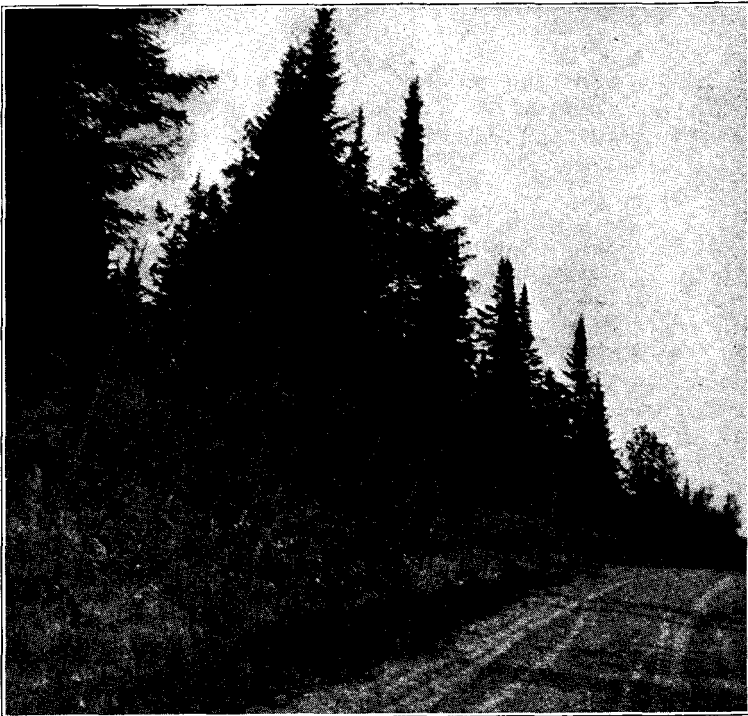


UNIVERSITY OF MINNESOTA
AGRICULTURAL EXPERIMENT STATION

EFFECTS OF FOREST FIRES ON LAND CLEARING AND CROP PRODUCTION

M. J. THOMPSON
NORTHEAST EXPERIMENT STATION



UNIVERSITY FARM, ST. PAUL

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EFFECTS OF FOREST FIRES ON LAND CLEARING AND CROP PRODUCTION

BY M. J. THOMPSON

Northeast Demonstration Farm and Experiment Station, Duluth

Introduction

The Northeast Experiment Station is located seven miles north and east of the center of the city of Duluth, Minnesota, and lies just outside of and adjoining the corporate limits. It was established by legislative enactment in 1911. The site was selected by the University Board of Regents in 1912, and some initial work was done the same year. Development operations and building construction were begun in earnest in the spring of 1913.

The land purchased consisted of 250 acres, nearly 95 per cent of which was covered with a heavy forest growth. Altho scattered pine stumps could be found where the timber had been removed decades before, the stand was looked upon as virgin forest, growing on a stony clay loam soil. A tree and stump census disclosed the following distribution of species: Balsam, 68.5 per cent; birch, mostly white, 10.2 per cent; pine, mostly dead stumps, 8.2 per cent; tamarack, 6.9 per cent; the rest scattering and including considerable cedar, some spruce, tamarack, mountain ash, and Balm of Gilead.

From the nature of the case, investigation in problems of farm development was the first duty undertaken. This work has been carried on for 12 years, and the clearing operations are now practically completed. Previous findings have been published in the reports of the station for 1915, 1916, 1917, 1918-19, 1920, 1921, and 1922-23, and also in Agricultural Experiment Station bulletin No. 163, "Investigations in Cost and Methods of Clearing Land," and its supplement, No. 189, "Forced vs. Delayed Systems of Clearing Land."

Statement of the Problem

The Northeast Experiment Station is in the heart of the area devastated by the tremendous forest fire of October 12, 1918, that swept over northeastern Minnesota. Buildings, fences, lumber, timber, and livestock to the value of \$25,000 were destroyed by the fire. This experience is probably unique in the history of similar institutions in the United States. As it is a commonly accepted doctrine that fire is an effective agency in land clearing, and as the entire station acreage, both cleared and uncleared, has been burned over, it was decided to

capitalize on the opportunity and make a study of the effect of the fire in reducing costs of clearing land.



Fig. 1. Field "F," April, 1919, the Spring Following the Fire
Note the larger birch timber and the smaller balsam.

Additional considerations are involved, however. In many cases the soil itself, as well as the forest cover it supported, was more or less burned. This led to the question of the degree of productivity of these soils as compared with their pre-fire state of fertility. A study of this problem has been incorporated as a project in this work. Supplementary investigations dealing with the relative efficiency of tractor and horsepower in stump removal, and seasonal adaptation for such phases of land clearing as brushing and stumping have also been incorporated.

As the type of soil and the character and condition of vegetation are the most important limiting factors in land clearing operations, it should be understood that the findings recorded and the conclusions drawn are limited in their application to the cutover areas with soil and vegetation similar to those found at the Northeast station. The fire affected portions of St. Louis, Carlton, and Aitkin counties, with a small fringe in Itasca county. But the balsam-clay loam combination is found in portions of Lake, Cook, Pine, Kanabec, and Koochiching counties as well.

