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Costs of Clearing Land on Minnesota Farms

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INTRODUCTION

New information in agriculture derives from two sources—the labors of the investigators and the accumulated experiences of farmers themselves. The contribution of the farm operator comes largely within the field of farm practice and management. This bulletin is an analysis of the costs of reclaiming stump and stone land in northeastern Minnesota. The work was done entirely by farmers, on their own farms, but was systematized and closely checked to preserve and insure the accuracy of the findings.

Two types of men, the specialist and the farmer, clear land. The findings of the former are most exact and complete, but the standards set by trained men can not be universally applied in clearing private farms, as the job must be done when and as the farmer can. The farmer's labor and material costs on both light and heavy soils can be approximated, and these findings should be of first importance to new farmers who will do the same job under like conditions. To this end are assembled the results of 122 farmers in eleven counties (Fig. 1) in clearing 371 acres of stumps and stones.

The clearing of stump and stone land continues to be a live industry in fourteen Minnesota counties, from and in Beltrami and Clearwater counties eastward and Pine County northward. During the decade, 1920-1930, when agriculture generally was "marking time," 3,693 new farms came into being in this region—263 per county, 370 per year. Two counties showed a loss in number of farms, but every one showed an increase in cleared acreage. In number of farms, the maximum increase reported was 58.6 per cent, and the average increase for the 14 counties was 15.2 per cent. In 1930 there were 773,443 improved acres in the 14-county area; in 1935 the figure was 1,006,683, an increase of 233,240 acres, or 30 per cent.

In 1935 a Federal Farm Census was taken. The 14 counties that constitute the cut-over area of northeastern Minnesota reported an increase of 8,446 farms, or practically one-third in five years. The amount of increase in tilled acreage is a better basis for comparison. The new acreage in corn, potatoes, grain, and hay reached the impressive total of 215,963, more than 43,000 acres per year. If land clearing was an

[1] This project was conducted jointly by the Section of Land Clearing, Division of Agricultural Engineering, University of Minnesota, and the Bureau of Agricultural Engineering, United States Department of Agriculture.

A. J. Schwantes, B. H. Gustafson, Clarence Johnson, J. J. McCurdy, and Alvin Stinson rendered valuable service in early stages of the project. The hearty co-operation of 122 farmers made this project possible.

active occupation in 1920-1930, it was doubly so in the five-year period following, 1930-1935. Moreover, legislation, enacted in two states and contemplated in a third, whereby explosive may be paid for with labor, has resulted in a notable stimulation to land reclamation in the effort to keep the feed supply fully adequate for livestock needs. Therefore, the findings recorded in this bulletin, experiences gathered from more than 100 farms, on all soil types, and expressed in unchanging units of time and material, should be helpful to a large group of farmers, both new and old. As the farms already established are only one-third improved, the job is far from complete.

This bulletin is not concerned with the justification for clearing land. Its purpose is limited to finding the facts about this industry, which engages the labor of thousands annually, in the hope that a more adequate knowledge of these facts will enable other men to do a better job and at lower cost.

PURPOSE OF THE STUDY

The purpose of this study has been to determine the cost of clearing stump and stone land in the cut-over section of Minnesota: (1) In terms of units of labor and material per acre; (2) on the four major types of soil of potential crop value (sand, sandy loam, clay loam, clay); (3) following certain types of timber cover, usually associated with the distinctive types of soil; (4) under the four headings—brushing, stumping, breaking, and picking stones and roots; (5) where the owner does the work himself under supervision of the University. This enterprise involves two processes: (1) Classification and location of test fields; (2) scope and character of data recorded.

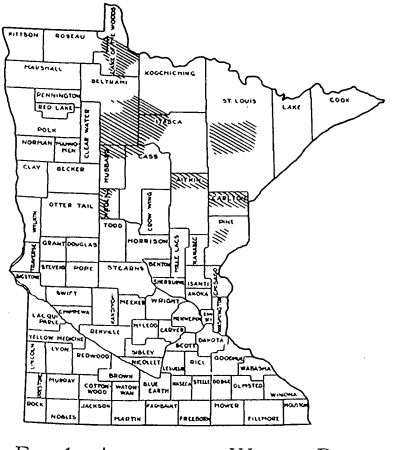

FIG. 1. AREAS FROM WHICH DATA WERE OBTAINED

CLASSIFICATION OF SOILS

When this work was begun, only a small part of the land in northeastern Minnesota had been soil-surveyed and mapped. Many types of soil exist in this region. Through the courtesy of the Division of Soils, the different types were grouped under four main heads for the purpose of this investigation. These are: (1) Sand, which shall be designated as type "A"; (2) sandy loam, type "B"; (3) clay loam, type "C"; (4) clay, type "D." As far as possible, the number of locations used was based upon the ratio of the number of acres of the given type to the entire

potential farm land. There were 33 co-operators on sandy soil, 17 on sandy loam, 56 on clay loam, and 16 on clay soil proper. Figure 1 shows the distribution of fields, by counties. The plots were chosen to secure as widespread distribution as possible, compatible with ease of supervision. The number of locations, by county, were: Aitkin 18, Beltrami 37, Carlton 12, Cass 1, Itasca 4, Koochiching 3, Lake of the Woods 12, Pine 1, Roseau 2, St. Louis 13, Wadena 6; not definitely recorded, 13. Differences in conditions of stumps and soils within each type together with the relative efficiency of the operator all have a bearing on the final cost. While these soils now bear a varied forest cover, certain forest crops are usually associated with each type. Type A grew jack pine in profusion and still does. Type B grew largely white and Norway pine. Type C produced balsam, birch, and white pine. Type D produced large white pine and some hard woods.

FARMER CO-OPERATORS

On Clay Loam Soil

Co-operators	Post Office	County	Co-operators	Post Office	County
C. O. Thompson	Poposky	Beltrami	Peter Kokkenen	Cloquet	Carlton
S. E. Randall	"	"	Ralph McNeil	Shovel Lake	Aitkin
Mike Zaborac	Nebish	"	Martin H. Jalmer	Cloquet	Carlton
Frank Karlorick	"	"	John Reimer	Cromwell	"
Halvor Peterson	Bemidji	"	William Wathern	Shovel Lake	Aitkin
Lake Julia Sanatorium	Poposky	"	Emil Halin	Carlton	Carlton
Henry Bolstad	Blackduck	"	Tom Cunningham	Shovel Lake	Aitkin
Sam Dodson	Northome	Koochiching	M. L. O'Brien	"	"
J. J. Neary	"	"	John Oberg	Hibbing	St. Louis
Joseph Plenel	"	"	Charles Kuusela	"	"
Carl Johnson	Tenstrike	Beltrami	Harry Fischback	Hill City	Aitkin
Arthur Spears	Shooks	"	Hubert Jamme	Swatara	"
Herbert Nast	Tenstrike	"	Conrad Angermo	"	"
Clarence Johnson	Blackduck	"	Fred Berg	"	"
John Cann	"	"	Ed Lloyd	Sebeka	Wadena
Jeff Fortier	"	"	Ole Vasson	Bemidji	Beltrami
Frank Spears	Shooks	"	P. M. Lunden	Jacobson	Aitkin
Albert Gustafson	Hibbing	St. Louis	Oscar Johnson	Hill City	"
William Moerke	"	"	G. L. Dodge	Turtle River	Beltrami
Emil Eliason	"	"	Axel Heppola	Menagha	Wadena
C. M. Curby	"	"	Rudolph Erdman	Sebeka	"
John Queel	"	"	Ernest Foix	Hill City	Aitkin
Ade Siiter	Cloquet	Carlton	Arthur Hill	Hibbing	St. Louis
Andrew Ketola	"	"	J. Stanko	Blackduck	Beltrami
Chris Steinhart	Swatara	Aitkin			

* Not definitely recorded.

On Clay Soil

Co-operators	Post Office	County	Co-operators	Post Office	County
A. K. Halte	Baudette	Lake of the Woods	Swan Palmquist	Roosevelt	Roseau
Eldor Rippy	"	"	Ed Bouner	Carp	Lake of the Woods
Henry Bergquist	"	"	Carl P. Olson	Williams	"
George Jenson	Big Fork	Itasca	A. Hytson	Wirt	Itasca
A. C. Grove	Roosevelt	Roseau			
Henry Bergquist	Baudette	Lake of the Woods			

* Not definitely recorded.

