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**Clearing and Improvement
of Farm Land
in Massachusetts**

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CLEARING AND IMPROVEMENT OF FARM LAND IN MASSACHUSETTS

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INTRODUCTION

Since 1940 an increasing number of Massachusetts farmers have made use of heavy equipment to improve farm lands. Power machines, such as the bulldozer and the gas shovel, have made possible the completion of tasks that were impossible with hand tools and the usual farm machinery. In most instances improvement work has been limited to a few acres on an established farm, but in a few cases whole farms have been developed on land that had been abandoned for many years. By land reclamation the acreage of cropland, orchard, pasture, and poultry range has been increased, fields have been enlarged, and obstructions that have interfered with intensive use of land have been removed. In addition, drainage of lowlands has increased the acreage of crop and pasture land.

Some of the land improvement work in recent years has been done at high cost per acre. However, tasks that formerly were costly in terms of human labor now often require only a few hours with power equipment. Savings in time and man labor have paid for use of the machinery. The increase in land improvement activity raises many questions in the minds of farmers and of farm leaders. On what kinds of land will improvement work pay for itself? What are the least expensive and the most effective methods? What other possibilities are there of increasing the size and the operating efficiency of a farm? What factors must be considered by the landowner in deciding whether or not to undertake the particular task of clearing? Is it sound agricultural policy to encourage farm land improvement when in the same community other farm lands are going out of agricultural use?

During the summer of 1945 and early in 1946 a number of farmers who had made land improvements were interviewed. Data were obtained on the kinds and amounts of work performed, the time and the charges for heavy equipment, the costs of the job, and past and intended use of the land. The owners or operators of bulldozers and power shovels who were doing the work, by the job or at a specified rate per hour, were also interviewed. The summarization and presentation of these data may serve as guides to other land owners who are contemplating land improvement work.

In this study attention has been devoted to use of heavy equipment and power machinery which is not usually found on the farm. The physical methods of land improvement³ have been appraised generally in the course of the study and attention necessarily has been devoted to engineering problems. However, interest and analysis have been concentrated upon the economic significance of this work. The primary purposes behind the study as a whole have been to appraise the methods used in farm land improvement, to examine the results in

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³The terms "land improvement," "land reclamation," and "land clearing" are used in this report to denote methods used and types of activity.

CLEARING FARM LAND

terms of cost-benefit comparisons, and to study the significance for the future of agriculture in Massachusetts.

The methods employed in land improvement work in Massachusetts in recent years are quite different from such activity a century ago. The economic setting and the outlook for the future have changed. A hundred years ago farming was a much larger part of the whole economy. There were relatively fewer other opportunities and means of making a living. Also, farming was largely on a self-sufficing basis, with most of the essentials for living coming from the farm. It is another proposition to clear land and make a living in a complex exchange economy in which most of the requirements for living are obtained by purchase with money obtained from sale of farm products. Part of the larger change in outlook is indicated by the changes in number of farms, acreages in farms, and acreage of improved land.

According to the census of agriculture, there were 31,897 farms in Massachusetts in 1939 with a total of 837,632 acres of improved land, an average of 26 acres per farm. In 1849 there were 34,069 farms listed which contained 2,133,436 acres of improved land or 62 acres per farm. Changes in types of farming were largely responsible for this variation in improved acreage per farm. A larger number of intensive vegetable, small fruit, cash crop, and poultry farms with a limited acreage of improved land were listed in recent years of the census. An increase in the number of part-time farms has tended to reduce the average acreage per farm. The commercial dairy, cash crop, vegetable, and fruit farm of recent years contained a greater acreage of improved land than was indicated in the census for 1939.

From a regional and national point of view there is now sufficient land in farms to supply needed quantities of food and fiber. Future requirements for food probably can be met from increased production per acre. All farms will need to operate more efficiently. In many parts of the United States the future will undoubtedly mean fewer but larger farms. Larger economic units will be needed to support the people who make their living from farming. Likewise in Massachusetts, increasing the size of farm will mean fewer farms. If the adjustments in size of farm can be made only through expensive land improvement operations, it is all the more important that careful study be given to costs and probable returns, before the work is undertaken. It is also important to remember that what will work for the individual will not necessarily work for a group or for all the people in a town or a county.

The only data available on acreages of land improved by use of power equipment in recent years are a set of estimates. No accurate measurement or count

TABLE I.—ESTIMATE OF FARM LAND IMPROVEMENT BY STATES, FOR 1940-44.

Type of Land Improvement	Unit	Mass.	Conn.	Vermont	R. I.	Maine*
Land cleared						
Timber and brush.....	acres	2,730	6,083	2,289	2,545	430
Stumps.....	acres	1,365	980	510	215	80
Boulders.....	acres	1,860	3,733	1,541	370	1,020
Fruit trees.....	acres	450	1,364	79	145	—
Other.....	acres	1,400	—	400	125	—
Land drained.....	acres	1,390	2,340	8,734	—	415
<hr/>						
Total improved.....	acres	9,195	14,500	13,553	3,400	1,945
Stone walls removed.....	linear yards	10,100	30,666	7,330	3,000	1,600

* Estimates for Aroostook and York Counties in Maine.

has been made, but informed persons were contacted in many counties of five New England states, to obtain data on kinds and amounts of improvement work. Timber and brush removal were the most important kinds of land improvement work in Massachusetts, Connecticut, and Rhode Island. Drainage accounted for the greatest acreage of land improvement in Vermont because of the operations of Soil Conservation Districts for three years. Boulder and stump removal were important in Massachusetts, Connecticut, and Vermont, as was also the removal of stone walls to make larger fields. Approximately one-third of the land improvement work in these states in the five years 1940-44 was done in 1944 as farmer interest increased and farm income was available for the purpose. All of these types of land clearing were continued on farms in Massachusetts in 1945, and reclamation of wet lands by dynamiting ditches was increased by the Soil Conservation Districts.

Although data are not available year by year, farmers and machine operators agree that even during the war years, land improvement work expanded. There are several explanations, aside from the pressure of "food to win the war," and the long-time interest of progressive farmers in efficiency of operation. The higher farm incomes provided cash reserves that could be spent for land improvement. Owners of bulldozers and gas shovels were diverted from normal employment such as building work and road construction. Probably of more importance, however, it had been demonstrated that heavy equipment could perform the farm land improvement work effectively. The farmer who had enlarged a field, cleared off the boulders, or removed stone walls set an example for his neighbors. The use of heavy equipment for land improvement work was developed largely by the demonstration method on farms in Massachusetts.

When work was begun with the bulldozer or other equipment on the first farm in a community the operations were watched with considerable interest by neighboring farmers. As the work progressed and the speed, efficiency, and thoroughness of the operations were realized by other farmers, machines were hired for similar work on their farms. This means of expanding the area of land improvement work was particularly effective where field stones, boulders, and stone walls were removed. The thinning of young orchards and the removal of old trees to make way for replanting developed along this line with one grower in a community starting the method and others following his example. The results achieved by the Soil Conservation Districts in draining swamps and lowlands by blasting ditches also created considerable demand for this type of land reclamation work. The visual effect of seeded pasture, field crops, vegetables, and young orchards on land which was formerly covered with trees, brush, shrubs, stumps, or boulders convinced many farmers of the possibility of adding a few acres of land of a suitable soil type to their farm unit.

METHODS AND COSTS OF CLEARING AND IMPROVING LAND

Types of Equipment

A crawler or track type tractor with a *bulldozer blade* attached was the most widely used piece of heavy equipment for land improvement operations in Massachusetts. Various sizes and makes of these machines were used to remove stumps, boulders, and stone walls as well as to clear land of trees and brush and to grade soil to obtain level fields. The *grubber blade* with heavy teeth instead of the solid bulldozer blade reduced loss of topsoil in clearing operations. Soil shaken loose from roots sifted out between the teeth and was not piled with the debris of stumps and trees.



Figure 1.

- A. Topsoil Is Saved when the Grubber Blade Is Used to Remove Brush and Trees.
B. Subsoil Tiller Brings Roots to the Surface after Cleared Land Is Turned with Brush-breaker Plow.

Large cutaway or *bog harrows* of the disk type were used to prepare land for seeding to grass and clover mixtures after boulders, trees, stumps, etc., were cleared with the bulldozer. In some cases such harrows were used after the land had been plowed, but in most instances the bog harrow was used instead of the plow to break up the new ground. A *disk harrow* was used to pulverize the soil and prepare a seedbed for pasture mixtures. Harrows were used instead of plows on land where large boulders and stumps were not removed.

Brush-breaker plows were used to turn over new land where brush, stumps, trees, and boulders had been cleared with bulldozers. Shrubs and bushes were plowed under with these heavy-duty plows, and roots, small stumps, and stones were turned up and removed. For vegetable crops and sometimes for potatoes a *deep tiller* was used to break up subsoil and to rake out stumps, roots, and stones not removed previously.