The Land Cleared

A forty-acre tract was selected for clearing. Ten acres of this had been brushed and logged in 1914 and another ten acres in 1915. Both have been in pasture since. The remaining twenty acres were covered with a dense forest of the prevailing balsam-birch type. The count indicated something over 200 trees per acre. Scattered through the stand were the dead but largely undecayed white pine stumps, making up from 8 to 10 per cent of the entire number. The pine timber had been logged off perhaps 30 years before.

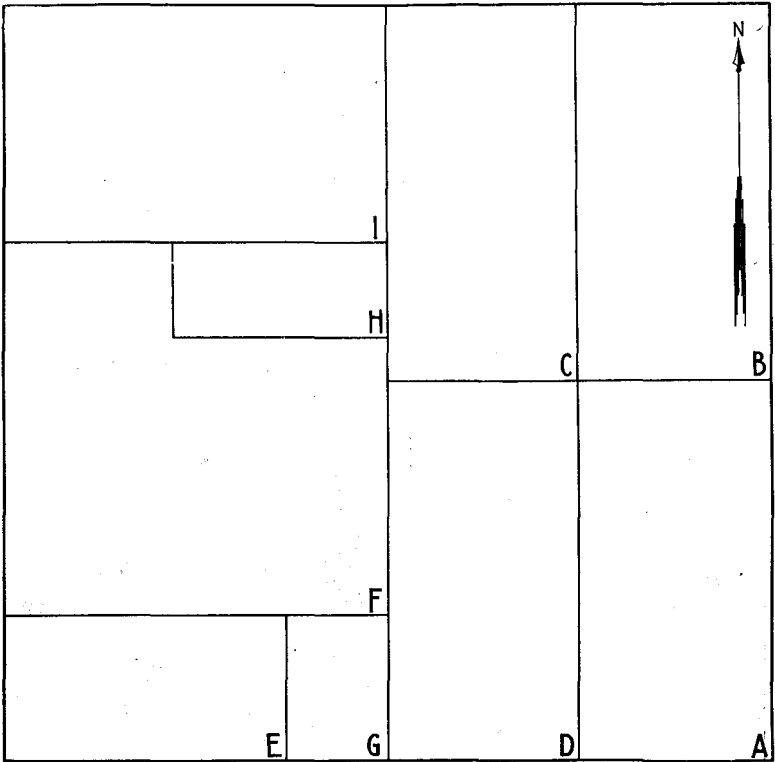


Fig. 2. The Fire Made Blasting of Large Birch and Pine Stumps Difficult

A. J. Schwantes and C. E. Johnson, both of the Division of Agricultural Engineering, University Farm, contributed greatly to the success of this project in their skillful handling of the explosive work. S. H. Marden, and later Herman Landre, both of the station staff, showed excellent judgment in handling labor and in field management of the projects.

Land clearing includes three processes: (1) removal of the overburden of timber, brush, and windfalls; (2) removal of the stumps, and (3) breaking and stoning, in the natural order of operations. This order will be followed in the development of this paper, and a comparison made with the cost in labor and material of a like process under other conditions in which fire was not a factor.

The chart on the next page shows the history of development.



Forty-acre Tract Devoted to Experimental Clearing

Field A—4.49 acres—

Brushed and logged, November 1914; stumped, June 1921.

Field B—4.61 acres—

Brushed and logged, November 1914; stumped, June 1921.

Field C—4.98 acres—

Brushed and logged, November 1915; stumped, June 1921.

Field D—5.06 acres—

Brushed and logged, November 1921; stumped, June 1922.

Field E—3.01 acres—

Brushed and logged, winter 1920-21; stumped, June 1921.

Field F—8.26 acres—

Brushed and logged, winter 1920-21; stumped, June 1924.

Field G—0.96 acres—

Plotted for crop experiments on burned land.

Field H—1.4 acres—

Plotted for crop experiments on burned land.

Field I—6.3 acres—

Irregular tract, used for tractor-team experiments and miscellaneous work.



Fig. 3. All Fences Required Reconstruction

Note the large timber, birch, and pine, with the smaller balsam, blown over. The debris on the ground is old dead timber.

TABLE I
CLEARING COSTS PER ACRE, FOLLOWING FIRE, TO STUMP-REMOVAL STAGE

	Tract 1		Tract 2		Tract 3		Average	
	Man hours	Horse hours	Man hours	Horse hours	Man hours	Horse hours	Man hours	Horse hours
Brushing	38.0	....	38.0	....	38.0	....	38.0	....
Felling timber	12.2	....	13.0	....	26.5	26.5*	12.8	....
Topping, trimming	53.7	....	54.5	....	66.5	....	58.2	....
Misc. operations	42.0	56.0	31.5	27.5	33.0	30.0	35.5	37.8
Burning brush	15.5	....	14.0	....	14.0	....	14.5	....
Total	161.4	56.0	151.0	27.5	178.0	56.5	159.0	37.8

* Horse power was used in pulling over the trees in this area.

