MACHINE TREE PLANTING

McClain B. Smith, Jr.

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A thesis submitted in partial fulfillment of the
requirements for the degree of
Master of Forestry

May 25, 1949

Ann Arbor, Michigan
May 25, 1949

Professor Leigh J. Young
School of Forestry and Conservation
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Dear Sir:

The report on "Machine Tree Planting," which you assigned in September, 1948, is hereby submitted in partial fulfillment of the requirements for the degree of Master of Forestry.

Mr. Charles Melichar, in charge of planting for the U. S. Forest Service, suggested this subject because I had had experience with planting machines on the Mississippi National Forests and because no one had presented the available information on machine tree planting in a single report.

Respectfully submitted,

McClain B. Smith, Jr.

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PREFACE

This booklet contains all the important information that the author was able to obtain on the present status of machine tree planting. It is by no means complete, and the author assumes full responsibility for any important omissions and for all inaccuracies. The silvicultural information is most limited, but it is hoped that the section presented here will serve as an introduction to this phase of machine tree planting and as a basis for further investigation.

The author will appreciate any additions, corrections, or comments. There is undoubtedly some pertinent information which has not come to the author's attention. Another planting season should add much to the present information on the use of the machines, particularly the newer ones. Much new silvicultural information should come to light during the next year. The author hopes to revise this booklet during the spring and summer of 1950.

M.B.S.

ACKNOWLEDGEMENTS

A report on "Machine Tree Planting" could not be prepared by one man without either extensive field work at great expense or the soliciting of information from many field men intimately acquainted with different phases of the subject. The author has done some field work, but by far the majority of information presented here has been obtained from publications and by correspondence with planting machine manufacturers and users. The very helpful information obtained in this manner is hereby gratefully acknowledged.

Special acknowledgement is due the following: Professor L. J. Young and other members of the faculty, School of Forestry and Conservation, University of Michigan, for their guidance and helpful comments; Professor J. E. Thornton and Mrs. Gloria Theodoroff, of the Engineering English Department, University of Michigan, for their help in organizing and editing the first draft of the report; Mr. Charles Melichar, in charge of planting, U.S. Forest Service, for suggesting the subject of the report and for much helpful information; Mr. P. C. Wakeley, Silviculturist, Southern Forest Experiment Station, for guidance and encouragement and for the use of many unpublished experimental data; Edwin R. Ferguson and Robert Allen, of the Southern Forest Experiment Station, for making the second examination of the Depth Experiment plots; my mother, Mrs. Janet W. Smith, and my aunt, Miss Rosalie Walker, for helping to make reproduction possible.

TABLE OF CONTENTS

INTRODUCTION

Although tree planting machines have been designed and used to a limited extent since the 1880's, they were not used extensively for purposes of reforestation until the years immediately following World War II. According to Duchaine[1] about 2,000 planting machines are now being used on national and state forests, on soil conservation projects, and on farms. Lumber and pulp and paper companies are using them on their properties, and even railroads are demonstrating them on farms.

To the author's knowledge no one has as yet collected the information available on machine tree planting and presented it in a single report. It is the purpose of this report to present the information available on tree planting machines and the techniques and silvicultural aspects of their use so that a man wishing to start a tree planting job, can tell which machine, if any, will best meet his needs. It is hoped that those already operating tree planting machines will benefit from the experiences of other users, reported herein.

Commercially manufactured machines used under forest

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[1]William J. Duchaine. 1949. Tree Planting Machines. American Forests, Vol. 55, No. 4, p. 23 (April 1949).

conditions are given thorough treatment in the first section of the body of the report. The second section deals more briefly with new machines used with wheeled tractors, machines used in the shelterbelt, machines used only in particular localities, and machines no longer being produced. The third section summarizes the available silvicultural information pertaining to the special problems of machine tree planting.

SUMMARY

As a result of their rapid development during and following World War II, tree planting machines are now used in many parts of the country. New machine models and new planting techniques are constantly being developed. Although there is great variety in machine design, on all present models a man must set the trees by hand in a trench prepared by the machine. The older types are usually towed by crawler tractors, but some of the newer machines are designed for use with wheeled tractors.

Most of the machines were designed for use under conditions that exist in specific localities. They vary in their effectiveness in the areas for which they were designed and in their adaptability to conditions that exist in other areas. Where machines can be used effectively, survival of machine-planted stock compares favorably with that of bar-planted stock, but direct costs of machine planting are about one-half those of bar planting. No machines have been designed to operate satisfactorily in heavy brush, in very rocky areas, or on very steep hillsides; in such places hand planting methods are still used.

The Lowther Standard planting machine is well designed and constructed, and medium-priced. It plants well under average conditions and will plant successfully in rough

areas in which many other machines cannot be used. It will not plant well in heavy clay soils and may not plant well in soft, wet soils. It is more widely used at present than any other tree planting machine.

The Reforestator is very effective for planting in Michigan. It has been tested in other areas but has not received wide use except in Michigan and adjacent areas. It is medium-priced.

The Badger is medium-priced, and plants effectively under most conditions in Wisconsin. It has not been used much elsewhere.

The medium-priced TreeP, the only tree planting sled, was designed especially for planting under conditions that prevail in the hilly country of New York State. It has not yet been used extensively, but preliminary reports indicate that it may prove very effective.

The Lowther Hillside Planter was designed especially for use on the rough hillsides of the Muskingum Conservancy District in Ohio. It will plant effectively on steeper slopes than any other machine; however, it is the highest-priced machine on the market.