On Sandy Soil

Co-operators	Post Office	County	Co-operators	Post Office	County
R. J. Cronemiller	Bemidji	Beltrami	I. C. Meadowcroft	Cass Lake	Cass
Bob Shadegg	"	"	P. O. Carlson	Bemidji	Beltrami
John Brooks	Blackduck	"	Ed Larson	"	"
G. Goodmanson	Turtle River	"	Joe Jaglowski	Rutledge	Pine
H. L. Becker	Tenstrike	"	John Koslucker	Hibbing	St. Louis
Elmer Howard	Sebeka	Wadena	Richard Kelm	Bemidji	Beltrami
H. P. Baldwin	Swatara	Aitkin	Konstant Kykyri	Gilbert	St. Louis
E. S. Reep	Rabey	"	Henry Anderson	Wilton	Beltrami
Waino Koski	Jacobson	"	M. Ristinen	Menagha	Wadena
Victor Bjorquist	Rabey	"	E. R. Moulton	Bemidji	Beltrami
Martin Katiranta	Cloquet	Carlton	Ole Johansen	Pitt	Lake of the Woods
George Paull	"	"			
Joe Frink	Chisholm	St. Louis	James Marka	Solway	Beltrami
Charles Kuusela	So. Hibbing	"	Joseph Lindell	"	"
Frank Koslucker	Hibbing	"	Emil Olson	Bemidji	"
Ole Knutson	Menagha	Wadena			

On Sandy Loam Soil

Co-operators	Post Office	County	Co-operators	Post Office	County
Overson Laurits	Big Fork	Itasca	Fred Lindman	Jacobson	Aitkin
George Campbell	"	"	F. E. Culp	Baudette	Lake of the Woods
J. Jolicour and Sons	Cloquet	Carlton			
Nels D. Nelson	Blackduck	Beltrami	Pat Bushaw	Bemidji	Beltrami
J. W. Stepp and Son	Williams	Lake of the Woods	Charles Bowman	"	"
			William Wittich	"	"
Julius Peterson	Pitt	"	Joseph Jolicour	Cloquet	Carlton
Theodore Peterson	"	"	Nick Johnson	"	"
T. W. Stanley	Baudette	"			

SCOPE AND CHARACTER OF DATA RECORDED

After a field was chosen, all available facts relating to its history and management were assembled. Measurements were then taken of the field and stumps, the stumps were counted, and some pictures were taken. The size of the fields varied from three-tenths of an acre to thirty acres, altho one acre was usually the minimum. The data recorded included kind of stump, condition, probable age, and actual diameter one foot above the ground. The count was grouped under the following headings as to diameter of stump: 4-7 inches, 8-11, 12-15, 16-19, 20-24, 25-29, 30-36, 37-50, 50 and over. Everything less than 4 inches in diameter was called brush. Throughout the project the farmers recorded all man and horse hours expended in the four clearing operations (brushing, stumping, stoning, and picking up roots) and in breaking, also the units of explosive caps, and fuse used. This information was checked by the University agent when he called to note progress and after the work was done.

The size, kind, and number of stumps on each field were recorded. Clay loam produced the largest variety, clay the least. It is often assumed that Norway pine is found most frequently on sandy loam, but the count does not support this belief. White pine is dominant on two soils, but is absent entirely on areas studied on the heavy clay that grew

the largest white pine, like jack and Norway pine. The count of trees on clay soil was taken at 7 of the 16 locations. The relative frequency of species found on clay soil may have been materially different if these species were known for all 16 locations. The Carlton County timber was harvested so long ago that many of the stumps have decayed. The Lake of the Woods clay area did not grow such massive white pines as the red clay district near Lake Superior in Lake and Carlton counties. Poplar and birch were numerous on all soils; likewise tamarack, balsam, spruce, ash, elm, and cedar in lesser degree.

Species of Trees Found on Each Type of Soil in Order of Their Relative Frequency

Type A, sand	Type B, sandy loam	Type C, clay loam	Type D, clay
Jack pine	White pine	White pine	Balsam
Norway pine	Poplar	Poplar	Cedar
Birch	Jack pine	Birch	Birch
Poplar	Tamarack	Balsam	Poplar
White pine	Norway pine	Cedar	Ash
Tamarack	Oak	Norway pine	Spruce
Balsam	Spruce	Elm	Elm
Oak	Birch	Maple	Tamarack
Spruce	Cedar	Tamarack	Balm of Gilead
Ash	Balsam	Ash	Basswood
Elm	Elm	Basswood	
Cedar	Alder	Oak	
	Ash	Spruce	
	Basswood	Balm of Gilead	
		Ironwood	
		Willow	
		Jack pine	

PRESENTATION OF FINDINGS

The term "land clearing" is used to cover the practices described in their application to northern soils. A better term is "stump and stone land reclamation." It is removing stones, stumps, and forest cover from the surface of the land to allow the free operation of labor and machinery in growing and harvesting food and feed crops.

The discussion of stump and stone land reclamation on 122 northern Minnesota farms will be presented from two angles—the operation and the soil. Four major operations are involved—brushing, stumping, breaking, and stoning. There are four kinds of soil, two of them heavy and two light. Findings are presented to show the comparative cost of a given operation on each of the four types of potential farm land, and to present the cost of all four operations on each type.

The statistical matter is voluminous, and the findings are reported in very condensed form. Anyone wishing to know the details may consult the Division of Agricultural Engineering.

Costs of commodities and labor vary, but units of time and material are relatively constant as long as present land clearing practices are followed. With these basic and constant factors and the existing scale

of local costs, the cost of clearing can be expressed at any time, anywhere, in monetary terms. Costs are determined upon the acre basis. The findings reported are flexible enough to meet all conditions of stump land reclamation.

Brushing

The brushing operation involves cutting, piling, and, usually, burning all standing material up to four inches in diameter, and includes the smaller windfalls and the debris covering the ground. The removal of heavy material such as fallen logs may be, and sometimes is, included in this operation, but more frequently it is associated with stumping.

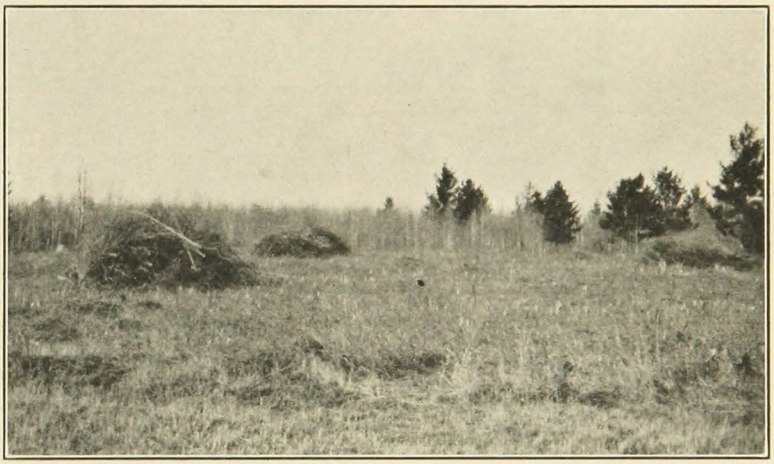

FIG. 2. BRUSHING OPERATION IN PROGRESS

There are four ways of removing brush: (1) Using hand tools such as ax, scythe, and brush hook; (2) fire; (3) ruminant animals, as cattle and sheep; (4) mechanical method, as the brush mower. The work may be done at any time of the year, altho fall, winter, and spring are best. Then the weather is cool, the brush is free of leaves, the footing is firm, and other work does not press. Brushing was done on only 66 of the 122 farms in this project, as in many cases the land was in stump pasture when taken over. Some of the farmers doubtless followed every practice and brushed in every season. Brushing is often done several years in advance of stumping. Grass seed is sown and several years of pasture intervene. This is known as "delayed" clearing. It is of particular value when green timber in addition to brush must be harvested, for the natural agencies such as decay of stumps and debris, and settling and packing the soil, become the allies of the settler in his reclamation job. Horses are usually not used in the brushing operation. Two farmers reported horse labor. Both removed the stumps. The standing brush was small enough to be cut with an ordinary mower.