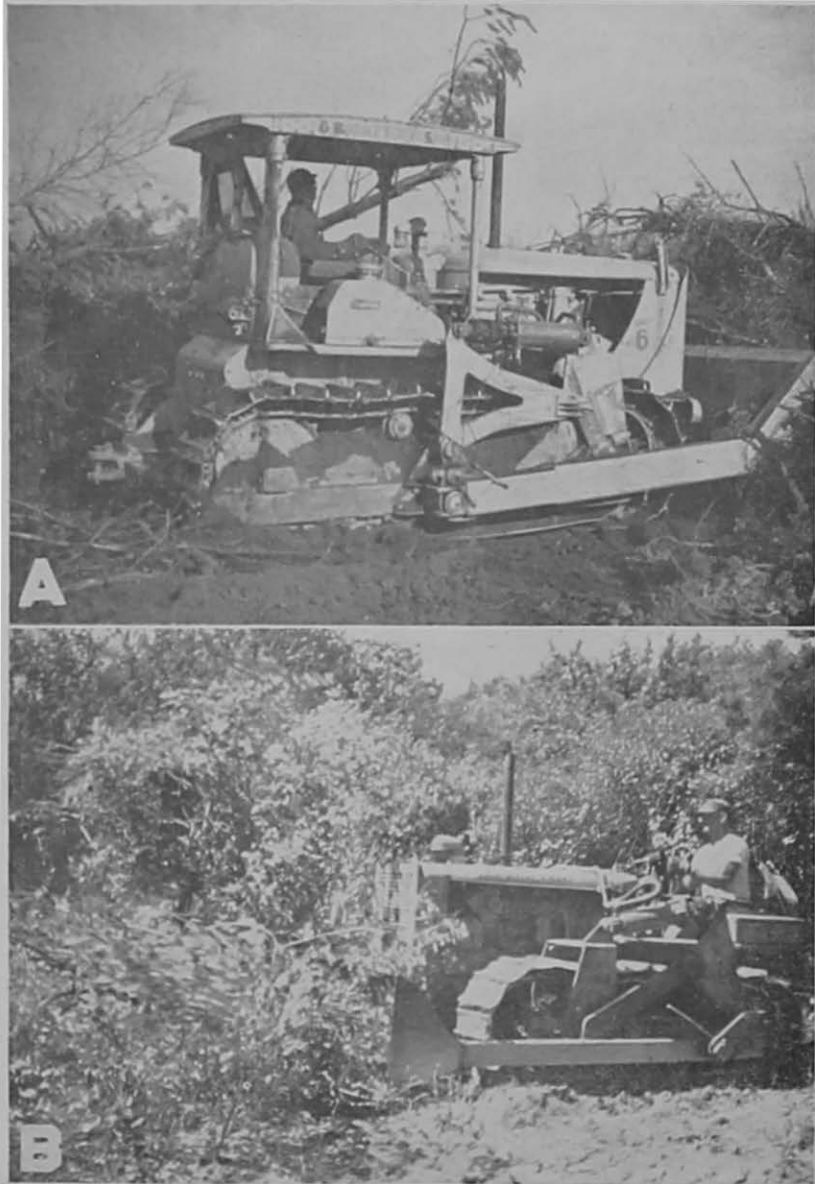


Figure 2.

- A. Large Bulldozer Clearing Woodland for Orchard.
B. Bushes Are Removed with a Small Bulldozer.

Power shovels were used to dig drainage ditches and trenches where stone walls were to be buried. Shovels were also used to remove boulders and stumps and to load stone walls on trucks in cases where walls were hauled away. Some apple trees have been removed with small shovels, which were used also in the construction of cranberry bogs. Dragline excavators were used to remove topsoil from cranberry bog land and in digging drainage ditches on Soil Conservation District projects.

Other equipment which was used in various phases of land improvement activity included dump trucks, chain saws, and ordinary farm equipment such as tractors, plows, harrows, dumpcarts, and stoneboats.

Clearing Brush and Trees

Many areas of land with various combinations of brush and tree growth have been cleared in recent years for a variety of purposes. One of the first instances of woodland clearing with power machinery was on a tract of sandy loam soil for *vegetable crops*. Pine and deciduous trees to 18 inches in diameter, plus oak, birch, and brush were cleared from 300 acres with a bulldozer owned by the farmer. Trees were pushed out and cut for lumber and cordwood. Stumps and brush were piled in windrows with the bulldozer and burned. The land was then plowed to a depth of 15 inches with a brush-breaker plow, after which a deep tiller was used to bring roots and sticks to the surface to be picked up and hauled away. Costs of clearing this large area varied with the type of tree cover. Pine land was cleared more rapidly than oak or birch trees and brush. Costs were calculated at about \$50 per acre to clear and plow pine land, and from \$75 to \$100 per acre for oak and hardwood cover of trees, stumps, and brush. One acre of scrub pine was cleared per day with the bulldozer but 12 to 15 hours were needed to remove the hardwood growth and stumps. Farm labor was used and the bulldozer was farmer owned, which reduced the cost per acre below contractor's charges for similar work.

Bulldozer costs for clearing deciduous trees and brush on a farm of upland stony loam soil for a new *apple orchard* ranged from \$85 to \$100 per acre plus \$25 per acre for treatment and seeding to obtain a new sod for young trees. Costs were high because of the stony soil, the hardwood cover, and the thoroughness of the job. About 12 hours of bulldozer work per acre were needed in clearing this land.

In one case, woodland clearing at a contract price of \$150 per acre for the bulldozer, gave poor results because the operator was not experienced in clearing for agricultural uses. Operations were stopped on another farm because too much topsoil was being removed with the brush and stones.

On farms where brush was cleared for *poultry range* and trees left for shade, the charges for bulldozer work were about \$50 per acre. Where brush was cleared for seeded range or for pasture, the costs ranged from \$45 to \$100 per acre for bulldozer work and from \$50 to \$110 for total clearing. Woodland was cleared for orchards, vegetables, and cash crops at \$85 to \$150 per acre for the bulldozer work and about \$10 per acre for picking up roots, sticks, and stones before the land was plowed. Costs of clearing for these crops were greater because a more thorough job was necessary in order to get the land in shape for plowing. Where pasture and poultry range were harrowed before seeding, less care was necessary in the clearing operations.

Clearing Shrubs and Bushes

Land that had reverted to a cover of bushes and shrubs was cleared for pasture and crops in various areas in Massachusetts. Much of this acreage had been tillable cropland and pasture but had been abandoned when prices of farm products were low in the early 1930's. Higher prices for farm products, particularly milk and potatoes, have encouraged the reclamation of this land for hay, pasture, and crops.

In one instance pasture land which had reverted to juniper, hardhack, sheep laurel, and other shrubs was cleared with a medium-sized bulldozer at the rate of one acre per eight-hour day. Many boulders were pushed out as well as a few small trees on this stony loam soil. Debris was pushed into a swamp and stones were piled in a row as the base for a road to a woodlot. This land was too stony to be plowed so the seedbed was prepared by repeated harrowings. Roots, sticks, and stones were picked up between harrowings and then the land was limed, fertilized, and seeded with a mixture of Ladino clover and grass. The cash costs for the bulldozer were about \$45 per acre and additional costs for labor, seed, fertilizer, and lime added another \$45 so that an improved seeded pasture was obtained for about \$90 per acre.



Figure 3.

Seeded Improved Pasture (right) Was Made from Rough Land (left) by Bog Harrow Treatment.

In other worn-out pastures which had reverted to shrubs and bushes, the land was improved by repeated use of a bog harrow. Juniper and other large shrubs were pulled with a tractor, chain, and special type of hook. In areas relatively free of stones the cover was cut with a heavy-duty mower before harrowing. Clearing of hardhack and sheep laurel cover with a bog harrow has been found satisfactory because the cover can be disked under and topsoil is not removed. Another method consisted of harrowing alder swamps with a bog harrow when the ground was frozen in order to break the stems and allow grazing of shoots the following season. When the land became dry enough to be harrowed and seeded, a fertilized pasture was available for long-season grazing.

Costs of these methods of renovating old pastures were difficult to obtain because farm equipment and farm labor were used in slack seasons. The cash expense for operating machinery, for wages of hired labor, and for seed, fertilizer, and lime ranged from \$35 to \$60 per acre for improving old pastures that had reverted to shrubs and bushes. The grazing capacity of such pastures varied with the type of soil, amount of fertilization, moisture available, and the mixture of grasses and legumes seeded. It is important to seed the combination of grasses and clovers adapted to soil and moisture conditions of the reclaimed land.

A considerable area of abandoned crop and hay land which had reverted to blueberries, shrubs, and bushes has been reclaimed in recent years for potato production, especially in the Berkshire Hills region. Brush and bushes were cut or pulled out and the smaller growth was plowed under with heavy brush-breaker plows and crawler-type tractors. In some fields the cover was light and potatoes were grown the same season, or the next season in the case of fall plowing. In some cases the land was harrowed several times the following season to kill sprouts before a crop of potatoes could be grown. Stones and roots were picked to facilitate the use of machinery in potato growing. Cash costs of reclaiming this land were relatively low—from \$15 to \$30 per acre.