A plan was advocated of cutting the roots loose on one side, attaching a rope or cable 20 feet or more up a tree, and pulling it over with horse power. This was tried at two places, but was not satisfactory and the practice was discontinued. The ground soon was covered with trees lying in all positions. It was impossible for either men or horses to accomplish anything unless each tree was trimmed at once on felling. This again slowed up the work.

These data are of special interest when compared with the time consumed in like operations with green timber. This contrast is shown in Table II.

TABLE II
BRUSHING AND LOGGING COSTS UNDER GREEN AND BURNED CONDITIONS

Operation	Green timber		Burned timber		Per cent saving occasioned by fire
	Man hours	Horse hours	Man hours	Horse hours	
Brushing	63.3	....	38.0	....	40.0
Felling, trimming timber	80.5	....	67.5	....	16.1
Burning brush	9.9	....	14.0	....	-46.7
Misc. operations, skidding logs, poles	65.0	37.5	35.6	37.8	40.1
Total	218.7	37.5	155.1	37.8	

Brushing is done more cheaply after a fire than before, for several reasons. The fire removes all the small material usually taken by a scythe or other light tool as well as the dry, rotten windfalls. Footing is improved. The charred brush left standing can frequently be broken over, but if a season or two intervenes, allowing a second growth of several feet, this gain is largely lost. There is less occasion to chop into the ground, more freedom in using the brushing tools, and less dulling and wearing of tools.



Fig. 4. Effect of the Fire on Stumps

The fire burned away the organic matter close to the stump, having the effect of raising it above the ground level. The stumps in the foreground are typical of the effect on dry balsam.

The saving in felling and trimming is materially less. Unless the work is done at once following the fire, the wood dries out and hardens, and will often turn an ax. This is especially true of balsam, the knots of which are extremely tough. Moreover, men are somewhat reluctant to handle blackened, charred wood and consequently the accomplishment is less. There is more work with the saw and less with the ax. The large saving in miscellaneous work is very easily explained. There was less material to handle. By the time the timber was cut it had dried out and was much lighter. The ground surface was smoother and freer from small snags and other obstructions.

Burning the brush was much more expensive after the fire than before, as the combustible material—balsam needles, birch bark, and rotten wood—had been largely consumed, leaving nothing for kindling the fire or maintaining it under damp or unfavorable conditions.

Taking the same price for man labor under both conditions, 26.6 cents per hour, the cost of farm labor employed by the month, the burned land clearing to stump removal stage, was done at a saving of \$16.90 per acre. Horse labor was about the same in both cases. Horse labor does not vary, as it is confined to the one operation of skidding poles and logs, the number of which is about the same in each case. This item of cost will vary with the price of labor, and the proper comparison is that of units of labor expended in each instance.

Stump Removal

Stump removal is the second operation in clearing land. In Table III are presented some details relative to the number and the percentage blasted and pulled. The detailed count was taken only on fields A, B, C, and E.

TABLE III
METHODS OF STUMP REMOVAL

Item	Field A	Field B	Field C	Average Fields A, B, C	Field E	Field I
						Dead, unburned tract, 1918
Actual size of field, acres	4.48	4.61	4.97	4.69	3.00	5.44
No. stumps per acre	175	216	267	219	290	314
No. stumps per acre pulled	147	190	235	191	211	207
No. stumps per acre blasted	28	26	32	29	79	107
Per cent pulled direct	84	88	88	87	72.7	66
Per cent blasted direct	16	12	12	13.3	27.3	34

The dead unburned tract, cleared in 1918, is strictly comparable to Fields A, B, and C, prior to the forest fire. Owing to the fire, 20 per cent more of the stumps were pulled direct and the percentage to

be blasted was reduced by nearly two thirds. The effect of the fire in reducing clearing costs is especially notable in Field E, which was green timber before the fire, and where the fire seemed even more effective than four years of decay in Field I. This can best be understood from the photographs showing the soil burned away from the stump with a large space underneath and producing the effect of the stump being raised above the surface of the ground. Seven stumps were left to be reblasted in Field C and 20 in Field E, nearly three times as many, as the stumpage was not so old. The following analysis of labor costs includes work done in 1921, 1922, and 1924.



Fig. 5. Pasture on Burned Over Land

Pastures were left in a very "patchy" condition but completely recovered the first season, as the new clover-grass seeding healed over the bare spots.