Uncleared lands have earned the general title "cut-over," as the merchantable forest crop has long since been harvested and the present forest cover consists of only stumps and brush. Such timber as remains is usually growing on what is now considered mostly non-agricultural land. Swampy and peaty soils grow small trees that are used for paper, and the very stony uplands grow what pine is left. These investigations deal with the normal, or usual, type of cut-over land that is converted into farms. Particularly on the stony clay loam, however, there still remains considerable timber, usually balsam or birch. In some cases this is second growth that has reached the merchantable stage. Occasionally a little material in excess of four inches was found on a test plot but not enough for a special classification, and the value of the timber usually offsets the cost of removal.[2]

Table 1. Labor for Brushing on 66 Farms and Four Types of Soil

Type of soil	No. of tests	Total acres brushed	Av. acres per farm brushed	Man hours per acre	
				Maximum	Weighted av.
Sand	20	66.7	3.3	69.2	15.1
Sandy loam	16	54.4	3.4	150.9	49.7
Clay loam	25	63.0	2.5	94.8	30.2
Clay	5	9.5	1.9	95.0	9.3
Total, weighted av., and max. for all soils	66	193.6	2.9	150.9	29.5

The actual range was from 1.4 hours to 150.9 hours. One man spent more than two weeks on the job, five times the usual time. Even for a good pasture crop, one might hesitate to invest that much labor.

Clay, the richest soil, perhaps, in plant food elements, and judged by the timber it grew, produced the lightest brush. It grew fewer trees but larger ones, and these were choice logs. The soil was harvested cleaner. Clay and sandy loam grew more timber of secondary size and value. More was left on the land to add to the labor of clearing. The brush is always light on sandy soil. It is difficult to conceive that clay would grow less brush than sand, and that sandy loam would require double the labor of either to clean up. The brushing of nearly 200 acres, however, affords some measure of the labor required to clear a tract of land to the stumping stage. The prospective brusher can plan to spend from one to five days on the job, depending on location. Three full days can be considered a normal figure for brushing an acre.

Stumping

The term "stumping" is comprehensive. It includes all operations between brushing and breaking. Under it, four specific jobs are listed: blasting, pulling, piling, and burning. The first two can properly be

[2] For specific information on the reclamation of land carrying a heavy crop of balsam and birch see p. 10, Bull. 163, Investigations in Cost and Methods of Clearing Land, by M. J. Thompson. Minn. Agr. Expt. Sta. 1916. (Out of print.)

included under the head "removing stumps," as blasting is not always done. Either the stumps are decayed or they are so small they can be pulled readily. For example, among the 122 co-operators, 96 had occasion to blast and 26 did not. Blasting can also be dispensed with if a stump puller is used. None was used by these co-operators. Stump pullers have passed out of land clearing practice, generally, in this district in recent years, but when employed, dynamite usually is used in conjunction with them. Many persons consider burning a major job in clearing. Brushing is incomplete until the brush has been burned, and stumping is incomplete until the extracted stumps have been removed by fire or otherwise. So in planning a job or describing it, all facts relating to brush removal and stump disposal should be grouped around these heads. Stumping usually follows several seasons after brushing. A pasture period may intervene. For farm records on the sub-operations involved in removing stumps see Tables 11, 12, and 13.

To many persons, the removal of stumps is synonymous with land clearing. It is really but one of four jobs, tho the largest one, in the conversion of a previously forested area into crop land. The three other operations of brushing, breaking, and stoning and root picking involve labor only. This job includes the use of materials as well. The statistical information will be more intelligible if it is supplemented by a comparison of the number and size of stumps blasted on each type of soil.

It will be noted that the *size* of the stumps increases progressively with the greater clay and the lesser sand content of the soil, and with one exception the *number* to be blasted increases as well.

To stump an acre requires (on the average) less than three days on sandy soil to less than six days on heavy clay. These results agree closely with the experiences of northern farmers. Sandy jack pine lands are more readily cleared than sandy loam soils, which carry fewer stumps but larger ones; also heavy soils require more labor for stumping than light soils. The experiment checks experience in all cases. The reader, however, should base decisions less on the average than on the range. The average of normal is used in planning a clearing job, but the upper limits of cost should be considered as well. The important fact is how far beyond the average the cost may possibly go. However, the top figure of 174.5 man hours per acre on clay loam is unusually high, because the stumps were green and there were many of them. Of 46 operators, only 3 spent more than 90 hours in stumping. The man with the highest record on sandy soil spent 88 hours blasting 117 stumps; the man next below spent 25 hours blasting 140 stumps. The average was less than 13 hours per acre, one-sixth as much. The hours of horse work are in proportion to those of man labor and require no discussion.

Altho sandy land is cleared more easily, it actually requires more explosive than sandy loam. While the stumps are two inches smaller in diameter, they are twice as numerous. The big white pine stumps on red clay are naturally most exacting of all. It took 11 sticks of explosive to

Table 2. Labor Expended in Stumping Land on 104 Farms and Four Types of Soil

Section A, Labor

Type of soil	No. of tests	Acres stumped	Av. acres per farm	Man labor per acre, hr.		Horse work per acre, hr.	
				Maximum	Weighted av.	Maximum	Weighted av
Sand	29	121.6	4.2	116.0	28.4	55.0	16.1
Sandy loam	14	54.4	3.9	105.0	38.1	80.0	23.0
Clay loam	46	117.0	2.5	174.5	49.4	174.5	39.2
Clay	15	27.3	1.8	78.6	58.4	114.0	54.9
Total, max., and weighted av. for all soils	104	320.3	3.1	174.5	41.7	174.5*	27.3*

Section B, Materials

Type of soil	Sticks of explosives per acre		Feet of fuse per acre		No. of common blasting caps per acre	
	Maximum	Weighted av.	Maximum	Weighted av.	Maximum	Weighted av.
Sand	360.0	90.0	181.8	57.3	159.1	52.4
Sandy loam	292.8	104.4	200.0	66.4	125.0	43.0
Clay loam	600.0	158.8	400.0	110.1	300.0	69.6
Clay	425.5	165.4	208.3	99.2	183.3	76.6
Total, max., and weighted av. for all soils	600.0	126.5	400.0	83.7	300.0	59.7

Section C

Type of soil	Total stumps per acre	Stumps blasted per acre	
		No.	Weighted av. diameter, inches
Sand	102	40	9.2
Sandy loam	49	37	11.1
Clay loam	78	52	13.2
Clay	80	63	14.6
Weighted av. for all soils	82	46	11.3

* A total of 256.7 acres and 84 locations was involved.

clear one acre and 600 sticks to clear another. The high acre took 100 times as much fuse and 150 times as many caps as the low one. These variations show how important it is to use judgment in land reclamation.

Stumping includes four related processes—blasting, pulling, piling, and burning. It took nearly 42 hours[3] to stump a normal acre. The first quarter, or 10 hours, was spent in blasting. Almost exactly one-third of the total, or less than 1½ days, was used in pulling stumps. The two jobs used about 2½ days. Piling (31 per cent) took almost 13 hours, a little more time than blasting, and a little less than pulling. Burning (12 per cent) took the remaining 5 hours.

Breaking

The third major operation in reclamation of stump and stone land is breaking the virgin soil. This includes disking and general seedbed preparation because the land is really not cleared until it is ready for the

[3] See Table 2, Sec. A.