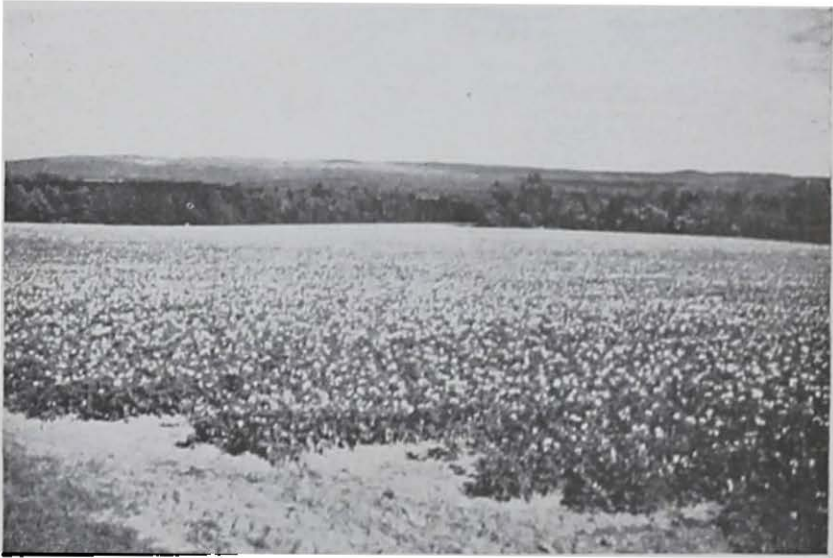


Figure 4.
Hilltop Potato Field after Brush and Shrubs Were Cleared from Former Hay Land.

Removing Stumps

Clearing of stumpland for pasture and crops increased after the 1938 hurricane when many stands of pine trees were blown over. The use of bulldozers and gas shovels for this work had become common by 1944 and heavy equipment had been used to remove stumps on several farms as early as 1940. Costs were high in these early years because efficient methods of removal and disposal of stumps had not been learned. In one instance a gas shovel was used to lift out pine and oak stumps and pile them in windrows for burning at a total cost of \$160 per acre. These stumps were too green to burn and the windrows had to be broken up to allow them to dry out before they could be burned. Labor, bulldozer,

and fuel-oil costs of burning these stumps amounted to \$60 per acre, cost of the gas shovel was \$80 per acre, and bulldozer charges for grading land and pushing out boulders amounted to \$20 per acre. The gas shovel has been more expensive than the bulldozer for stump removal and the latter machine has been necessary for leveling the land after the shovel had removed stumps.

A typical example of stump removal for pasture occurred on a Connecticut Valley farm where 20 acres of pine and hardwood stumps were pushed out with a bulldozer and the land leveled at a cost of \$58 per acre. Less than 10 hours was required per acre to remove these stumps, which ranged from one to two feet in diameter. Some were used to fill low, wet areas in the lot while others were piled

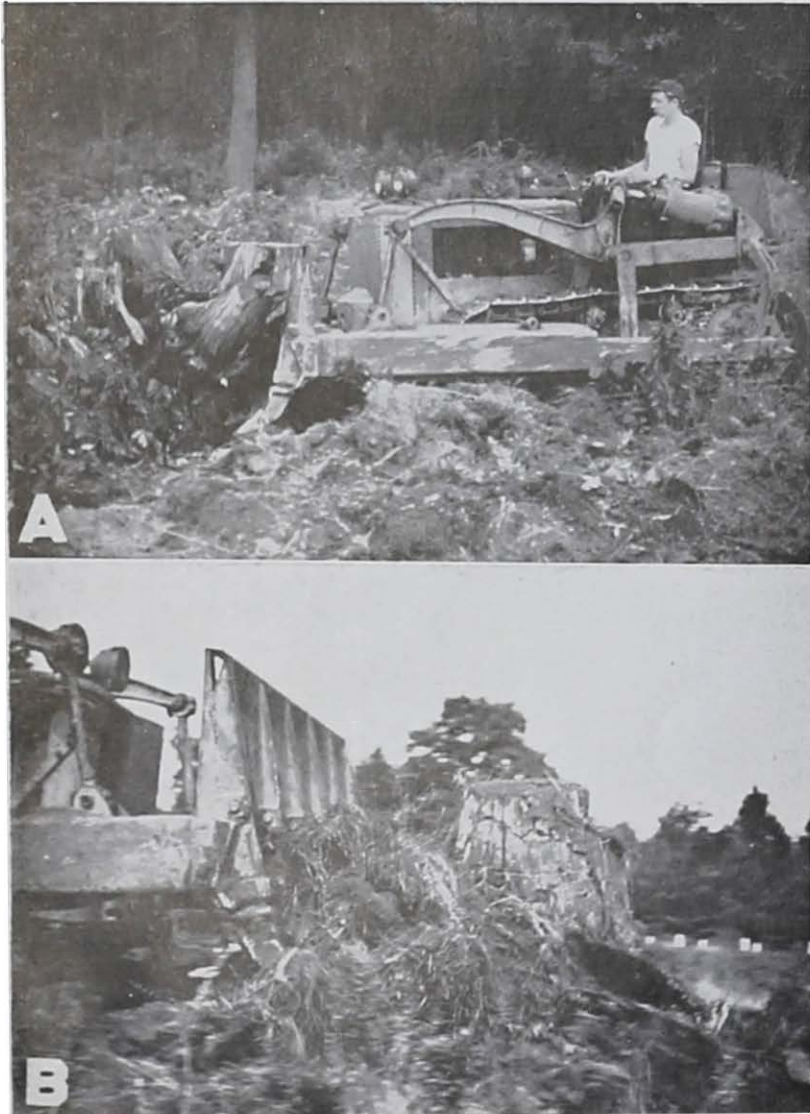


Figure 5.

- A. Removing Stumps with Grubber Blade Saves Topsoil.
B. Pushing Out Stump with Grubber Blade.

in windrows to be burned. Topsoil was deep enough here so that the field was graded and the stumps were covered in low areas to make a 20-acre level pasture over former swampy woodland. Total costs including picking roots, harrowing, fertilizer treatment, and seeding were less than \$100 per acre for a Ladino clover and grass pasture with high grazing capacity.

Records on 13 farms where 75 acres of stumpland were cleared with a bulldozer showed costs ranging from \$30 to \$125 per acre for the bulldozer. About 12 hours were required per acre to push out hardwood stumps and grade the land. Pine stumps were removed on sandy soils in 6 to 10 hours per acre at a cost of \$30 to \$50 per acre for the bulldozer, while costs for hardwood stumps on a stony heavy soil were nearer \$100 per acre. The use of a power shovel to lift stumps and of trucks to haul them in addition to the grading work with the bulldozer increased total machinery costs to about \$125 per acre for pine and hardwood stumps up to 30 inches in diameter. One advantage of using a shovel or clam shell bucket was that soil was shaken from the roots as the stumps were pulled. The grubber blade type of bulldozer was equally effective when stumps were pushed into swamps.

Pine stumps were cleared on sandy soil for seeded poultry range at costs ranging up to \$100 per acre where considerable grading and brush removal was required. In another instance, pine stumps to two feet in diameter on heavy loam soil were pushed out by the bulldozer in 6.5 hours for \$33 per acre. Stumps were hauled away in a stoneboat by the owner, the land was plowed and harrowed, roots were picked up, and a hayland mixture was seeded after fertilizer treatment. Total cash costs of clearing and seeding were less than \$50 per acre.

Hurricane stumps and broken stubs were pulled with a farmer-owned crawler tractor and chain on ten acres of clay loam soil for \$12 per acre. Total costs were about \$25 per acre for piling stumps in a windrow, picking stones and roots, and harrowing with a bog harrow. The land surface was uneven where stumps had been pulled and on this wet soil the grass seeding had died out where water was standing. Total costs were about \$50 per acre for a seeded fertilized pasture. On farms where labor and equipment are available, stumps on small acreages can generally be removed at less cost by the farm crew than by hiring a bulldozer or power shovel, but grading will not be so effective and more time is required.

Removing Stone Walls

Where stone wall removal has been undertaken, the purpose has usually been to combine several small fields into one large field for more efficient use of machinery. Three methods have been used by farmers in Massachusetts depending upon the crops to be grown, size of wall, equipment available, and soil conditions: (1) use of bulldozer alone, (2) combination of bulldozer and gas shovel, and (3) use of bulldozer, gas shovel, and dump trucks.

Costs usually were lowest where a bulldozer was used to make an "allweather road" from stonewalls. A shallow trench about 8 feet wide and 3 feet deep was scooped out along the wall and the stone wall was pushed into the trench. Stones were spread in a layer about one foot deep and covered with soil to make a drained roadway about one foot above the level of the surrounding land. This method of removing stone walls has been used in orchards to make roads to other blocks of trees and also to provide longer rows for spraying or dusting with larger machinery. Stone walls were buried in shallow trenches in pasture and hayland in many instances and the strip was seeded. On one farm the walls were pushed into a trench in a swampy spot to furnish drainage for seeded pasture. Costs of removing stone walls by the bulldozer working alone ranged from 75 cents to

\$1.25 per linear yard of stone wall about 2 feet wide by 4 to 5 feet high. Charges for the bulldozer were less than \$1 per linear yard in most cases. Costs varied according to size of wall, size of bulldozer, type of soil, distance stones were pushed, and time spent in grading.

One of the most common methods of taking out stone walls is the combined use of bulldozer and power shovel to bury the stones. A trench about 6 feet deep and 8 to 12 feet wide was dug along the wall by the shovel and the stone wall was pushed in by the bulldozer. In many cases the shovel was used to cover the stones with gravel and subsoil from the top of the pile of dirt.