TABLE IV
DISTRIBUTION OF MAN AND HORSE LABOR PER ACRE

Item	Field A		Field B		Field C		Field D		Field E		Field F	
	Man hours	Horse hours	Man hours	Horse hours	Man hours	Horse hours	Man hours	Horse hours	Man hours	Horse hours	Man hours	Horse hours
Piling debris	1.3	2.7	2.9	2.0	0.7	1.1	0.0	0.0	5.2	6.3	..	..
Pulling, piling	18.5	17.0	21.2	22.8	0.0	0.0	27.1	27.1	25.9	25.9	22.8	22.8
Piling, after blasting	13.7	13.7	14.8	13.8	35.3	31.4	10.3	10.3	22.2	22.6	8.2	8.7
Blasting	2.4	..	2.2	..	1.9	..	2.0	..	7.1	..	2.7	..
Burning	2.9	..	2.9	..	2.9	..	2.9*	..	2.9*	..	2.9*	..
Total	38.9	33.4	44.0	38.6	40.8	32.5	42.3	37.4	63.3	54.8	36.6	31.5

* In these tracts the stump piles were worked over, all available material was cut for fuel and the rest was burned. While the same amount of time is allowed, the actual time spent in burning and branding is considerably less, as more than half the material was removed for fuel.

Fields A, B, C, D, and F may be averaged for comparison with Field E. This group of five, tho stumped at different times, represents a combined effect of decay (delayed clearing) and fire in reducing cost of operations, while Field E was largely of green timber when burned in October, 1918, tho not stumped till 1921. The average man labor for the five fields is 40.5 hours, as compared to 63.3 hours of Field E. The margin is less for horse labor, being 34.7 and 54.8 hours, respectively.



Fig. 6. Damage to Pasture by Fire of Oct. 12, 1918

The fire destroyed much of the organic matter on the surface, exposing a greater number of stones for the first picking.

Reducing the differences to percentages, there is a saving of 35.7 per cent in man labor and 36.7 per cent in horse labor in favor of the five-field group. Fields A and B were cut off four years before the fire and stumped three years after it; C and D were cut off three years before and were stumped four and three years, respectively, following it. There is a very close similarity of labor costs in all four fields. Field E was largely green standing timber in 1918, with a burned fringe on the south edge. It was cut off two years later and stumped the following spring. The roots, especially of the birch, were still

green and matted, thus materially increasing the cost of labor. Field F was killed by the fire, brushed and logged two years later, but not stumped until the sixth season after the fire. It was the cheapest job of all, demonstrating the progressive effect of decay. Further to determine the effect of fire, a comparison will be made with the clearing costs on the adjoining twenty acres, stumped just previous to the fire.

TABLE V
LABOR UNITS IN STUMPING LAND UNDER BURNED AND UNBURNED CONDITIONS

	Green unburned		Green burned		Ripe unburned		Ripe burned	
	Man hours	Horse hours	Man hours	Horse hours	Man hours	Horse hours	Man hours	Horse hours
Blasting	30.8	...	7.1	...	7.7	...	2.3	...
Piling refuse material	13.0	...	5.2	6.3	14.4	28.8	1.7	1.9
Pulling, piling small stumps ..	0.0	...	25.9	25.8	17.4	34.8	22.1	21.8
Pulling, piling after blasting ..	35.0	69.5	22.2	22.6	44.3	88.5	18.0	16.7
Burning	3.6	...	2.9	...	1.5	...	2.9	...
Total	82.4	69.5	63.3	54.7	85.3	152.1	47.0	40.4



Fig. 7. Use of Stumps for Fuel

More than 50 per cent of a stump pile is salvaged for fuel. The wood is excellent for furnace, heater and boiler.

It will be noted that under "Ripe unburned stumps" both man and horse labor items are very high. Two circumstances explain this. (1) Very little blasting was done, so more labor was necessarily expended in pulling the entire stump. As a result, the item of labor was almost identical with that for green stumps. A saving was effected in explosive, as the bill was reduced from \$26.91 to \$13.09. This will be referred to later. (2) This work was done during the war when labor

was scarce and poor. One man worked with a team instead of two. Under these conditions the horses stand idle much of the time while with two men they work almost continually. As a result the horse hours are nearly double the man hours, but are much less in every other case.

The striking reduction in time required for blasting, which is always done with high class labor, will be emphasized in Tables 6, 7, and 8.

TABLE VI
UNITS OF BLASTING MATERIAL CONSUMED PER ACRE, ON BURNED AREA

Item	Field A	Field B	Field C	Field D	Field E	Field F	Average
Dynamite, lbs. (or equivalent)	13.7	11.0	14.1	17.5	62.9	15.5	14.4
Caps, number	30.0	28.0	39.0	25.0	86.0	22.0	29.0
Fuse, feet	54.0	47.0	65.0	30.0	150.0	33.0	46.0

TABLE VII
UNITS OF BLASTING MATERIAL CONSUMED PER ACRE, BURNED AND UNBURNED AREAS

	Green unburned area	Green burned area	Ripe unburned area	Ripe burned area
Dynamite, lbs. (or equivalent)....	171.0	62.9	41.0	14.4
Caps, number	211.0	86.0	57.0	29.0
Fuse, feet	313.0	150.0	92.0	46.0

TABLE VIII
SAVING IN EXPLOSIVE MATERIALS DUE TO FIRE

Item	Green stumpage	Dry (ripe) stumpage
	Per cent	Per cent
Dynamite, lbs. (or equivalent)	63.1	64.9
Caps, number	59.2	50.9
Fuse, feet	52.1	50.0

The saving in explosive materials consumed is materially greater than the labor saving. To one conversant with land clearing practice this is readily understood. A certain minimum amount of force is required to remove stumps whether burned or decayed. As the use of explosive is eliminated, it must be replaced by labor, tho in reduced measure.