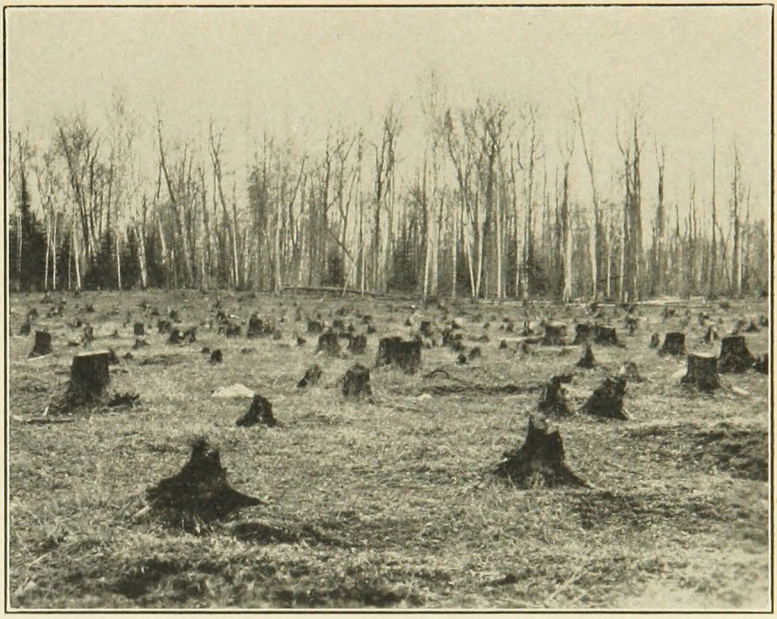

FIG. 3. FIELD READY FOR STUMPING

crop, and until the land is plowed and disked, stoning and root picking can not be finished; indeed, the greater part must follow, as plowing and disking will bring many stones and roots to the surface. The tables indicate that breaking was done on 75 farms and disking on 64 farms. In nearly all cases, this was done with horse work. It is not within the scope of this discussion to choose between horses and other sources of power. The co-operators represent a cross section of up-state farmers, small operators of family-sized farms. A team was needed for growing the crop. Stumping and breaking was done between the peaks of crop demands. As the greater part of the clearing in the Lake States is done in units of well under 5 acres per farm per year on farms of from 80 to 100 acres, the use of dynamite and horse power in clearing and breaking probably represents good farm economy. There is no duplication of power equipment for part-time jobs and there is no cash outlay for hire. The fixed cost of horse maintenance is distributed over more hours of gainful labor. The breaking was confined to no particular month or season.

Breaking and disking are related but distinct operations. On contract clearing, disking may not be included, but it is really a part of the reclamation when the farmer does his own work on his own farm. To make the report complete, the relative amount of time used on each should be given. Roughly, breaking required about three times as many man hours as disking, and about twice as many horse hours. The ratio for man hours was 2.7 to 1.0; for horse hours 2.1 to 1.0.

Table 3. Breaking and Disking on 76 Farms and Four Types of Soil

Type of soil	No. of tests	Total acres broken	Av. acres per farm	Units of time used			
				Man hours		Horse hours	
				Maximum	Weighted av.	Maximum	Weighted av.
Sand	28	86.8	3.1	50.6	14.0	63.8	29.0
Sandy loam	10	38.0	3.8	60.0	21.2	80.0	39.9
Clay loam	30	83.8	2.8	78.0	25.6	140.0	42.7
Clay	8	12.2	1.5	35.3	19.2	60.0	39.3
Total, max., and weighted av. for all soils	76	220.8	2.9	78.0	20.1	140.0	36.9

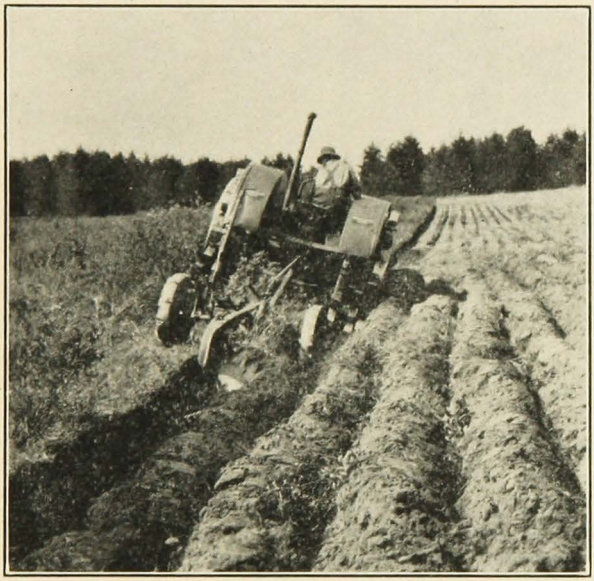

FIG. 4. BREAKING SANDY LAND WITH A TRACTOR

Farmers on sandy loam broke more land per farm, but the easiest breaking was done on sand. This checks with farm experience. This kind of soil, probably deposited by water and lying level, carries few or no stones. Stones and larger root accumulations add three-fourths of a day to an acre on sandy loam, and more than a full day on clay loam. There is a distinct drop in the time required to break clay soil. Much of this soil is old lake bed, so it is free of stones. Less time is needed for roots, for not only were the stumps fewer, but, owing to their size, they were blasted heavily, removing everything above and below the surface. It took a man and a team two 10-hour days to break and disk the average acre. The range was from just under 1½ days for sandy soil to 2 days for sandy loam and the average for all soils, to more than 2½

days for clay loam. Most of the breaking was done by two-horse teams. Breaking land submits rather well to measurement and standardization. There is a certain definite volume of soil to turn over, whereas the amount of brush and the number and size of stumps and stones are constant variables. The presence of stones and remnants of stumps directly modify the time required to plow an acre, and affect the cost.

Stoning and Picking Up Roots

The conifer country—northeastern Minnesota, upper Wisconsin, and northern Michigan—was long ago covered with glaciers. There are stone deposits throughout the region, but they are not uniformly distributed. The jack pine sands, usually level, are free of stones, as they were laid by water. This holds true of the red clay on the north and south shores of Lake Superior, old lake bed, as well as the clay soils of the large valleys and the bed of glacial Lake Agassiz, the country southward from Lake of the Woods, but the sandy loam and the clay loam soils constitute the great mass of the probable crop land area. The topography of these districts is gently rolling to hilly, and there are varying numbers of stones.

The best farm practice is to pick the surface stones before plowing, again after plowing, and a third time after disking. If land is to be stoned, it should be done thoroly. A thoro picking at time of breaking is good economy. There will be successive and secondary pickings in years to follow, but unless the land is subject to erosion these will be relatively minor jobs. Doubtless some explosive was used in removing the larger stones. It is better to blast all stones larger than two men can readily lift into a wagon or roll onto a low truck or stone boat. Dragging large rocks across the field is not only wearing on the horses but it wastes time. When explosive was used, it is reported in the total consumed for all clearing operations, including both stumps and stones. We are concerned here with labor only, in stone removal. As more or less debris and root remnants come to the surface with breaking and disking, the picking of this material is included with stoning.

Some may think that stones constitute a problem on a larger percentage of the farms in this region. Jack pine sand and red clay are free of stones, as already stated, being deposited by water. Stones are most numerous on clay loam. One-fifth of the co-operators reported data on stones. Most of them are good farmers. They avoid stones in choosing a farm and delay or avoid clearing such stony areas as they have. This bulletin deals with costs only. For methods of removing stones, see Minnesota Bulletin 250.[4]

We have a history of stoning 80 acres of tilled farm land. Since, to many persons, stones are a greater limitation to farming than stumps, the findings will bear some study by type of soil. The sand farms report

[4] Stoning Farm Lands, by A. J. Schwantes and M. J. Thompson. 1929.

Table 4. Stone and Root Removal Requirements on Four Types of Soil

Types of soil	No. of tests	Total acres	Av. acres per farm	Units of time			
				Man hours		Horse hours	
				Maximum	Weighted av.	Maximum	Weighted av.
A. Stoning on 26 Farms							
Sand	6	14.0	2.3	36.9	14.2	26.1	15.3
Sandy loam	3	14.5	4.8	5.7	4.8	10.0	2.4
Clay loam	16	46.1	2.9	153.0	13.6	156.0	15.8
Clay	1	5.0	5.1	2.0	2.0	4.0	4.0
Total, max. and weighted av. for all soils	26	79.6	3.1	153.0	11.4	156.0*	12.3*
B. Picking Roots on 38 Farms							
Sand	16	48.9	3.1	18.8	4.0	12.5	4.5
Sandy loam	6	23.1	3.9	7.1	4.7	11.1	9.0
Clay loam	9	28.0	3.1	26.7	9.8	24.5	9.4
Clay	7	16.3	2.3	8.0	2.9	14.0	4.5
Total, max. and weighted av. for all soils	38	116.3	3.1	26.7	5.4	24.5†	6.6†

* A total of 73.2 acres and 23 locations was involved.