Figure 6.

- A. Burying Stone from Wall in Trench Dug by Bulldozer.**
- B. Removing Stone Wall and Stumps with Power Shovel and Dump Trucks.**

bulldozer then pushed the other soil into the trench and graded topsoil over a strip 10 to 20 feet wide. The stones generally were covered about three feet deep and topsoil was graded as the last operation so that grass and crops could be grown. In the wet season of 1945 no difference could be noticed in the growth of silage corn, potatoes, and hay on the strips where stone walls had been buried that spring and the previous fall. The cost of this method ranged from 85 cents to \$1.10 per linear yard of ordinary stone walls 3 by 3 feet or 4 by 2 feet in size. Generally two-thirds of the total cost was for the shovel and one-third for the bulldozer. A smaller proportion of time was spent with the shovel, however, because in most cases the charge per hour was higher than for the bulldozer.

Another method of taking out stone walls, especially where there were stumps along the wall, combined the use of the power shovel, bulldozer, and dump trucks. The shovel was used to load the stones from the wall and any stumps in the fence row on trucks to be hauled to a swamp or other waste land and dumped. The bulldozer was used to pile loose stones for the shovel, to push stumps on the bucket for loading, to push stones and stumps into the swamp after they were dumped, and to fill and grade the trench left by the removal of the wall. Because more equipment was used in this method, costs were higher, ranging from \$1.15 to \$2.25 per linear yard of wall. The more costly job included one stump per rod and the work was done on wet ground so that considerable time was lost by all the equipment. Under normal operating conditions costs by this method should range from \$1.00 to \$1.50 per linear yard. The rates charged for equipment in 1945 and 1946 were \$6 to \$9 per hour for the power shovel, \$5 to \$8 per hour for the bulldozer, and \$3.50 per hour for each truck and driver.

A method of stone wall removal was reported where a stoneboat about 5 by 12 feet in size and made of sheet steel was used to haul the stones. This stoneboat was drawn along the wall, the stones were pushed on by the bulldozer, the load was drawn to the edge of a swamp by the bulldozer, and the stones pushed off into the swamp. When the distance is short and a large load can be hauled, this method may be economical. Such equipment could be used to haul stones a short distance to fill low wet areas or ditches where topsoil had been pushed off. The drained area could be utilized for crops or pasture after topsoil was graded over the stones.

Removing Field Boulders

Boulders in the hay and crop fields on Massachusetts farms are serious obstacles to the use of machinery in planting, growing, and harvesting crops. In some cases larger boulders have been broken by "mudcapping" with dynamite and the fragments removed with a stoneboat. Crawler type farm tractors have been used to pull out small boulders, but this was a slow and laborious procedure.

The acre cost of removing boulders with the bulldozer varied widely depending upon the number and size of boulders, size of bulldozer, experience of operator, and method used. Records show that a small bulldozer for which the rate charged was \$4 to \$5 per hour required more than twice as much time to remove the same quantity of boulders as a large machine at \$8 to \$10 per hour.

In removing boulders with a bulldozer the most common procedure was to push the soil from two sides of the boulder so that the blade could be placed under the boulder for a lifting and pushing motion to roll it to the surface. Boulders were pushed into a swamp or into a row to make a rough stone wall around the field. Boulders that were too large to be pushed out were buried in holes dug by the bulldozer or shovel and where a stone wall was buried some field boulders were pushed in also. In a few cases large boulders were drilled and split with a charge of dynamite so that the bulldozer could push them out.



Figure 7.

- A. Boulders Recently Pushed Out With a Bulldozer.
B. Pushing Boulders into a Wall at Edge of Field.

Cost of removing boulders as the first step in pasture improvement ranged from \$30 to \$120 per acre for the bulldozer charge with \$50 to \$70 the most common amount. Additional costs of picking smaller stones and broken fragments ranged from \$10 to \$25 per acre to make total costs of \$70 to \$90 per acre before the land was harrowed or plowed. The time required to remove boulders ranged from 12 to 15 hours per acre in most cases.

Costs of clearing rough stony land for row crops were \$20 to \$30 higher per acre because a more thorough job was necessary. Where a power shovel was

used to dig a trench and a bulldozer to push stones into the trench and bury them, costs were over \$200 per acre for the machinery. Boulder and stone removal was more expensive than stump, brush, or woodland clearing for comparable purposes.

In cases involving a few scattered boulders on hay or cropland the costs of removal ranged from \$20 to \$40 per acre for the bulldozer and \$5 to \$10 per acre for picking stones. In one instance about 100 boulders were removed from 8 acres of hayland at a cost of \$17 per acre. Scattered boulders were removed from vegetable land in southeastern Massachusetts with a large bulldozer at a cost of \$35 per acre on land with 25 boulders per acre. Disposal of boulders was sometimes a problem on crop fields since considerable space was needed around the field boundary for them. Generally there were swamps or areas of waste land into which the boulders could be pushed.



Figure 8.
Fruit Tree Being Pushed Out by Bulldozer.

Removing Apple Trees

Bulldozers and power shovels have been used to remove old apple trees to make space for new orchards and to thin bearing orchards by removing alternate rows of trees. Costs have ranged from 30 to 50 cents per tree for removal and in recent years the sale of cordwood has paid the cost of cutting and removal.

In one operation a 20-year orchard was thinned and 240 trees in alternate rows taken out with a large bulldozer in about 10 hours at a cost of 36 cents per tree. Cordwood was cut, the brush burned, and stumps hauled away on a stoneboat. More space and light were available for the remaining 27 trees per acre.

Old apple trees up to two feet in diameter were removed from a stony loam soil with a small power shovel at a cost of 40 cents per tree. The method used was to push the tree over with the bucket against the trunk about 10 feet off the ground. The bucket was then placed under the roots to lift the tree out. Trees were dropped once or twice to shake dirt from the roots. In this operation the

shovel took out two rows of trees in one trip through the orchard and left them in a windrow. Sale of cordwood paid for the cost of tree removal, cutting wood, and hauling stumps to a swamp with a tractor and stoneboat. Trees in rows were pushed out with the bulldozer in $2\frac{1}{2}$ minutes per tree, and by the power shovel in 4 minutes per tree. In the latter case, trees were older and larger. The bulldozer was easier to maneuver than the gas shovel and was more adaptable for removal of scattered trees. The land was graded after tree removal and trees were pushed out of the orchard in some instances. Soil was shaken from roots and sod was not torn up by tracks when the gas shovel was used.



Figure 9.
A. Blasting a Ditch Through Swampy Pasture Land.
B. Ditch Blasted in Heavy Wet Land.



Figure 10.

Dragline Excavator Widening a Ditch on Soil Conservation District Drainage Project.

Drainage

The need for drainage of pasture, hay, or crop land has been a problem on practically every farm in Massachusetts. In many cases ditches and brooks have become so clogged with silt, grass, and weeds that water has backed up on pasture and crop land. Many acres of land have become unproductive and efficiency of farm operations has decreased because of the difficulty of using farm machinery on this wet land.

Restrictions on the sale and use of dynamite during wartime prevented the blasting of ditches for farm drainage and the cost of using power shovels was usually too great. However, records were obtained showing that ditches were dug at a cost of 10 to 15 cents per linear foot and drainage was provided at a cost of \$15 to \$25 per acre. In some cases insufficient drainage was obtained because of lack of cooperation by neighboring farmers in providing a proper outlet by continuing the ditch.

In the spring of 1946, the drainage program for land improvement gained considerable impetus when Soil Conservation Districts were organized and the blasting of ditches was begun under supervision of the district. Dynamite was purchased in ton lots to reduce the cost and a bonded operator was hired for blasting. The work has consisted chiefly of opening old ditches by blasting a deeper and wider channel. The quantity of dynamite used has depended upon the type of soil and the size of ditch needed to furnish sufficient drainage. A ditch about 10 feet wide and 5 feet deep was blasted through a sandy loam soil by placing a full stick of dynamite every 18 inches with a half stick between these. On the same soil a lateral ditch about 6 feet wide by 3 feet deep was blasted by placing one-half sticks at 15-inch intervals. Dynamite for the main ditch cost 10 cents per linear foot and for the lateral ditch 4 cents per foot. Total cost of blasting these ditches and the charge for a tractor and grader to open smaller ditches amounted to \$20 per acre of cropland drained.

In another instance two neighbors cooperated with the Soil Conservation District to blast a ditch through a swamp. This ditch was almost completely filled with silt and coarse swamp grass. A channel 8 feet wide at the top and 3 feet deep was blasted by setting sticks of dynamite 15 inches apart. Twelve boxes of dynamite or 1200 sticks were set in this 1600-foot ditch by four men in $3\frac{1}{2}$ hours. The blasts were made in 300-foot sections and the men worked in two crews setting dynamite from the ends of each section. Dynamite for this ditch cost \$105, charges of the blaster for time, caps, and wire were \$9, and labor at 50 cents per hour was \$7. Total costs were about 8 cents per linear foot of ditch. The work was accomplished in less than half a day. Surface water had drained from 15 acres of swamp in two days and two acres of wet hayland were drained enough to be harvested.