Thus far, costs of the various operations and savings recorded have been expressed in terms of labor and material, as the cost of both, expressed in money, has varied greatly during the last ten years, while this work was in progress. Nevertheless, this work will be of added interest to many if the actual cost of clearing these several tracts following the fire, is recorded.

These cost items are given in Table IX. Skilled labor is charged at 53 cents per hour and common labor at 26.6 cents; dynamite, 24½ cents a pound, caps, 2 cents each, and fuse 1 cent a foot. By "dynamite equivalent" is meant war salvage explosive—picric acid, sodatol, pyrotol, or TNT:

TABLE IX
STUMPING COSTS PER ACRE, LABOR AND MATERIAL

Item	Field A	Field B	Field C	Field D	Field E	Field F	Average
Blasting labor	\$ 1.27	\$ 1.19	\$ 0.94	\$ 1.06	\$ 3.78	\$ 1.42	\$ 1.18
Man labor, general	9.70	11.13	9.35	9.95	14.16	9.02	9.83
Horse labor, general	5.01	5.78	4.88	5.63	8.20	4.56	5.17
Dynamite	3.33	2.67	3.75	4.66	16.74	3.76	3.63
Caps	0.60	0.56	0.78	0.50	1.72	0.44	0.58
Fuse	1.54	0.47	0.65	0.30	1.50	0.33	0.66
Total	\$21.45	\$21.80	\$20.35	\$22.10	\$44.37	\$19.53	\$21.05

Table IX indicates that the stony clay loam soil covered with stumps dead before the 1918 fire is being cleared at the Duluth station up to the breaking and stone picking stage for less than \$25 per acre. In presenting these data it might be of interest to say something of the farm practices followed in getting them. Only month labor is employed. Some of these men are at the institution through several seasons so they become adapted to the work. No special men are employed, as the work is done between late spring planting and early haying, and again in late October before freezing weather. A definite plan is followed. The farm foreman, working with his men, is on duty throughout the job. Instead of using a few men for a longer time the entire crew is thrown in for perhaps a week. This undoubtedly makes for economy, for the men are fresh on the job and do not tire of it. Four trips are made over the field: (1) pulling stumps with a team; (2) following with a wagon to pick up loose material; (3) blasting; (4) cleaning up blasted material.

The reader is led to inquire how this compares with clearing costs of green and ripe stumps before the fire and how the combined net savings of labor and material work out. To find this it is necessary to reduce all operations to the same base price, that of 1914 being taken. At that time skilled man labor cost 30 cents an hour; unskilled, 20 cents; 33 per cent dynamite cost 12 cents per pound; 40 per cent, 13 cents, and 60 per cent, 15 cents.

TABLE X
COMPARATIVE COST OF STUMPING LAND, USING 1914 FIGURES AS BASIS

Item	Green stumps, unburned area	Green stumps, burned area	Ripe (dry) stumps, unburned area	Ripe (dry) stumps, burned area
Man labor	\$22.15	\$13.58	\$17.97	\$10.14
Horse labor	5.66	4.21	11.46	2.98
Material	26.91	9.45	9.16	2.27
Total	\$54.72	\$27.24	\$38.59	\$15.39

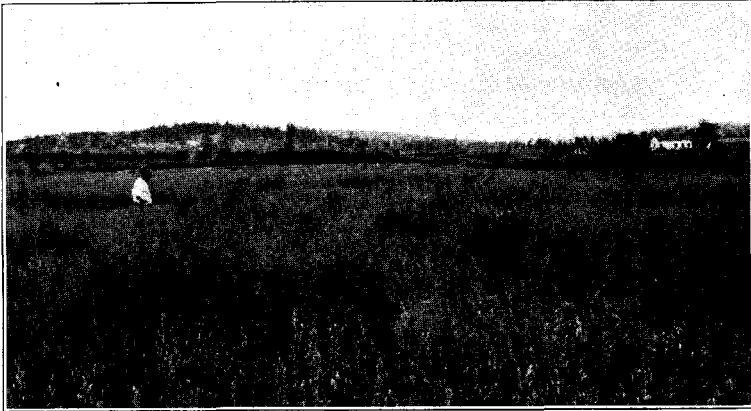


Fig. 8. Oats on Old Fire Plots, August, 1922
Field "E" in the rear.

It must be clearly understood that the 1914 cost figures are used for a basis of comparison only, and are from $1/3$ to $1/2$ below actual costs so far as the second, third and fourth columns in Table X are concerned, but are correct for the first column. The actual cost of removing green burned stumps in 1914 was \$54.72. Applying the same price level to all cases, we have a clearing cost for burned green stumps of \$27.24, a saving of 50.22 per cent. With 1914 price levels the acre cost of stumping the dry unburned area would be \$38.59 and of the burned dry stumps, \$15.39, a saving of 60.12 per cent.