† A total of 81.1 acres and 27 locations was involved.

a cost of stoning much higher than usual. Individual farm reports indicate that two are very high and the others very low, about 3 man hours per acre, or about the same as clay. The two high-cost farms were on the edge of a sand plain and adjacent to a glacial moraine with its stone

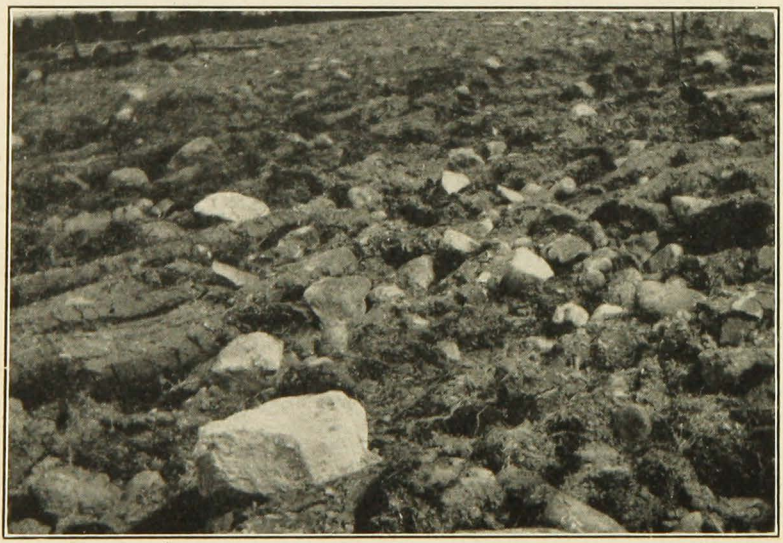

Fig. 5. Plowed Field Ready for Stoning

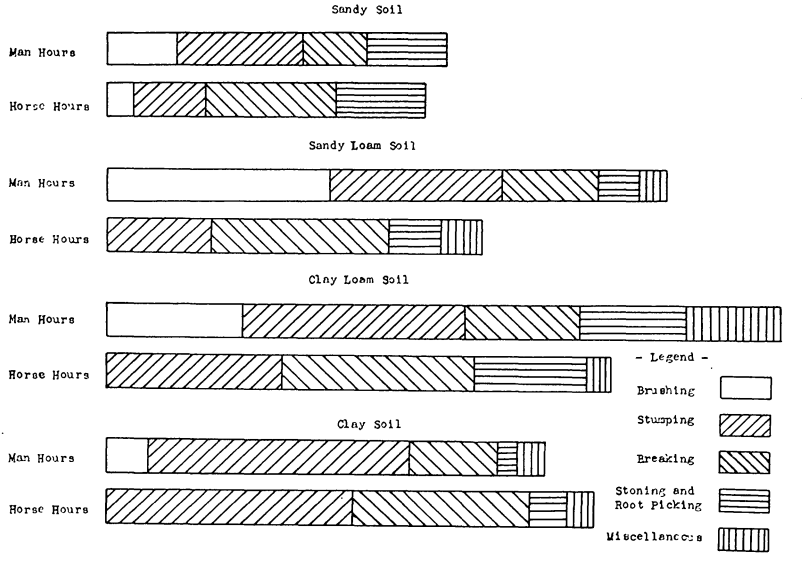

FIG. 6. DIVISION OF LABOR FOR FOUR STEPS IN CLEARING

deposits and some outwash along its borders. Yet two men working less than two days cleaned up the very worst acre. On the other sandy acres, as on the clay, two men and a team, working an hour and a half, stoned an acre. Stoning sandy loam took twice as much time as average acres of either sand or clay, but at that took only a quarter of a day for each of two men and a team. The big job of stoning is on clay loam. At one extreme location two men and a team were occupied for 7½ days. Either they were inferior workers or the acre was marginal land that should never have been touched. A review of the time spent in blasting on clay loam soil (Operator No. 29) bears out this conclusion. Fifteen other co-operators on clay loam soil had stoning problems. The top man of the group spent 40 hours, a rate of two men and a team for 2 days, or little more than one-fourth as long. The average acre of clay loam required the labor of one man and two horses for 1½ days for stoning. This is not an unreasonable investment. Indeed, records on file at this office indicate charges far greater than this on prairie soils in southern Minnesota. Averaging all farms and soils, stoning took the labor of two men and a team for ½ day in cleaning up an acre of land.

When stumping is done and land is broken, a lot of debris is exposed. The picking of this material is really one job, for it is all done at the same time. But as the remnants of stumps occur on every acre and stones in substantial numbers on but some of them, and as the stone problem looms large in the minds of many men, it seemed advisable to set out the information separately under the same general heading. The reader can then have a conception of the labor requirements in stoning on both light and heavy soils.

Roughly, one-third of the farmers reported picking up roots. About half those reporting had sandy soil. The job was lightest on clay soil, heaviest on clay loam. This is understandable. Clay soil grew big pines tho fewer in number. Large charges were used in blasting. Stumps came out in large segments, and there are no tap roots in this soil. So the pick-up job was small. On clay loam the stand is mixed, being composed of both hardwoods and conifers in varying stages of decay, and does not permit of as clean a job of blasting and pulling. Many hardwood stumps are so much decayed that they can be neither blasted nor pulled but come out with the breaking plow. This means more pick-up material. The loose, sandy soils yield their content of wood more readily. Top roots are a problem. But the breaking at the surface is not excessive if the stumps are properly blasted.

Miscellaneous Labor

Miscellaneous labor covers incidentals. For the most part it was spent in filling stump holes, a questionable practice that still persists. Most operators prefer, if possible, to fill the stump holes by plowing over them and disking around them. Progress may be slower, but it is cheaper and eventually the land is leveled. Farmers on sandy land reported no miscellaneous labor charge, as the holes were both fewer in number and smaller in size than on heavy soils.

Table 5. Miscellaneous Labor Units on Three Types of Soil

Type of soil	No. of farms	Total acres	Acres per farm	Weighted av. per acre	
				Man hours	Horse hours
Sandy loam	6	28.5	4.8	5.9	9.?
Clay loam	10	28.6	2.9	20.1	5.1
Clay	3	6.5	2.2	5.5	5.6
Total and weighted average for all soils	19	63.6	3.4	12.2	8.1*

* A total of 26.8 acres and 9 locations was involved.

One man spent 117 hours on miscellaneous labor, another 13.3 horse hours. This work is really "trimming off" the job. Men usually spend from ½ day to 2 days on it. The time can not be charged against any specific division of the work, so it was classed "miscellaneous." Only 15 per cent of the farms was involved. These miscellaneous charges do not properly have a place in a systematized and well executed timber land reclamation project, in this region.

Mechanics of Clearing; Comparative Costs

A comprehensive view of the various processes as integral parts of a single enterprise is presented in the following tables. One table shows man labor in all its relations; another, every application of horse work; and the third, the facts on the use of explosives.

Tables 6, 7, and 8 show summarized averages of every unit of labor and materials involved in the major operations and the mechanics of clearing land on the 122 farms.

Table 6. Total Man Labor Units, Four Operations, in Clearing Land

Operation	Total tests	Weighted av. of hours of labor per acre				
		Sand	Sandy loam	Clay loam	Clay	Weighted av.
Brushing	66	15.1	49.7	30.2	9.3	29.5
Stumping	104	28.4	38.1	49.4	58.4	41.7
Breaking	76	14.0	21.2	25.6	19.2	20.1
Stoning and picking roots	53	18.2	9.5	23.4	4.9	16.8
Miscellaneous	19	.....	5.9	20.1	5.5	12.2
Total of all operations	.....	75.7	124.4	148.7	97.3	120.3

Table 7. Total Horse Work Units, Four Operations, in Clearing Land

Operation	Total tests	Weighted av. of hours of labor per acre				
		Sand	Sandy loam	Clay loam	Clay	Weighted av.
Brushing	2	5.8	.....	.....	.....	5.8
Stumping	84	16.1	23.0	39.2	54.9	27.3
Breaking	76	29.0	39.9	42.7	39.3	36.9
Stoning and picking roots	44	19.8	11.4	25.2	8.5	18.9
Miscellaneous	9	.....	9.3	5.1	5.6	8.1
Total of all operations	.....	70.7	83.6	112.2	108.3	91.2*

* Brushing for sandy soil not included.