Some of the advantages of blasting a ditch over digging with a power shovel were that cost was usually lower, less time was needed to obtain drainage, soil was scattered instead of piled along ditch, blasting was done in areas too wet to use shovel, and farm labor was used to set the dynamite instead of hiring extra labor.

Combinations of Improvement Activities

One of the most common combinations of land improvement activities was the removal of field boulders and stone walls on the same farm and at the same time. This occurred especially in southeastern Massachusetts on dairy and vegetable farms. In one such case 24 acres of land were cleared of boulders at a cost of \$126 per acre for machinery plus \$7 for picking stones. At the same time 500 linear yards of stone wall were buried in a low area of the pasture at a cost of \$1 per yard. The stone wall removal increased the total cost per acre to \$147 to obtain plowable pasture and cropland.

On another farm 630 yards of stone wall were removed from hayland and 6 acres of pine stumps were cleared with a combination of bulldozer, power shovel, and dump trucks. The walls were loaded on trucks and hauled away and the trench was graded at a total cost for machinery of \$1.46 per linear yard. The stumps were pushed out by the bulldozer for \$83 per acre. Loading with power shovel and hauling with trucks increased the cost to \$118 per acre.

Without exception the woodland and brush clearing operations involved the removal of old stumps, particularly oak and chestnut. On the stony types of soil many boulders were removed at the same time, which partially accounted for the variation in costs per acre for clearing woodland. Stump and boulder removal were combined in a few instances and land was graded. In several cases of clearing land for pasture improvement a drainage program was needed, and conversely, much of the swamp land which was drained by blasting ditches was improved to make pasture.

Variations in Costs

The cost has varied per acre of land improved, yard of stone wall removed, foot of ditch blasted, and apple tree removed on these farms. Many of these variations in cost per unit can be reduced by using the most efficient and least costly method in future land improvement operations.

One of the more common reasons for differences in costs was the *size of bulldozer* used for the job, particularly in removing boulders and stone walls. Usually the smaller machines at a lower rate per hour removed boulders at greater costs per acre than larger bulldozers. An example of this variation in costs occurred in two separate clearing operations on one farm. Boulders were cleared from 10

acres in 1940 at a cost of \$45 per acre with a large bulldozer at the rate of \$9 per hour. Two years later a small machine at \$5 per hour was used to remove boulders of similar size and number on an adjoining 14-acre field, and the cost was \$164 per acre. The smaller machine could not push the largest boulders and costs were \$20 per acre for filling and blasting these large boulders into smaller pieces.

Stone walls were removed on this farm in these two years by the same machines with a similar cost relationship. A trench was dug with the larger machine, the stone wall pushed in, and topsoil graded over the stones at a total cost of 85 cents per linear yard. A wall in the adjoining field was buried by the smaller machine by the same methods at a cost of \$1.20 per linear yard. The differences in cost per acre between large and small bulldozers were not as great for stump removal and clearing of woodland as for removing boulders and stone walls, but generally the larger machine with an experienced operator did the job at a lower cost.

Costs have also varied because of differences in *kinds of equipment and methods* of land improvement, especially in stone wall removal. In two cases where a stone wall was loaded on trucks with a power shovel and a bulldozer used to push stones and fill the trench, the costs were \$1.75 per linear yard to remove the wall. Where walls of similar size were buried by the bulldozer in a trench dug by the power shovel, the costs were about \$1 per yard. When the bulldozer was used to scoop a shallow trench in pasture or orchard and bury stone walls, the costs ranged from 65 cents to \$1 per linear yard for walls of comparable size. It is questionable whether the latter method should be used to remove walls from cropland since the stones are covered with less than two feet of soil.

In the case of stump removal, the cost for machinery was about \$115 per acre where a power shovel was used with either trucks to haul stumps or bulldozers to push them into piles. Where the stumps were pushed out and piled or buried by the bulldozer, the costs were about \$80 per acre for similar stumps in the same type of soil. The bulldozer cost ranged from \$40 to \$100 per acre for removal of pine and hardwood stumps on sandy to stony loam soils.

The variation in costs of machinery because of differences in *amount of work done* in clearing was more difficult to measure. In the case of boulder removal for crop production, the costs for the bulldozer and for picking stones was \$142 per acre on seven farms where 36 acres were cleared. The time required for the bulldozer was 25 hours per acre at \$5 per hour. This land was formerly rough stony pasture and was cleared for hay, corn silage, and truck crops. On similar land where boulders were removed to improve the pasture, total costs for bulldozer and picking stones were \$74 per acre on six farms for 38 acres of rough land. The time required was eight hours per acre at about \$8 per hour. Scattered large boulders were removed from hayland and cultivated crop land for \$28 per acre on five farms for 62 acres. Time required was only four hours per acre at about \$6 per hour. Boulder removal was more thorough when crops were to be grown than when pasture was seeded. Stones were removed so that machinery could be used for plowing, planting, cultivating and harvesting. In the case of pasture the land was harrowed instead of being plowed and some of the largest boulders were not removed.

The same cost relationship was observed when stump or woodland was cleared for crops or for pasture. Stump land was cleared for pasture at about \$65 per acre for machinery and hand labor for picking roots, but on similar land when cleared for cultivated crops the costs were about \$80 because of more thorough removal of small stumps, roots, and sticks in order to plow and cultivate the land. When used for pasture the cleared land was usually harrowed, fertilized, and seeded without being plowed.

The comparative cost of any type of land improvement between machinery hired at a specified rate per hour or on a contract basis per unit was generally lower by the hourly rate particularly where woodland and brush were cleared. For example, rather heavy growth and stones were cleared on stony loam soil at \$90 per acre at the hourly rate as contrasted to clearing of lighter growth on a sandy soil for a \$125 per acre contract price. In the same way, stone wall removal with the bulldozer alone was contracted at \$1 per linear yard while on a neighboring farm at the rate of \$6 per hour the cost was 75 cents per yard to bury the wall. A contributing factor to these higher costs was the tendency of company farms and owners of rural estates to contract for their land improvement on a unit basis. Improvement work on commercial farms whether dairy, fruit, tobacco, or potato was more thoroughly planned and closely supervised than on the rural estates and costs were seldom excessive when measured against benefits accrued. A few instances were observed where land was cleared on a marginal type of soil at great expense and the cost could never be returned under any system of farm operation.

ECONOMICS OF LAND CLEARING AND IMPROVEMENT ON COMMERCIAL FARMS

The costs of land improvement work are usually high on an acre basis. Total costs per acre for an economic unit may be prohibitive when improvement costs are added to the other capital requirements in land, buildings, livestock, and equipment for a new farm. For the farmer who wants to expand his size of business, the economic venture may be justified in many instances. However, the question is not alone how much is the total cost; it is also what are the alternatives and the probable benefits. The costs of *not making* necessary adjustments may exceed the actual costs of improvement.

In another study, improvement in land utilization is designated as the field of adjustments in Massachusetts agriculture which promises the most profitable results. Many farms are inadequate in land resources, both as to area and as to quality. Rough terrain, stony soils, presence of boulders and stone walls, small fields, and improper drainage have delayed the mechanization which has proved to be profitable in other parts of the country. As Dr. Rozman states, "The fundamental problem remains one of consolidating the scattered fields, and

TABLE 2.—REQUIREMENTS FOR ADJUSTING 100-139 ACRE FARM TO STANDARD ONE-MAN DAIRY FARM.

Standard* Land Requirements One-man Family-Type Dairy Farm	Acres	Present Farm Land Uses	Acres	Types of Improvement Needed	Costs
Hay land	25	Hay land	19	Shift 6 acres crop land to hay— stone wall removal	\$200
Crop land	10	Crop land	16		
Improved pasture	10	Plowable pasture	15		
Open pasture	25	Other land	24	Boulder and stone wall removal— \$20 per acre	300
Wood land	50	Woods	46	Clearing and stoning 20 acres for improved pasture—\$25 per acre	500
Farmstead	5	Farmstead	5		
Total acres	125	Total acres	125	Total cost	\$1,000

* Standards for Massachusetts Dairy Farms—Dept. Agr. Econ. and Farm Mgt., Massachusetts State College.

where necessary, increasing the total amount of arable land on farms in order to obtain an efficient and economic family unit capable of using modern mechanical methods."⁴

In order to demonstrate the economic significance of adjustments in farm land utilization through clearing and improvement, a dairy farm in the 100-139 acre size group of the agricultural census was adjusted to the standard requirement for a one-man dairy farm. The necessary adjustments and costs are shown in Table 2. Boulders and stone walls were removed from crop and hay land for about \$500. Other open pasture was cleared of occasional bushes and boulders for another \$500 to furnish more improved pasture for a larger herd.

Much the same type of comparison could be made with poultry farms, to indicate the amount of improvement needed to develop poultry ranges. Also, standards might be set up for fruit farms, showing the amount of renovation and enlargement necessary on apple orchards; or for vegetable farms, to show the probable extent of clearing and improvement work needed to build an economic unit. Selected cases are presented to illustrate the effects on size, organization, and farm income where improvement work has been done. The majority of farms on which heavy equipment has been used for land clearing and improvement in recent years are above the average in acreage, livestock numbers, and volume of business. Many of the units are 2- or 3-man farms. Likewise, in the future most of the improvement will probably be done on the larger than average farms, to enable more efficient operations and to expand the volume of business.