It is unlikely that a forest fire would have any appreciable influence on breaking costs, altho cleaning the surface of snags, rotten wood, moss, and other debris facilitated plowing to some degree. The effect was so slight that no attempt has been made to extend the project to cover breaking costs. Stone work was ignored for the same reason. Burning off the leaf mold, moss, and other forest cover did not increase the number of stones but doubtless exposed a greater number in the surface foot of soil. In this way there would be a larger pick of stone in the first breaking.

The material here presented represents a measurement of forest fire effects in a particular enterprise. It should be noted that the effects of an extensive forest fire in clearing up the country are much more pronounced than is the case with an ordinary brush fire. With these two facts in mind, the question now arises, "Where can these facts be applied outside districts in this and other burned-over areas with like soil and vegetation?" In conversing with settlers concerning anticipated clearing operations, we have frequently heard the wish expressed that the "fire would run over it" to simplify the job. Uncontrolled fire, the most wasteful and expensive, was the ancient and universal method when land meant everything and timber nothing. But in the present day of depleted forest resources, the firing of a tract with even a modest timber stand is classed as a calamity. Timber loss and soil injury far exceed the saving in clearing.

But we have areas of stumps, windfalls, and brush which can be and are fired to advantage. Controlled fire is the greatest natural agency in clearing land. It is indispensable in reclamation of peat and, with rapid firing these soils are actually improved. With careful supervision and neighborly co-operation considerable areas have been burned over in a short time and a community fire hazard was eliminated. The writer recalls one such instance in St. Louis County when the forestry officials co-operated with the farmers in burning over a half section tract on a given day. The township constitutes an excellent unit for this work, with the resulting double benefit of simplified clearing and reduced fire hazard.

But supreme caution must rule in all burning operations, and at all times and seasons. Both law and custom have provided certain definite regulations for fire control. The "Burning Permit Law" requires settlers in the cutover districts to obtain burning permits in the absence of snow on the ground or a freshly plowed firebreak. These are issued by representatives of the state forester, town officers, or other authorized person, there being no limit to the number.

In very dry periods issuance of permits may be suspended. The ideal time to burn is in the spring before the frost has left the ground. Burning is often done after fall freezing and before heavy snow. A poor time is after a severe frost that dries vegetation. It is always better to start a fire late in the afternoon or toward evening. There is less danger of its getting beyond control.

For the proper construction of fire breaks, W. T. Cox, formerly state forester, advises the following in Minnesota Farmers' Institute Annual No. 33: "If I were to specify what would constitute a reasonably safe freshly plowed firebreak, I should say that for the burning

of stubble or grass land, six or eight furrows should be sufficient. For burning peat lands, a ditch full of water or a ditch dampened and patrolled, or six or eight furrows plowed around on high land should be sufficient. Brush and timber fires in open places will throw sparks so far that narrow plowed strips are really of little use unless watched by men constantly on the job until the fire is out."

Tractor Versus Horse Power in Stumping Land

There has been much discussion concerning the relative merits of tractor power and horse power for land clearing purposes. Two projects dealing with this question were planned and completed at the Duluth substation in 1923. One was done in June, the other in October. Uniform areas were selected in order to equalize the contest. The object in each case was to determine both rapidity and completeness of clearing. Two men accompanied the team and two worked with the tractor, a machine of popular make.

	Project 1, June 1923		Project 2, Oct. 1923	
	Tractor area	Team area	Tractor area	Team area
Area	0.725 acre	0.725 acre	1.00 acre	1.00 acre
Pulling stumps, hours	6½ (machine)	6½ (team)	14.4 (machine)	22 (team)
Picking roots, team hours.....	1	1½	4	..
Picking roots, man hours.....	13	16	36	44
Stumps remaining to be blasted..	16	18	26	26

One team hour consists of the labor of two horses for one hour. A slight margin is indicated for the tractor in both cases with about equal efficiency in completeness of job and number of unpulled stumps. The ground was firm and dry, the land was high, the stumps were well decayed, and the tractor was new and well manned. Under these conditions the tractor did satisfactory work. While the tractor can be used for the pickup and cleanup work, horses are better. Stumping is usually done at odd times between rush seasons, often on wet ground where tractor operation is difficult.

Seasonal Adaptation of Clearing Land

(A) **The brushing season.**—"Brush should be cut at that season of the year when the likelihood of second growth is most remote. In this instance (1921) four tracts were measured off and one each cut in August, September, October, November. Careful observations made the following spring and summer disclosed no material difference in the amount of second growth. The old notion that August is the best and only month for cutting brush was not borne out."—(From 1921 station report.)

Control of second growth is largely a matter of good farm practice regardless of the time when cut. Unless follow-up methods are employed, there is always some second growth, irrespective of the time cut. On the other hand brush may be cut any month in the year if followed at once with sheep, with grass and clover seed scattered at the same time.