Table 8. Material Units Used, Stumping Land, Four Types of Soil

Materials	Sand	Sandy loam	Clay loam	Clay	Weighted av. on average acre for all soils
Explosive, sticks	90.0	104.4	158.8	165.4	126.5
Fuse, feet	57.3	66.4	110.1	99.2	83.7
Common blasting caps	52.4	43.0	69.6	76.6	59.7

In planning to clear the mythical "average" or normal acre, one would first set aside 12½ working days for the whole job. The first 3 days would be occupied in brushing, the next 4 days in stumping, 2 days more in breaking and disking; the total, roughly, 9 days. Before the crop could be sown, nearly 2 days would have to be spent cleaning up the surface roots and stones. The final 1½ days would be used finishing the job—filling stump holes and doing odds and ends.

The horse labor is spent differently. Breaking is the big job. Others follow in declining order—stumping, stoning, picking up roots, and miscellaneous. The horse labor per acre is only 9 days, distributed thus: breaking, 3¾ days; stumping, 2¾ days; stoning and picking up roots, 1¾ days, and miscellaneous, ¾ day.

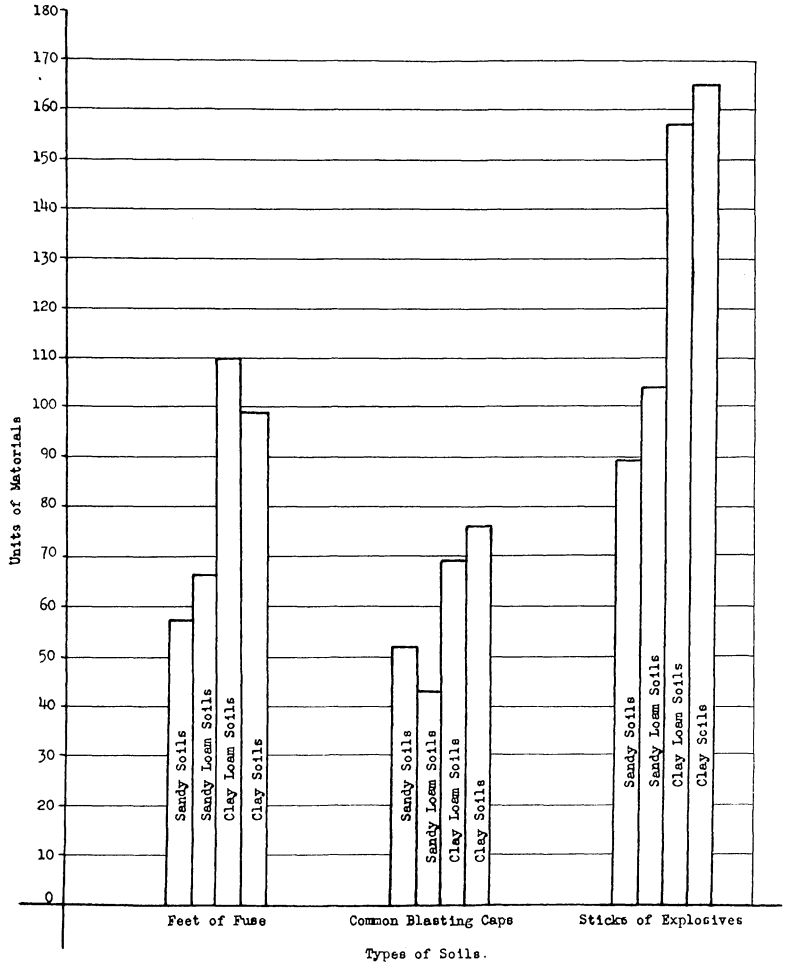

FIG. 7. MATERIALS USED PER ACRE

Blasting would require 126.5 sticks of explosive with corresponding lots of caps and fuse. It is remarkable how closely this checks with accepted estimates. Men trained in the art of land clearing often take the figure 50 pounds per acre as a basis of estimate. The material used, mostly war-salvaged stocks, ran close to 3 sticks a pound and up to 6 ounces a stick.

In each of the four types of soil one acre has absorbed more labor or more material than any other in the clearing process. These maximum costs have been assembled in Table 9.

The 92.5 hours for brushing was arrived at by averaging the highest brushing charge for an acre of sand, of sandy loam, of clay loam, and of clay. Every other figure was determined in the same way. These figures are impossible from a practical viewpoint because of two factors—inefficient labor working on impossible land and possible actual logging. In the latter case, salvaged timber would create a credit. Being more than three times the normal in several cases, these figures of top cost have a negative value only. They show what happens when marginal labor works on really marginal land.

Table 9. Average Clearing Cost Units: Four Highest Acres

Operation	Man hours	Horse hours	Sticks of explosive	Fuse, feet	No. of caps
Brushing	92.5	.....	.....	.....	.....
Stumping	118.5	105.9	.....	.....	.....
Breaking	56.0	86.0	.....	.....	.....
Stoning	64.6	64.6	.....	.....	.....
Miscellaneous*	46.6	9.2	.....	.....	.....
Totals	378.2	265.7	419.6	247.5	191.9

* Maximum for heaviest three types of soil.

Cost per Acre on Light and on Heavy Soils

A close study has been made of land reclamation from the viewpoint of operations, or clearing mechanics. Table 10 shows the unit costs that have gone into the clearing of a half-section of land scattered in small lots over 122 farms in 11 Minnesota counties.

Table 10. Total Labor and Material Requirements per Acre, Four Types of Soil

Type of soil	No. of tests	Hours of labor		Units of material		
		Man hours	Horse hours	Sticks of explosive	Fuse, feet	Common blasting caps
Sand	33	75.7	70.7	90.0	57.3	52.4
Sandy loam	17	124.4	83.6	104.4	66.4	43.0
Clay loam	56	148.7	112.2	158.8	110.1	69.6
Clay	16	97.3	108.3	165.4	99.2	76.6
Total and weighted av.	122	119.7	88.4	126.5	83.7	59.7

Beyond question, sandy soil is the cheapest to clear. Sandy loam soil is second. Man hours are a trifle high, but the cost of explosives is lowest on the heaviest three types of soil. We grant third place to clay soil and fourth to clay loam—the highest of all types in cost of clearing. The clay soil required about $2.00 worth of material more per acre than clay loam, but needed fewer units of labor, which, priced as low as 10 cents an hour, would be $5.50.