There is no reliable source of data for estimating the acreage of land in the State on which it would pay to perform improvement work. The decisions in this respect must be made on an individual basis, measuring probable costs against probable benefits and considering alternatives. In many cases, the only possibility for increasing the size of unit is through land improvement, because no suitable land can be purchased.

Costs of land improvement through use of heavy equipment will need to be compared in individual instances with costs of expanding size of business through purchase of additional land. If adjoining fields can be acquired at reasonable prices and if this available land is well adapted to the use intended, purchase rather than improvement may well be the choice. On the other hand, if additional land is available only at a distance or at high prices per acre then purchase is undoubtedly the more expensive. The persons interviewed in this study were usually of the opinion that it was cheaper to spend money on lands within the boundaries of their farms than to purchase additional crop, pasture, or orchard lands.

The choice will depend upon the particular situation. The small farm with limited acreage will not be able to make extensive additions to cropland or pasture through land reclamation. If the farm is to be enlarged, purchase of more land is the only possibility. The larger farm, with a woodlot, a sizable tract or two of unimproved pasture land, or a swampy area—any one of which is potential crop or pasture land—may be able to do the improvement work just as economically as to buy more land.

Costs and Returns

In a majority of cases the costs of land improvement on the farms studied were paid from current earnings and accumulated savings. Whether funds were on hand or were borrowed each activity has to meet the test of the return that may result from the improvement. Capital invested in land improvement work

⁴Massachusetts Agricultural Experiment Station Bulletin 430, page 7.



Figure 11.
Insufficient Grazing on Stump Land.

is no different from capital invested in land or buildings. What are the benefits that have been realized or may be expected? How much does land improvement work affect income per acre treated, or income per farm? The results vary with the type of work done, the kind of land, and the use to which the land is devoted after the work is done. Specific examples of benefits are given in the following cases.

Case A-1—Twenty acres of stumpland were cleared and pasture improved on a 30-cow dairy farm in Franklin County. The case is presented as an example of the way costs may be met through increased farm returns. The stumps were taken out, stones and roots were removed, and the low spots were filled and graded. A bulldozer was hired at \$6 per hour to do the heavy work. The field was seeded in the fall of 1944 and was pastured in 1945. The soil, a heavy and

TABLE 3.—COMPARISON OF COSTS AND RETURNS FOR IMPROVING 20 ACRES OF STUMP LAND FOR PASTURE.

Land Use	Previous Acreage	Present Acreage	Type of Improvement	Cost	Returns per Year
Crop land	55	55	Removing stumps (with bulldozer)	\$1,170	
Pasture	18	38	Picking roots and stones	60	Pasture for 30 cows for 5 months at \$3 per month = \$450
Stump land	30	10	Harrowing	40	
Farmstead and woods	15	15			
			Total costs	\$1,270	
			Cost per acre	\$63.50	Returns per acre \$22.50

sandy loam, was well adapted to the use intended. Liming, fertilizing and seeding costs on the 20 acres of pasture are excluded, because these are operational rather than land improvement costs.

When good pasture land can be developed from stump land in this manner, the improvement costs soon pay for themselves in additional production per acre. The stump land undoubtedly produced some feed before it was cleared, so not all of the value of pasture can be counted as an increase. The differences in production between the stump land and the Ladino-clover pasture were about the same as those between native grass and clover-grass pasture in 1942⁵. On this basis the stumpland produced about one-fifth as much grazing valued at \$4.50 per acre per year. The difference of \$18.00 per acre per year was the increased return for land improvement and pasture seeding. Approximately 60 percent of the total cost of the pasture was for land improvement. Therefore the return is \$10.80 per year per acre and the land improvement work would be paid for in six years of grazing.

Although number of cows has not been increased to expand the size of business, 20 acres of good pasture land have been added. The expenditure of \$1270 is justified on this basis alone, because of the feed supply added to the farm. In addition, the improved pasture land can be used for crops or hay.

Case A-2—Stumps and stones were removed from three acres to provide additional pasture on a 30-acre dairy farm with 17 cows. The contrast with case A-1 is striking because of difference in type of soil. More work was done per acre on a smaller tract of land, at more than twice the cost, to provide none-too-good pasture. The additional acreage was not sufficient to furnish the necessary amount of land nor to decrease feed costs appreciably.

TABLE 4.—COMPARISON OF COSTS AND RETURNS FOR IMPROVING 3 ACRES OF STUMP LAND FOR PASTURE.

Land Use	Previous Acreage	Present Acreage	Type of Improvement	Cost	Returns per Year
Hay	15	15	Remove stumps	\$324	Pasture for 4 cows for 4 months at 13 per month
Pasture	10	13	Level and fill	78	
Stump land	3	0	Bog harrow	10	
Other	2	2	Pick stones	20	
			Total cost	\$432	
			Cost per acre	\$144	Returns per acre \$16

A power shovel and a bulldozer were hired by the hour. Some of the stumps were buried and others were burned. At \$144 per acre the costs were high, considering the quality of the improved pasture that resulted. Seeding, liming, and fertilizing costs per acre were about the same as in Case A-1; therefore 80 percent of total pasture costs consisted of land improvement. On this basis pasture value per acre attributed to land improvement work amounted to about \$13 per year.

Case B-1—Boulders were removed from a 10-acre field on a 60-cow dairy farm in 1940. The land has been used for five years, for both crops and pasture.

⁵Returns from Pasture Treatment. C. R. Creek. FM-13, April 1943. mimeo.

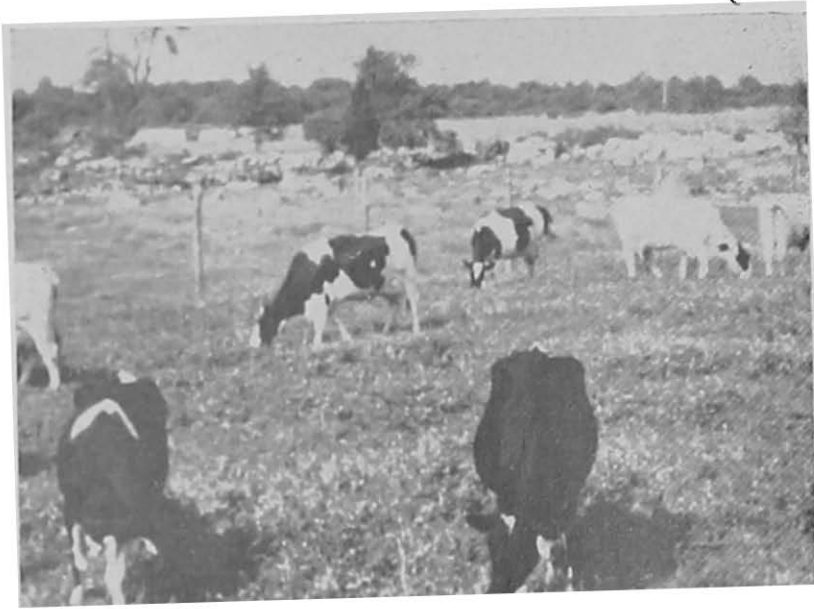


Figure 12.
High Yielding Ladino Clover Pasture on Land where Boulders Had Been Removed.

Power machinery could not be used before, because the stones were too many and too large. The work of removing boulders with a bulldozer and picking the stones cost \$57 per acre. The stony loam soil is suitable for crops and produced yields of 15 tons of corn silage per acre. Crop land had been added to the farm at a cost of \$57 per acre, at a time when good crop land in that community was selling at \$100 per acre.

On the same farm, another 14-acre field was cleared of boulders in 1944. A small bulldozer was used, and many of the boulders were broken by blasting. Costs amounted to \$188 per acre for all boulder removal work. Soil type, number and size of boulders, and general condition of the two fields were the same. The differences in cost are accounted for by size of bulldozer used. Returns per acre in crops and pasture showed little variation between the two fields.

Putting the two together, 24 acres were added to the farm, doubling the acreage of cropland and increasing pasture by 50 percent. The differences in costs of the two fields are extreme. The 10-acre field will easily pay for itself in a few years. The main justification for the second field at the higher cost is that the farm was overstocked and more crop and pasture land had to be added to help support the number of milk cows kept. It was to the economic advantage of the owner to add crop and hay land at \$188 per acre rather than decrease the number of cows; but the same benefits from the work which was done at a cost of \$57 per acre produced higher returns.

Case B-2—On another farm many large boulders were removed from 5 acres at a cost of \$250 per acre and this tract of crop land was added to the farm in the place of poor pasture and unsightly boulders. Although cropland was increased by a third, and the new land was needed, only high yields of vegetables over a period of years will pay the costs of the improvement. The high cost per acre, plus the fact that the farm is a small business unit makes it questionable whether the benefits will justify the work that was done.