Fig. 9. Sunflowers on New Fire Plots, August, 1922

(B) **The stumping season.**—It is usually agreed that the proper time to stump land is in the spring. But owing to the pressure of other duties the bulk of the stumping is frequently delayed until October, after the crops are all under cover. In 1923 a project dealing with this subject was carried through at the Northeast Experiment station, Duluth, stumping being done in May, June, and October.

TABLE XI
DATE-OF-STUMPING PROJECT

	May 29	Jun: 26	October 25
Size of field, acres	0.868	0.840	0.671
Hours spent in stumping—			
Man	40	35	26
Horse	40	35	26
Picric acid used, lbs.	6	5	4
Fuse used, ft.	15	12	10
Caps used	12	9	7

In Table XII the cost of clearing each tract is given at the prevailing prices of 53 cents for skilled labor, 26.6 cents for unskilled, 10 cents per pound for explosive (war salvage), 1 cent per foot for fuse, and 2 cents each for caps.

TABLE XII
DATE-OF-STUMPING PROJECT—COSTS

Item	May work	June work	October work
Cost of man labor	\$11.17	\$ 8.84	\$ 7.44
Cost of horse labor	6.00	5.25	3.90
Cost of explosive material	0.99	0.80	0.64
	\$18.16	\$15.89	\$11.98
Cost per acre.....	\$20.92	\$18.92	\$17.85

The results of this work seem to indicate that the accepted belief as to the proper season for stumping work is incorrect, but this is not true. The fact is established, however, that, like all general statements, this must be qualified.

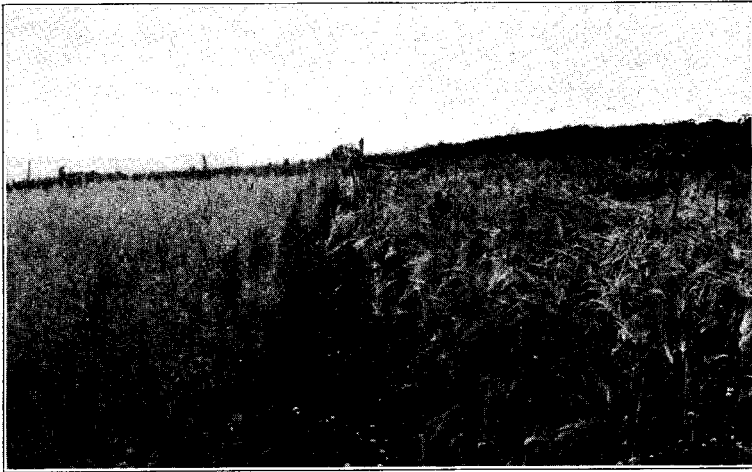


Fig. 10. Oats, Barley, and Sunflowers, August, 1922

This shows the south side of Field "C." Note the excellent stand of alsike between the plots and scattered through them.

Three conditions brought about this result. (1) The spring was very dry, the ground being fully as hard as in summer and fall. (2) The stumps were not extremely large, and the root systems were well decayed. (3) The heavy burning of and about the stumps in 1918 tended to equalize the job at whatever season done. In the fall of 1924 the ground was very wet and stumping could be done as cheaply as in the ordinary spring, but such autumns are the exception. With stumps of considerable size and root system, especially in light soils where the roots penetrate deeper, and with normal seasonal conditions, spring stumping is usually good practice.

Grubbing Swamp Land

A very heavy stand of cedar grew on the north eighty of the station tract previous to the 1918 fire. It included some balsam and spruce and an occasional pine stump. The soil varied from a clay outcrop at the west side to five feet or more of decayed peat at the east end. The clearing done following the fire was a typical grubbing operation, as there was scant footing for explosive in the muck bottom and none for horses until drained or frozen. The five-acre tract required 1,710 man hours of labor, or 342 hours per acre, to grub and pile the stumps and wood. Burning was done intermittently during the winter to prevent danger from fire. In June, 1924, a tract of 5.62 acres was contracted for in like manner. This required 670 hours, or 119.2 hours per acre. The average of the two operations is 231 hours per acre. This is an admittedly expensive operation, but the land involved is typical of the soils being devoted to head lettuce, celery, and cauliflower in southeast and central St. Louis County, which have had an established rental value up to \$50 per acre per year over a term of years.

Crop Production on Burned Virgin Soil

Following the great fire of October 12, 1918, there was much discussion as to whether or not the soils that had been burned over had been injured for crop production. As the fire had extended to all portions of the station farm, a project was undertaken and a study of the problem was begun and carried through five seasons. In 1920, a tract containing six tenth-acre tracts on virgin mineral soil that had been severely burned was set apart for this purpose. A second tract was selected in 1921, and the first was continued. Both were upland soil, and represented average conditions, as the first maintained a heavy timber growth and the second a lighter forest cover. In 1922, toward the close of the work, the south halves of the hay plots had a light dressing of manure (2 tons per acre per year) to get the comparative effect.