Table 11. Cost of Clearing Operations

Clearing operation		No. of co-operators	Acres involved	Total units expended*	Weighted av. hr.†	Per acre basis Max.‡	Av.‡	Min.‡
Sand								
Acres cleared		33	132.0	.....	4.0	30.0	.....	1.0
Brushing	M.H.§	20	66.7	1,009.5	15.1	69.2	19.4	6.3
Brushing	H.H.‖	2	5.5	15.1	5.8	7.7	5.9	4.1
Blasting stumps	M.H.	24	102.8	967.8	9.4	88.0	12.9	2.1
Pulling	M.H.	26	109.9	1,071.0	9.8	35.0	13.5	1.0
Pulling	H.H.	24	101.9	890.0	8.7	35.0	12.6	1.3
Piling and burning	M.H.	29	121.6	1,114.0	9.2	26.1	12.4	1.0
Piling and burning	H.H.	19	90.2	665.5	7.4	32.3	10.5	1.4
Piling¶	M.H.	18	55.4	444.0	8.0	20.0	8.7	1.3
Piling¶	H.H.	13	41.6	281.5	6.8	20.0	7.8	1.4
Burning¶	M.H.	18	55.4	180.0	3.3	10.0	3.7	0.8
Breaking	M.H.	28	86.8	891.0	10.3	37.5	11.8	3.2
Breaking	H.H.	28	86.8	1,755.5	20.2	46.7	22.2	8.5
Disking and harrowing	M.H.	19	58.0	215.0	3.7	7.5	4.4	1.2
Disking and harrowing	H.H.	19	58.0	512.0	8.8	30.0	10.6	2.4
Stoning	M.H.	6	14.0	199.0	14.2	36.9	11.1	0.8
Stoning	H.H.	5	11.4	174.0	15.3	26.1	12.7	4.3
Picking roots	M.H.	16	48.9	196.5	4.0	18.8	5.2	0.8
Picking roots	H.H.	10	30.0	134.0	4.5	12.5	5.5	1.1
Miscellaneous	M.H.	.....	.....	.....	.....	.....	.....	.....
Miscellaneous	H.H.	.....	.....	.....	.....	.....	.....	.....
Total man hours		.....	.....	5,663.8	75.7	319.0	90.7	16.4
Total horse hours		.....	.....	4,163.0	70.7	190.3	80.0	23.1
Blasting Materials								
Sticks of explosive		25	104.4	9,391.0	90.0	360.0	112.1	19.3
Common blasting caps		25	104.4	5,468.0	52.4	159.1	65.1	6.3
Feet of fuse		25	104.4	5,986.0	57.3	181.8	73.9	11.4
Sandy Loam								
Acres cleared		17	62.6	.....	3.7	10.0	.....	1.0
Brushing	M.H.§	16	54.4	2,705.5	49.7	150.9	43.4	9.1
Brushing	H.H.‖	.....	.....	.....	.....	.....	.....	.....
Blasting stumps	M.H.	13	53.4	514.0	9.6	30.8	10.6	0.3
Pulling	M.H.	10	40.4	505.0	12.5	40.0	13.4	0.3
Pulling	H.H.	10	40.4	493.5	12.2	40.0	13.8	0.7
Piling and burning	M.H.	14	54.4	870.5	16.0	45.0	18.4	3.3
Piling and burning	H.H.	11	36.8	397.0	10.8	40.0	15.2	4.4
Piling¶	M.H.	9	33.4	417.0	12.5	40.0	15.8	4.5
Piling¶	H.H.	6	15.8	204.0	12.9	40.0	17.5	5.0
Burning¶	M.H.	9	33.4	219.5	6.6	15.4	7.0	2.8
Breaking	M.H.	10	37.1	610.5	16.5	40.0	17.0	2.3
Breaking	H.H.	10	37.1	1,037.0	28.0	40.0	27.0	9.0
Disking and harrowing	M.H.	10	38.0	177.0	4.7	20.0	6.2	1.6
Disking and harrowing	H.H.	10	38.0	451.0	11.9	40.0	14.5	5.9
Stoning	M.H.	3	14.5	70.0	4.8	5.7	5.1	4.5
Stoning	H.H.	3	14.5	34.4	2.4	10.0	5.4	0.4
Picking roots	M.H.	6	23.1	109.0	4.7	7.1	4.6	1.0
Picking roots	H.H.	3	10.4	94.0	9.0	11.1	7.7	2.0
Miscellaneous	M.H.	6	28.5	167.0	5.9	16.0	6.7	1.6
Miscellaneous	H.H.	4	18.7	174.0	9.3	13.3	10.6	6.4
Total man hours		.....	.....	5,728.5	124.4	355.5	125.4	24.0
Total horse hours		.....	.....	2,680.9	83.6	194.4	94.2	28.8
Blasting Materials								
Sticks of explosive		13	53.4	5,575.0	104.4	292.8	108.6	10.7
Common blasting caps		13	53.4	2,295.0	43.0	125.0	44.7	2.0
Feet of fuse		13	53.4	3,546.0	66.4	200.0	65.9	3.3

Clay Loam

Clearing operation		No. of co-operators	Acres involved	Total units expended*	Weighted av. hr.†	Per acre basis Max.‡	Av.‡	Min.‡
Acres cleared		56	148.4	.....	2.7	10.0	.....	0.3
Brushing	M.H.§	25	63.0	1,899.8	30.2	94.8	33.5	1.4
Brushing	H.H.‖	.....	.....	.....	.....	.....	.....	.....
Blasting stumps	M.H.	46	117.0	1,363.6	11.7	53.9	13.0	1.1
Pulling	M.H.	39	101.4	1,847.8	18.2	120.6	16.8	1.2
Pulling	H.H.	37	97.3	2,189.8	22.5	174.5	21.1	1.2
Piling and burning	M.H.	37	89.0	1,731.8	19.5	53.8	19.6	3.8
Piling and burning	H.H.	31	73.1	1,221.0	16.7	66.7	19.3	3.8
Piling¶	M.H.	16	44.3	673.0	15.2	40.0	17.5	4.1
Piling¶	H.H.	14	34.1	604.0	17.7	66.7	22.3	5.0
Burning¶	M.H.	22	51.1	299.0	5.9	13.3	6.0	2.5
Breaking	M.H.	30	83.8	1,570.5	18.7	62.7	19.5	0.9
Breaking	H.H.	30	83.8	2,406.1	28.7	80.0	29.5	3.5
Disking and harrowing	M.H.	27	72.1	495.5	6.9	32.8	8.7	1.7
Disking and harrowing	H.H.	27	72.1	1,011.0	14.0	60.0	15.9	2.5
Stoning	M.H.	16	46.1	629.0	13.6	153.0	20.7	0.8
Stoning	H.H.	14	42.3	669.0	15.8	156.0	22.7	1.6
Picking roots	M.H.	9	28.0	275.1	9.8	26.7	11.1	2.4
Picking roots	H.H.	8	26.1	244.0	9.4	24.5	8.4	3.4
Miscellaneous	M.H.	10	28.6	575.0	20.1	117.4	22.9	1.5
Miscellaneous	H.H.	3	6.3	32.0	5.1	6.7	5.0	3.0
Total man hours		.....	.....	10,388.1	148.7	715.7	165.8	14.8
Total horse hours		.....	.....	7,772.9	112.2	568.4	121.9	19.0
			Blasting Materials					
Sticks of explosive		48	124.4	19,755.2	158.8	600.0	180.5	15.3
Common blasting caps		48	124.4	8,655.0	69.6	300.0	76.6	7.9
Feet of fuse		48	124.4	13,695.0	110.1	400.0	108.5	14.1

Clay

Clearing operation		No. of co-operators	Acres involved	Total units expended*	Weighted av. hr.†	Per acre basis Max.‡	Av.‡	Min.‡
Acres cleared		16	28.1	.....	1.8	5.6	.....	0.6
Brushing	M.H.§	5	9.5	88.0	9.3	55.0	17.0	2.0
Brushing	H.H.‖	.....	.....	.....	.....	.....	.....	.....
Blasting stumps	M.H.	13	25.3	227.5	9.0	17.0	11.7	2.0
Pulling	M.H.	11	15.7	228.1	14.5	43.0	18.5	2.5
Pulling	H.H.	11	15.7	314.2	20.0	78.0	25.0	2.5
Piling and burning	M.H.	15	27.3	953.7	34.9	68.6	31.1	12.5
Piling and burning	H.H.	12	20.7	723.2	34.9	68.6	29.3	8.0
Piling¶	M.H.	7	11.3	332.0	29.4	42.0	22.8	13.0
Piling¶	H.H.	4	4.7	74.0	15.8	26.5	13.9	8.0
Burning¶	M.H.	7	11.3	44.0	3.9	13.3	5.8	1.2
Breaking	M.H.	7	11.0	140.0	12.7	26.0	14.1	1.2
Breaking	H.H.	7	11.0	272.0	24.7	34.3	25.6	22.0
Disking and harrowing	M.H.	8	12.2	79.2	6.5	17.1	8.6	1.2
Disking and harrowing	H.H.	8	12.2	178.3	14.6	25.7	17.0	4.3
Stoning	M.H.	1	5.0	10.0	2.0	2.0	2.0	2.0
Stoning	H.H.	1	5.0	20.0	4.0	4.0	4.0	4.0
Picking roots	M.H.	7	16.3	47.0	2.9	8.0	4.5	1.4
Picking roots	H.H.	6	14.6	66.0	4.5	14.0	6.0	1.8
Miscellaneous	M.H.	3	6.5	36.0	5.5	6.3	5.4	4.0
Miscellaneous	H.H.	2	1.8	10.0	5.6	7.5	5.8	4.0
Total man hours		.....	.....	1,809.5	97.3	243.0	112.9	28.8
Total horse hours		.....	.....	1,583.7	108.3	232.1	112.7	46.6
			Blasting Materials					
Sticks of explosive		13	25.3	4,184.0	165.4	425.5	200.9	18.8
Common blasting caps		13	25.3	1,939.0	76.6	183.3	100.3	18.0
Feet of fuse		13	25.3	2,509.0	99.2	208.3	123.1	18.0

* Total units expended for all co-operators involved.
† Total units expended divided by acres involved.
‡ Maximum, average, and minimum per acre basis.
§ M.H. indicates man hours.
‖ H.H. indicates horse hours.
¶ Columns not added to totals.

