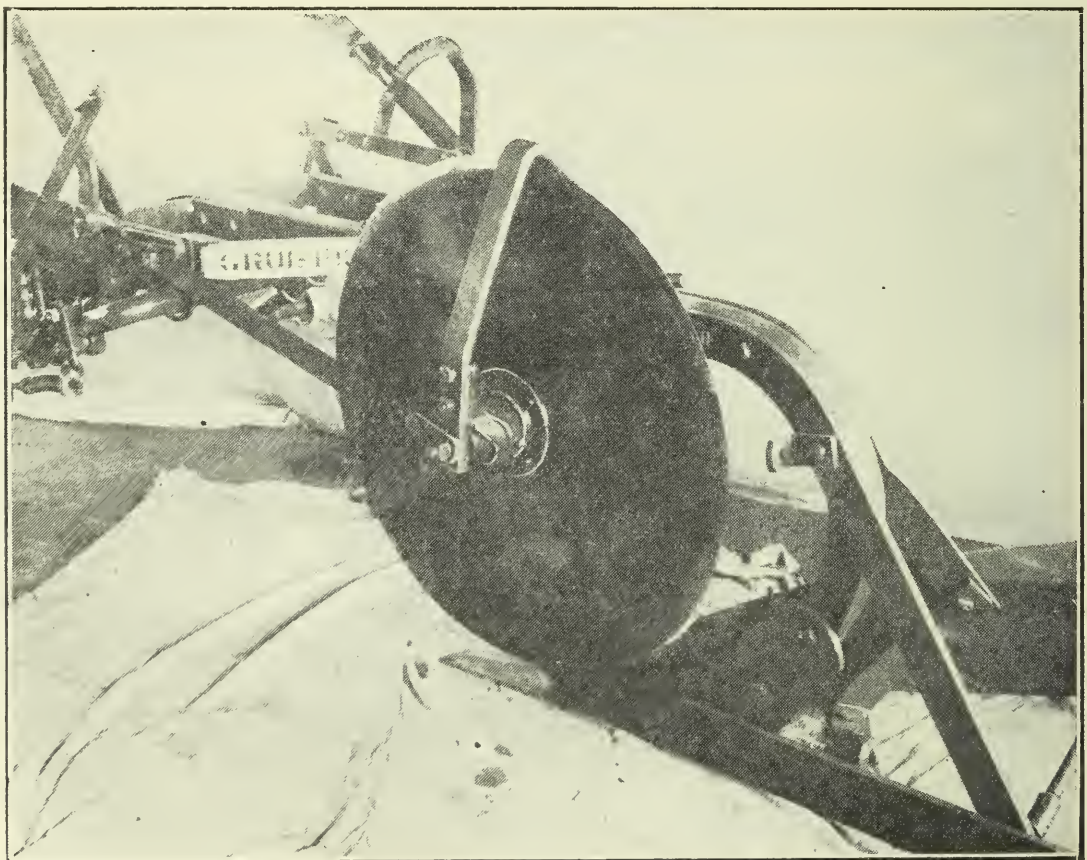


FIG. 28.—Rolling Coulter for Breaking Ploughs—Large disk coulters have proved very useful when ploughing land covered with moss. These coulters will cut moderate sized roots in the soil and will prevent clogging of the plough in most lands. (Photo courtesy Massey-Harris Co., Ltd., Toronto, Canada.)

found useful on very rough land. It is similar to an ordinary single disk, but is more heavily built and is equipped with disks about 22 inches in diameter. The disk tends to cut small roots and pieces of wood into smaller pieces which aids in increasing the speed of the decomposition process.

A good system to follow is to clear and plough the land in late summer, disk as often as possible and replough in the late fall. Disking and harrowing the land will tend to level it fairly well, but where extremely rough conditions exist, depressions may have to be filled or knolls levelled off by hand or by means of a horse- or tractor-drawn scraper.

Fertilizing and Cropping

If the ploughing and disking have been carefully done throughout the season, and an attempt should be made to only clear an area which can be thoroughly done, the land should be ready for a crop the following season. If manure is available an application of 12 to 15 tons per acre might be made during the winter and the land disked in the spring. Applications of commercial fertilizer will usually prove beneficial. For recommended rates and formulae for various soils and crops the reader is referred to Publication 585 of the Dominion Department of Agriculture, "Manures, Fertilizers and Soil Amendments," or to the recommendations of the various provincial fertilizer Boards or Councils. If the soil is sour or acid in reaction, ground limestone should be applied.

Various crops may be adapted for growing on newly cleared land, depending somewhat on the soil type and the type of farming being followed. It is often desirable to grow a crop of grain such as wheat, oats or barley, the first year. This may be seeded to a grass and clover mixture of red clover, alsike and timothy. In regions where alfalfa grows well some alfalfa seed should be added to the seed mixture.

Seeding in this way provides for one year of grain and two or three years for hay or pasture without the necessity of reploughing. This allows time for the decay of small roots, pieces of wood and plant refuse. A good stand of clover or alfalfa tends to improve the condition of the soil by increasing the nitrogen content. Following this treatment the area may be worked into the regular cropping plan of the farm.

COST OF LAND CLEARING

There are wide variations in the cost of clearing land due to soil conditions, timber cover, methods employed, equipment used, acreage involved and labour costs, etc. With these variations it is evident that average costs are of limited value in estimating the cost of proposed land clearing projects. In heavy timber the clearing of land by hand and team methods may cost \$250 per acre while the removal of scrub brush with power equipment may cost only \$10 per acre. Although hand methods of clearing lands are much more costly than power methods, the hand method will, no doubt, still be used in some instances when small areas of one or two acres are to be cleared.