As observations made during the growing season are important, we quote from 1921-22-23 reports: "The year 1920 was very favorable for grains, but as 1921 was very hot, the farm yields of oats and barley ranged from 50 to 75 per cent of normal, not only on this group of plots but over the entire farm. Potatoes, with a production of not quite 100 bushels per acre yielded true to form on new land with hot, dry summer conditions. Silage production was up to the average of the farm, and clover-timothy hay closely approached it. Careful observations over a two-year period seem to indicate that the first year's

crop on severely burned land is subnormal except in the case of sunflowers. They grew remarkably well. . . . On the well drained upland, where the burn was heaviest, grass made the best catch. As clover and grass seemed to thrive in the ash, the showing of hay was fair."



Fig. 11. First Crop of Oats on Burned Land, August, 1922
This field is the same land shown on title page. Field "C," north side.

TABLE XIII
YIELDS ON BURNED VIRGIN MINERAL SOIL

	Oats	Sunflowers	Potatoes	Hay
	Bu.	Tons	Bu. discard	Tons
1920	22.98	8.81		....
1921	24.30	9.80	83.44	1.33
1922	31.08	7.43	101.01	1.54
1923	30.05	7.02	98.10	1.15
1924	45.80	....	....	1.56
Average	30.84	8.26	94.18	1.39

To get a proper understanding of the effects of the forest fire on crop production, comparison must be made with production on virgin soil, unburned, and covering as nearly as possible the same seasons. We will then have three sets of conditions: (1) Upland virgin soil, severely burned, as above; (2) Unburned upland, cleared, cropped at once, without clover or manure grown or applied at any time; (3) Unburned upland, pastured in advance of stumping, and reinforced by droppings of cattle, decay of wood, and clover-grass sod. These are

known locally as the "delayed clearing" plots. The comparison is made in Table XIV.

TABLE XIV
AVERAGE YIELD PER ACRE OF CROPS GROWN ON BURNED AND UNBURNED SOIL, 1917-1924

Condition	Years	Oats		Potatoes		Sunflowers	
		Bu.	Tons	Bu.	Tons		
(1)*	4-5	30.84	1.39	94.18	8.26		
(2)*	7-8	33.65	...	114.70	5.93		
(3)*	4-5	45.60	1.53	157.12	7.02		

* These numbers refer to corresponding numbers in text above.

At the close of the five-year period, the observations made in the early years of the test are borne out. Sunflowers have not only done as well as in other virgin soil locations but slightly better. This variation is probably due entirely to local conditions or circumstances. Hay has done about as well, but oats and potatoes are noticeably lower in yield. We may probably safely conclude that the destruction of humus and the reduction or suspension of bacterial action for a time by the forest fire will account, in part at least, for the decreased relative production.

Summary

1. At the Northeast station 66 per cent of the timber growth was balsam fir, ten per cent birch, eight per cent pine, the rest scattering, growing on a stony clay loam soil.

2. This station lay in the heart of the forest fire of October 12, 1918, and suffered a loss aggregating \$25,000 in buildings, livestock, and equipment.

3. Three processes are involved in land clearing operations: brushing, stumping, breaking-stoning.

4. The fire occasioned a saving of 40 per cent in man labor in brushing; 16 per cent in logging; 40 per cent in skidding and miscellaneous work; but burning brush required 46 per cent more time. Horse labor was almost identical with pre-fire data.

5. Using current labor prices for men employed by the month, the saving to stump removal stage was \$16.90 per acre.

6. The fire seemed more effective than four years of decay in reducing stumping costs.

7. Stumps that were dead, partially decayed, and burned, were cleared at a saving of 35.7 per cent in man labor and 36.7 per cent in horse labor compared to stumps that were green when burned.

8. Post-fire clearing of green stumps was done at a saving of 23.1 per cent in man labor and 21.2 per cent in horse labor.

9. Post-fire clearing of ripe, dry stumps was done at a saving of 44.9 per cent in man labor.

10. The principal saving in stumping dry stumps as compared with green stumps is in explosive, rather than labor.

11. The fire caused a saving of 58.14 per cent in explosive material used for removing green stumps, and of 55.3 per cent for dry stumps.

12. The actual cost of post-fire clearing of dry stumps was \$21.05 per acre, an average of five tracts.

13. Using 1914 price levels, post-fire clearing of all conditions of stumpage was done at a saving of 55.17 per cent of pre-fire costs for both green and dry stumps.

14. Controlled fire is the greatest natural aid of man in clearing land.

15. Under very favorable conditions, a light tractor showed a slight advantage over horses in speed of stumping, but both were about equal in completeness of job.

16. Brush may be cut any month in the year if followed immediately by grazing of sheep and sowing of clover and grass seed.

17. With stumps of considerable size and root system, especially in lighter soils where penetration is deeper, and with normal seasonal conditions, spring clearing is usually good practice.

18. Grubbing two areas of swamp land averaged 231 hours per acre. Such land rents high for intensive gardening.

19. Comparing crop production on the burned virgin soil with production on like soil unburned, sunflowers produced equally well or better; hay about as good; oats and potatoes, distinctly less. Clover catches remarkably well in the ash.