Case C-1—Brush, trees, and some stumps were cleared from a sandy loam soil for a total cost of \$115 per acre which included the bulldozer charge of \$100 per acre and \$15 for burning brush and stumps. This land was well adapted to potatoes and produced 200 bags or over 300 bushels per acre. In the first year of cropping, a net profit of 75 cents per hundredweight was realized on potatoes. At this rate sales of 150 hundredweight or 250 bushels of potatoes per acre would pay for the cost of clearing in one year. Prices received for potatoes were high in this season and the margin of profit will be less in years of lower prices. Alternative uses may be needed for this land.

Case C-2—In several instances a similar type of cover was cleared and the land used for vegetable crops. In these cases the profits over cost of production in one year were more than equal to the clearing costs of about \$100 per acre. For a vegetable crop with a net return of only 40 cents per box, only 250 boxes per acre were required to pay clearing costs. With lower prices for vegetables the margin of profit from land improvement will be decreased, but the cost of land clearing also may be lower with more efficient methods and machinery.

Case C-3—When woodland was cleared on stony loam soils on sloping land for new orchard plantings the clearing costs were also about \$100 per acre. A less thorough job of removing stones and roots was performed because the land was not plowed. If interest and taxes were charged on this land for 12 years until the orchard came into production, a total cost of \$200 per acre would be accumulated on the land exclusive of seeding costs and trees. At a net return of 50 cents per bushel of apples over costs of production it would require the profits from crops of two or three years to pay costs of the land. When the margin of profit is greater in a period of higher prices the land costs may be paid in one or two years. Probable returns are used here to demonstrate the ratio between benefits and costs because the orchards have not been in production long enough to give figures on actual returns.

Case D-1—Benefits from land improvement work through drainage depend somewhat upon amount and distribution of rainfall. In ordinary seasons these ditches which were blasted will carry surface water rapidly enough to prevent killing of crops or grass by standing water.

In one case a ditch about 500 yards long was blasted for a total cost of \$120 for dynamite and labor. Three acres of land that had been too wet for harvesting during a rainy season were made suitable for hay. In addition, 12 acres of land were made suitable for pasture. An extra ton of hay per acre at \$15 per ton amounted to \$45 and three additional months of grazing on 12 acres at \$7.50 per acre gave a total return of \$135 on a drainage cost of \$120. Drainage costs were only \$8 per acre on this farm and two seasons of grazing would pay the total costs of reclamation and seeding.

Case E—The benefits of stone wall removal usually cannot be measured in terms of new land added to the farm. Stone walls were removed on most farms to combine several small lots into one larger field so that machinery could be used in crop production. This was true for hayland where tractor mowers, pick-up field balers, and field choppers were used and for cultivated crops such as potatoes where planters, sprayers, dusters, and diggers were used on long rows for more efficient production. Mechanized farming has been a powerful incentive to keep many young men on the home farm and the use of machinery has aided in obtaining and keeping a higher type of hired farm labor. An intangible benefit, but none-the-less important to many farmers was the satisfaction of seeing one large open field instead of small lots bounded by stone walls covered with vines,

shrubs, and weeds plus occasional trees and bushes in the fence row. Other tangible benefits such as weed, rodent, and disease control were fully as difficult to evaluate as the saving in time and effort through the use of machinery. On the basis of total acreage from the fields which were combined by stone wall removal, the costs ranged from \$15 to \$30 per acre on different farms. On cropland where machinery was used this cost might be repaid in lower production costs over a period of years. On pasture land there is little economic justification for stone wall removal except to facilitate reseeding and to destroy weeds and shrubs.

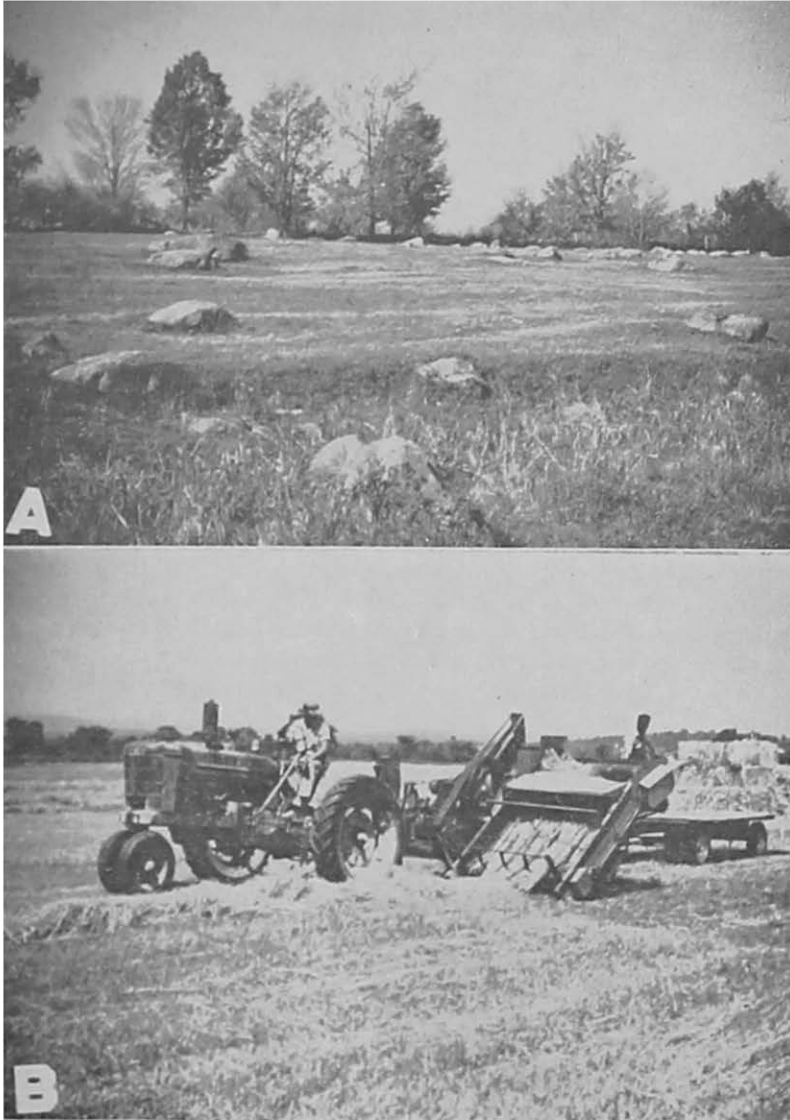


Figure 13.

A. Boulders in Hay Land Restrict the Use of Machinery such as Field Hay-Balers.
B. Labor Saving Machinery Can Be Used after Stone Walls and Boulders are Removed.

Other Benefits

All these types of land improvement work have resulted in economic benefits of some type whether measurable or not. The intangible or non-economic benefits were important to the farm living but did not assist in paying the cost of land improvement. For example, when the swamp was drained the mosquitoes disappeared and it was possible to make a road to a hay lot beyond the swamp after building a bridge over the ditch. In another instance a considerable sum over the value of the land was spent to clear large boulders from a field which was directly in view from the house. The owner knew that the cost was high but considered the satisfaction of an open field as partial payment. Where stone walls were removed, the satisfaction of no longer having the unsightly fence row in the field was a part of the benefits. In some cases stumpland was cleared chiefly because of the unsightly appearance of the field. Idle land which could be made productive was a challenge to many farm owners and considerable pride and satisfaction were gained when the work was completed. On many farms the crop plan and dairy feeding practices have been adjusted when a new pasture, or new area of silage corn or hay land was added to the farm unit through land improvement. Some poultrymen have grown replacements for the flock on new land which was cleared for range, when formerly pullets were purchased. Land improvement to increase the size of the farm unit as well as allow greater use of machinery has kept many people on the farm because a reasonable living without drudgery was in prospect.

The benefits accrue to the farm as a whole rather than to the reclaimed areas or farm enterprise in many cases of land improvement work. An improved pasture or hay field may result in significant adjustments in number of cows, growing of herd replacements, field organization, labor efficiency, and crop plans in addition to merely furnishing additional feed. The farm as a unit may produce a greater increase in income than the value of feed from the improved land.

Amortization of Land Improvement Costs

The amount of money which could be paid for land improvement for various crops and pasture may be determined by comparing the amortization costs per year with the yield of crops necessary to pay the costs. In Table 5, the costs of

TABLE 5.—ANNUAL CHARGE AND CROP YIELDS TO PAY LAND IMPROVEMENT COSTS

Cost of Land Improvement per Acre	Annual Carrying Charge*		Additional Yields per Acre Necessary to Pay Annual Costs**							
	5 yrs.	10 yrs.	Hay (tons)		Pasture (cow days)		Tobacco (pounds)		Potatoes (bushels)	
			5 yrs.	10 yrs.	5 yrs.	10 yrs.	5 yrs.	10 yrs.	5 yrs.	10 yrs.
\$50	\$11.80	\$6.36	0.6	0.3	120	60	39	21	12	6
100	23.60	12.73	1.2	0.6	235	130	79	43	24	13
150	35.40	19.10	1.8	1.0	355	190	118	64	35	19
200	47.20	25.46	2.4	1.3	470	255	158	85	47	25
250	59.00	31.82	3.0	1.6	590	320	197	106	59	32
300	70.80	38.19	3.5	1.9	710	380	236	128	71	38

*Interest for 5-year payment plan at 6% and for 10-year plan at 5% on unpaid balance.