Cost of Land Clearing with a Limited Amount of Equipment

The following data will give some idea of the costs of clearing land when hand and team methods are used for clearing operations in Eastern Canada.

Demonstration Farm, Monteith, Ontario.—In the development of this farm the land was cleared from virgin and cut-over timber land. Hand methods were used to remove cordwood, pulpwood and lumber logs. The brush was piled for burning and trash was destroyed by surface burning. The land was then seeded and the stumps were removed about 8½ years later by hand methods and blasting. This land had from 60 to 80 jack pine or spruce stumps per acre.

COSTS OF TIMBERING AND BRUSHING NINE ACRES ON THE MONTEITH FARM
(Ontario Department of Agriculture Bulletin No. 244)

Material	Amounts	Cutting	Skidding	Hauling	Roads	Totals
		\$	\$	\$	\$	\$
Lumber.....	22,642 ft.	36 88	28 58	17 25	2 72	85 46
Cordwood.....	30 cords	37 33	31 24	20 59	2 72	91 88
Pulpwood.....	50 cords	28 77	11 82	10 83	2 72	54 14
Brushing undergrowth.....						28 77
Axes, saws, etc.....						5 35
Milling lumber at \$4.25 per M.....						96 22
Total cost for nine acres.....						361 82
Average timbering and brushing cost per acre.....						40 20

COSTS PER ACRE OF CLEARING UP AND STUMPING ON THE MONTEITH FARM

Acres	Man Hours at 20c.	2-Horse Team Hours at 20c.	Explosives	Total
2½.....	127 hrs.—\$25.40	20 hrs.—\$4.00	\$9 64	\$ 39 04
Surface burning and cleaning up 15·2 hrs.....				4 36
Total cost for 2½ acres.....				43 40
Average cost per acre for cleaning and stumping land with 8½ year old stumps at 20 stumps per acre.....				17 36
Total cost per acre of timbering, brushing and stumping.....				57 56

Dominion Experimental Station, Kapuskasing, Ontario.—Five acres of timberland was cleared of lumber logs, pulpwood and cordwood by hand methods. The brush was piled and the land was then burned over to destroy the trash. Charging 35 cents per hour for teamsters, 34 cents per hour for labourers and 15 cents for horses, the cost of the above operations was \$40 per acre. In the same year the stumps were removed from one acre by pulling at a cost of \$63.00. The cost of the subsequent ploughing was \$10 to \$12 per acre. On the above project about 25 cords of pulpwood was removed per acre and the stumps ranged from 60 to 200 per acre. The stumps were jack pine and spruce, varying from 6 to 30 inches in diameter, and were pulled without the use of dynamite.

THE INFLUENCE OF THE AGE OF STUMPS ON THE COST OF REMOVAL
(Kapuskasing, Ontario)

Age of Stumps	Green	1 year	2 years	3 years	4 years
Year.....	1920	1921	1922	1923	1924
Cost per Acre.....	\$63 00	\$53 75	\$46 23	\$41 80	\$40 00

Cost of Land Clearing with Power Equipment

Where power equipment is used for land clearing the cost is commonly stipulated as the cost per acre or as the cost per hour of operating the equipment. On the basis of the cost per acre, there are variations due to land conditions, timber cover, etc., while on the cost per hour basis the variations are not so great since the operating cost of tractors and equipment is more readily defined than timber cover on land.

Under conditions favourable to the use of power land-clearing equipment, and where the acreage is sufficiently large to justify obtaining such equipment, the cost of clearing land by this method is much lower than by hand methods and much laborious work is eliminated.

The following table showing estimated costs will serve as a guide to land clearing costs when using power land-clearing equipment.

ESTIMATED COSTS OF CLEARING LAND WITH POWER EQUIPMENT
(Equipment Cost Including Depreciation, Repairs, Fuel and Operator)

Classification of Land or Operation	Equipment	Acres or Units Cleared per day	Equipment Cost per Hour	Cost per Acre \$
BRUSH CUTTING				
(a) Light cover, scrub brush, softwood, poplar etc. on firm well-drained land	Tractor 50-70 h.p. Brush Cutter	25-35 ac.	\$9-\$13	2.50- 4.50
(b) Medium cover, softwood up to 10-12'' on firm land	(as above)	15-20 ac.	\$9-\$13	4.50-6.00
(c) Heavy cover, softwood up to 10-12'' on firm land	(as above)	7-10 ac.	\$9-\$13	8.00-12.00
PILING WITH GRUBBER OR SWEEP				
(a) Light cover on firm land.....	Tractor 40-60 h.p. Sweep or Grubber	20-35 ac.	\$7-\$10	1.50-4.50
(b) Heavy cover on firm land.....	(as above)	15-20 ac.	\$7-\$10	4.50-6.00
STUMPING WITH BULLDOZER				
(a) Fifty, 3-year-old, 10-20'' Jack pine stumps per acre	Tractor 40-60 h.p.	4- 8 ac.	\$9-\$11	12.00-20.00
(b) 150 spruce stumps, 3-year-old, 8-12'' per acre...	Tractor 40-60 h.p.	4- 8 ac.	\$9-\$11	12.00-20.00
BREAKING LAND				
(a) Single breaker plough, softwood poplar stumps.	Tractor 40-50 h.p.	9-15 ac.	\$7-\$10	4.00-8.00
(b) Single breaker plough, dense small stumps.....	(as above)	3- 6 ac.		12.00-18.00

NOTE.—See also section on Power Equipment and Operating Costs.

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