Table 12. Summarized Labor Costs—Four Steps in Clearing

	Sand		Sandy loam		Clay loam		Clay	
	Hr.	Per cent of total	Hr.	Per cent of total	Hr.	Per cent of total	Hr.	Per cent of total
				Man hours				
Brushing	15.1	19.9	49.7	40.0	30.2	20.3	9.3	9.6
Stumping	28.4	37.5	38.1	30.6	39.4	33.2	58.4	60.0
Breaking	14.0	18.5	21.2	17.0	25.6	17.2	19.2	19.7
Stoning and picking roots	18.2	24.1	9.5	7.6	23.4	15.8	4.9	5.0
Miscellaneous	.....	.....	5.9	4.8	20.1	13.5	5.5	5.7
Total	75.7	100.0	124.4	100.0	148.7	100.0	97.3	100.0
				Horse hours				
Brushing	5.8	8.2	.....	.....	.....	.....	.....	.....
Stumping	16.1	22.8	23.0	27.5	39.2	34.9	54.9	50.7
Breaking	29.0	41.0	39.9	47.7	42.7	38.1	39.3	36.3
Stoning and picking roots	19.0	28.0	11.4	13.7	25.2	22.5	8.5	7.8
Miscellaneous	.....	.....	9.3	11.1	5.1	4.5	5.6	5.2
Total	70.7	100.0	83.6	100.0	112.2	100.0	108.3	100.0

Table 13. Summary of Blasting Data

Type of soil	Stumps per acre	Weighted average diameter	Stumps blasted per acre	Per cent of stumps blasted	Sticks per charge	Feet of fuse per charge	No. of stumps blasted per hour
Sand	102	9.2	40	39.4	1.7	1.1	5.0
Sandy loam	49	11.1	37	76.4	2.4	1.6	3.9
Clay loam	78	13.2	52	66.5	2.3	1.6	4.8
Clay	80	14.6	63	78.6	2.2	1.3	7.5
Weighted average	82	11.3	46	56.0	2.1	1.4	4.9

THE DOLLAR PRICE SCALE

Men think in terms of dollars. Yet the dollar has an ever-changing buying power. For this reason these data have been given in terms of unchanging units of labor and supplies to fit any price scale anywhere in the upper Lake States where the work is done in the same way, but readers who wish to interpret the cost in monetary values should have the opportunity to do so.

The work was done with low-cost dynamite or war-salvaged explosive of equivalent composition and strength. This dynamite was sold at $16 per 100 pounds, or 340 sticks, making the cost of one stick 4.7 cents. A price of 5 cents per stick is generous and will cover all situations for the decade 1922-1931. The war-salvaged explosive usually sold for $10 and less per 100 pounds of about 300 sticks. Four cents a stick is a liberal allowance.

Fuse sold for 90 cents a hundred, so one cent a foot is allowed. Caps sold for $1.60 a hundred; these are charged at 1.75 cents per cap. Farmers who cleared land through this period can apply their own cost records to our record of time and materials. Others will find these unit costs will cover all situations where local distribution functioned properly.

Labor prices are less stable and less uniform over the 11 counties than explosives. The best source of information available is the farm management data gathered on over 30 farms near Askov, in Pine County, through 1925, 1926, and 1927, the middle of the period under review. The average cost of man labor was reported at 20 cents an hour, and horse labor about 12½ cents. This is man labor employed by the month and furnished with board and lodging, the cost of which is included in the hourly rate. The horses were the farmers' property, and the rate per hour was arrived at by dividing the maintenance cost by the number of hours employed. Where better local rates are available, substitute them.

WHICH LAND SHALL WE FARM?

From the viewpoint of the engineer, this report is complete. On a close study of the mechanical operations involved, the relative cost of reclaiming four kinds of farm land, light and heavy, has been determined. It seems good economy to select land that is cleared at the lowest cost, if one is planning to purchase wild land and convert it into a farm. But the farm manager raises the question of relative productive power. (1) Which land will produce the most tonnage per acre under normal farm practices? (2) Which land will sustain production the longest? (3) Which land will produce the cheapest? These are important questions. Clay loam soil requires almost twice as many labor and explosive units as sandy soil, but if the same clay loam produces double the tonnage or maintains like production for twice as long, its clearing cost is justified equally with that of sandy soil. We find men operating all four soils. A principle of compensation is probably at work. There may be a ratio between cost and product that places all soils on a comparative basis.

SUMMARY

Reclamation studies on stump and stone land were made on 122 farms in 11 northeastern Minnesota counties.

The farms were grouped and studied as to type of soil—sand, sandy loam, clay loam, and clay.

A distinctive forest cover is associated with each type.

Reclamation studies on each type are grouped under four heads or processes—brushing, stumping, breaking, and picking up stones and roots.

Costs are expressed in terms of units of labor and material. Both normal or average and range are given.

Brush is removed in four ways—by manual labor, by grazing by ruminant animals, by fire, and by machinery.

Brushing was done on 194 acres and 66 farms. The time required per acre varied from one day on clay to nearly 5 days on sandy loam. The average was 3 days. This covers burning as well.

Stumping was done on 320 acres and 104 farms. Man labor ranged from less than 3 days on sandy soil to 5¾ days on clay with the mean 4 days (42 hours). Horse labor required was 2¾ days per acre.

Stumping covers four sub-divisions of labor—blasting, pulling, piling, and burning.

The 42 hours stumping time may be apportioned thus: Blasting 10 hours, or ¼ the time; pulling 1½ days, or ⅓ the time; piling 13 hours, or less than ⅓ the time; burning 5 hours, or nearly ⅛ the time.

Sandy soil took the least explosive; clay the most. The average acre required 127 sticks of explosive, 84 feet of fuse, and 60 caps.

The diameter of blasted stumps is as follows: On sandy soil, 9.2 inches; on sandy loam, 11.1 inches; on clay loam, 13.2 inches, and on clay, 14.6 inches.

Clear the easiest acre first, if it is productive mineral soil. Learn the job. Clearing costs are part of the capital charges against the land.

Breaking, including disking and seedbed preparation, was done on 221 acres and 76 farms. Horse labor was used in all cases.

Breaking was done most rapidly on sandy soil, most slowly on stony clay loam. The average acre took exactly two days to break, for man and team.

Eighty acres of land were stoned. This required more than one 10-hour day for the average acre. Clay was even freer of stones than jack pine sand.

Roots were picked off 166 acres. The job took just a fraction over ½ day of man labor per acre. The picking was lightest on clay soils, which grew the largest stumps.

Stump-hole filling and associated trimming jobs took over a day per acre. Only one out of seven farmers did this extra work.

Twelve days of man labor were required for all operations in clearing an acre and 9 days of horse labor.

The 12 days of man labor were distributed thus: Brushing, 3 days; stumping, 4 days; breaking-disking, 2 days; picking stones and roots, nearly 2 days, and miscellaneous, 1½ days.

To clear an acre of sandy land required 7¾ days; of clay, 9¾ days; of sandy loam, 12 days, and of clay loam, 15 days.

The amount of material used per acre varied in the following order: sand least, sandy loam, clay loam, and clay.

Breaking was the big job for horses. Other jobs in declining order were stumping, stoning and picking roots, and miscellaneous.

Inefficient labor on very marginal land explains the high figures in range of clearing costs.

Light soil was cleared at lower cost than heavy soil. This advantage might be counterbalanced by heavier and more sustained production on heavy soils. Crop data have been assembled for four seasons.

The following were prices in effect when these data were being gathered: Man labor, 20 cents an hour; horse work, 12½ cents an hour; explosive, 5 cents a stick; fuse, 1 cent a foot; caps, $1.60 a hundred. (Askov statistical route, 30 farms, 1925-1927).