**Hay at \$20 per ton, pasture at \$3 per cow per month, tobacco at 30 cents per pound, and potatoes at \$1 per bushel.

the land improvement work are amortized over a 5-year and 10-year period on the basis that money was borrowed to pay the original costs. The crop and pasture yields per acre are the amounts necessary to meet the annual costs of land improvement expenses in the first column. They do not include the yields necessary to meet the annual costs of production and are in addition to these yields.

When crops were valued at 1935-39 average prices for Massachusetts, land improvement costs up to \$100 per acre were paid with additional yields of hay on a 5-year payment plan. If hay is valued at \$20 per ton, it would take a yield of 1.2 tons per acre for 5 years to pay for land improvement work costing \$100 per acre. On a 10-year cost-spreading period 0.6 tons of hay were needed each year to pay this cost of land improvement. Likewise, it would take 25 bushels of potatoes per acre for 10 years to pay the cost of land improvement work at \$200 per acre. Additional grazing from pasture would carry a \$50 per acre land improvement cost over a 5-year period or a \$100 per acre cost over 10 years. Additional yields of tobacco over production costs would pay for improvement costs in either a 5-year or a 10-year period. Physical limits on the total yields of crops and days of grazing on pasture were the determining factors for the cost of land improvement which could be justified on net returns. Costs of production were paid first and the remaining yield was applied to repay improvement costs.

The costs for land improvement work, especially when the charges per acre are high, should be spread over a long period. High costs per acre cannot be expected to be covered by increased returns over two or three crop years. The usual time period in paying for a farm, when income is derived only from the land, is from 20 to 40 years. A farm is expected to pay for itself and furnish a living to its owner in this period. Land reclamation on any extensive scale should be handled in the same manner. There is no difference between paying \$50 an acre for land and another \$50 for improvement work and paying \$100 an acre for improved land. In either case, the charges should be spread over a number of years.

The spreading of costs over a period of years is one of the basic principles that must be remembered by the land owner when he is deciding whether or not to perform improvement work. The costs per year are to be compared to the additional returns per year. It is good farm practice to invest in land improvement that increases annual expenses by 10 percent, for example, if gross income is increased by more than 10 percent thereby.

In the case of a small amount of work or the improvement of only a few acres at moderate costs it is not necessary to spread the costs over a long period. The expenditure of \$200 to improve four or five acres of pasture may be spread over a two or three year period, and may be charged as operational expense. Interest charges are then lower than when costs are amortized over a long period. The contrast between short and long time financing is greatest in terms of small and large expenditures. A total outlay of \$200 usually can be carried in a year or two but a total outlay of \$2000 or more may have to be spread over a number of years as illustrated above. The decision between short and long time cost spreading rests on the two main factors of available cash and the amount of the charges. Extensive operations, on which total costs are high, may be financed over a long time and small amounts over a short time.

Developing New Farms

In only limited instances will it be profitable to develop new farm units from land not in farms. In the past few years a few farms have been carved out of forest and brush land, but these have been specialized cases. New farms have

been developed from abandoned dairy farms by clearing bushes and brush for growing potatoes. On the latter, improvement costs and land prices were low. Likewise, vegetable farms have been developed from raw land, but the soil types were favorable and savings from control of disease alone the first few years were calculated to pay for a good share of the improvement costs.

Land improvement has its greatest possibilities on land already in farms. Chief among the reasons for this is that when costs of land improvement are added to land costs, building costs, machinery, and livestock, the total will exceed considerably the amount for which a comparable farm can be purchased on the open market.

This study has concentrated upon cases in which a few acres per farm have been improved. No complete records have been obtained on whole farm developments, because the instances are few and specialized, and because in the future as in the past few years, the prospects are for most of the work to be done on land already in farms. The costs of whole farm development are too likely to be prohibitive. Undeveloped lands outside of farms may be improved and added to existing farms to better advantage than in making a whole new unit. Such addition not only will provide opportunity for enlarging non-economic units, but will require less expenditure for necessary buildings.

Future Work on Clearing and Improvement

The need for land improvement work is primarily on farms with limited crop and pasture acreage. The presence of boulders and stone walls as impediments to use of mechanical equipment, plus the small size of many of the farms, points to the desirability of reclamation. Land improvement which includes increasing the size of the farm and making present acreages suitable for use of power machinery is one of the main requirements to enable Massachusetts farmers to compete in agricultural production.

A high proportion of the persons on farms of less than \$1000 total value of product are in the group that work more than 100 days off the farm. Many of the small or low-income farms would be suitable for improvement work to some extent. If the combination of non-farm employment and farming produces a satisfactory income, such arrangement probably offers more economic security than would increasing the farming activity through land improvement to replace the non-farm job. The economic desirability of land improvement on commercial farms that provide the whole family income is a different proposition. It is on these farms that land reclamation under proper conditions will be of greatest economic importance in agricultural production.

No estimate can be made of the acreage that would be suitable and economically feasible for development. Decisions in this respect will have to be made on an individual farm basis, with the operator estimating costs and comparing these costs with probable returns. Nor is there any reliable method of forecasting the probable demand for land improvement work. Land reclamation can be expected to continue during the next decade much as it has from 1940 to 1945. When the wartime level of farm incomes drops to "normal" levels, fewer land owners are going to be interested in high-cost land improvement. The more progressive land owners who desire to increase operating efficiency will continue to undertake improvement work that has any prospect of paying out. Road construction machinery is being adapted to land improvement work, and new types of equipment are being developed to increase the efficiency of the work. With the formation of Soil Conservation Districts, it is likely that more individuals will be interested in farm land improvement, particularly if costs can be reduced below present contract prices per hour and per acre.



Figure 14.
Bushes, Shrubs, and Weeds Are Chopped and Mixed with Soil by Rotary Tiller as First Step in Pasture Improvement.

The organization and operation of Soil Conservation Districts offer opportunities to devote more specific attention to land improvement problems in the future. The district supervisors can assist in making heavy equipment available to farmers at reasonable rates. Farmers who are interested in land improvement work and conservation can focus public attention on the problems. The land owners, the district supervisor, and the technicians working together should be able to outline and put into operation a program of land improvement and soil conservation.

Soil Conservation Districts in other states have provided technical assistance and have made arrangements for obtaining heavy equipment. The details of the arrangements have varied from state to state and from district to district. In some cases the district acquires the machinery and furnishes the machine operator; in others, the district supervisors make arrangements to hire county- or state-owned equipment. In all cases, the land owner pays the costs of the work, either by the hour or by the job. The costs are often lower than the charges by commercial operators.

SUMMARY AND CONCLUSIONS

The acreage of improved farm land in Massachusetts has decreased by 50 percent in the last century and many adjustments have been made in crop and livestock production. Poultry and dairy enterprises which are dependent upon western grain areas for feed have supplanted sheep and beef cattle production. Vegetable and fruit production does not meet local demand. Intensive crops with a high value per acre have been substituted for grain crops. Lower production costs in other agricultural areas have been responsible for these shifts and for abandonment of much farm land in Massachusetts. However, efficiency of production has increased in many farm enterprises.

Improvement of abandoned farm land has been possible in recent years as a result of higher prices for farm products and availability of heavy machinery. Higher profits and technological advances in agriculture have increased the interest of farmers in land improvement and soil conservation. Removal of physical obstacles to the use of modern farm machinery is a primary requirement for desirable land use adjustments. The trend towards larger and more efficient farms will continue with the clearing and improvement of land in farms. Land improvement will be of greatest value on the commercial type of farm.

The decision to improve land should be made only after careful study of the economic and physical factors involved, including probable costs, expected returns, total benefits to the farm, type of soil, topography and location of land, type of cover to be removed, possible changes in the farm plan, and alternative uses for the money to be paid for improvements. If the work is undertaken, methods of land improvement should be fitted to requirements of the individual case. Costs may be amortized over a period of years and should be met by additional yields of crops or grazing over yields required to meet annual production costs.

The following conclusions are based on analysis of records on land improvement work, on case studies of individual clearing projects, and on appraisal of other information on the subject.

1. Type of soil and topography of land to be cleared should be adapted to agricultural use. High-producing crop land cannot be made on steep slopes or stony, gravelly soil.

2. Size and type of machinery should be adapted to the conditions for each job. Small bulldozers at low cost per hour may be more expensive than larger machines for heavy work. Combinations of machinery are often used for stump and stone-wall removal.

3. High costs per acre may be justified if the returns are also high. Low costs may prove more expensive if returns are low.

4. Profitability of land improvement work should be calculated on additional yields, prices, and values expected over a period of years.

5. Land improvement, particularly stone-wall, boulder, and stump removal, provides for increased mechanization of farm operations, more efficient use of labor, and less breakage of machinery.

6. Wet land was reclaimed at low cost per acre by blasting ditches. Technical assistance from the Soil Conservation Districts and cooperation of neighbors in obtaining outlets for ditches were important factors in this method of land reclamation.

7. Costs of land improvement work were usually paid from farm earnings.

8. New types of heavy equipment such as grubber blades for bulldozers, power rotary tillers, and steel stoneboats may result in lower clearing costs and more efficient work.

9. Land improvement may be of greatest economic importance on commercial farms.

10. Development of new farms by land clearing will be justified only in unusual cases for production of specialized crops with a high acre value.