The Purdue, Illinois Central, Lowther Shelterbelt, Whitfield, and other new machines have the advantage of being low-priced; they are all small, light in weight, and designed for use with the power lift of a wheeled tractor. Hence, their greatest effectiveness will probably be found in planting on the better sites and in small areas, particularly on farms.

The Minnesota machine, not commercially produced, was developed by the Minnesota Department of Conservation. Between low and medium in cost, it has been used most effectively to plant in light soils and on old fields in Minnesota.

Several machines have been developed and used effectively in the light soils of the shelterbelt.

The Lowther Special Planter, a variation of the Lowther Standard Planter, has been used effectively for wildlife planting in at least two regions.

The Simplex and Duplex machines, although they are no longer in use, had many good design features that are of interest in view of more recent developments in planting machines.

COMMERCIAL FOREST TREE PLANTING MACHINES

Five commercially manufactured machines, the Badger, the Lowther Standard, the Lowther Hillside, the Reforestator, and the TreeP are discussed in this section of the report. Machines which operate with wheeled tractors, machines used in the shelterbelt, machines used only in one locality, and machines no longer being used are treated in the following section.

All of the tree planting machines currently produced open a continuous trench into which the planter must set the trees by hand; all have a means for raising the planting parts from the ground; all employ packing wheels to close the trench and pack the soil about the roots. On most machines the packing wheels are toed in at the bottom so that they exert pressure both downward and toward the center of the trench. Both metal and pneumatic-tired packing wheels are used. Some of the machines are designed to open a furrow in the sod ahead of the trencher; others are not designed for furrowing, but at least two of them have furrowing attachments. The different principles involved in machine design are set forth in the following paragraphs.[1]

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[1]Many of the principles set forth here are covered in an article entitled "Design and Use of Mechanical Tree Planters," by F. B. Trenk and H. D. Bruhn in the Journal of Forestry, June 1947, 45:408-413.

Principles of Machine Design

Methods of Opening and Closing the Trench

1. A wedge-shaped trencher compresses the soil laterally. This type of trencher is always followed by heavy packing wheels. In some cases discs may be used behind the trencher to throw loose soil into the trench around the roots of the seedlings. The wedge-type trencher can be used only in light soils; it does not work well in heavy, stony, or root-bound soils. Example: S.C.S. machines.
2. A beveled flange on each side of the trencher raises the soil slightly before spreading it laterally so that it falls back into place, relatively undisturbed, under the weight of the packing wheels which follow. Examples: Lowther Standard, Lowther Hillside, TreeP.
3. A slanted snout at the front of the trencher raises the soil out of the trench and deposits it on either side. This type of trencher is followed by cover plates or berms, which guide the soil back into the trench where it can be packed by the packing wheels which follow. Examples: Badger, Reforestator.

Methods of Attaching Packing Wheels or Packing Wheel Assembly to Frame

1. Packing wheels are attached inflexibly to the

frame. Example: Lowther Standard.

2. Packing wheel assembly is hinged horizontally to the frame to permit only vertical motion relative to the frame. Examples: Reforestator, TreeP.
3. Packing wheel assembly is hinged on a vertical pin to permit horizontal swinging. Examples: Valdosta, Heavy S.C.S. machine.
4. Packing wheel assembly is attached by universal coupling to permit motion both horizontally and vertically. Examples: Badger, Lowther Hillside.

<u>Methods of Raising and Lowering Planting Assembly</u>

1. Power lift, as used on a trailing type tractor plow, is employed. Example: Reforestator.
2. Levers, requiring much physical effort are employed. Example: Forerunner of Badger.
3. Hand-operated hydraulic hoist is employed. Examples: Badger, Lowther Standard, TreeP.
4. Power-operated hydraulic hoist is employed. Example: Lowther Hillside (Power comes from a small gasoline engine mounted on the frame).
5. Power lift on tractor is employed. Examples: Purdue, Lowther Shelterbelt, Illinois Central.

<u>Technique of Machine Planting</u>

Planting crews consist of a tractor operator and one or two planters.[1] The tractor operator maintains the spacing between rows. With some machines proper spacing along the rows is maintained by the use of a measuring wheel, usually six feet in circumference, which rings a bell to indicate to the planter that a tree should be planted. With most machines, however, the planter develops a regular rhythm of setting the trees, and the tractor operator controls the spacing by the speed of the tractor. The latter method will generally maintain suitable spacing along the rows, but in some cases the planter may have to adjust his speed of planting. Most planting machines operate successfully when towed at speeds of two to three mph. Where machines operate properly, the ability of the planter to set the trees properly determines the quality of the planting.

Machine Descriptions

As a result of rapid development and constant incorporation of improvement, some variation may be found in machines of any one type. The machines described are the latest standard models about which information could be secured at the time of writing. For each machine discussed in this section, description of features is followed by an explanation of operation, summaries of advantages and limitations, and comments on field use. The comments on

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[1] The term "planter," when used in conjunction with the name of a machine, refers to the machine; otherwise, it refers to the man who sets the trees in the planting trench.

field use are largely summaries of information the author obtained by correspondence with foresters who supervise machine planting operations.

Badger Planting Machine

The Badger machine was designed especially for efficient operation in light soil in the Lake States by the Agricultural Engineering Department of the University of Wisconsin through cooperation with an equipment company.[1] Many machines, similar in design and construction to the Badger, have been constructed and used by the Wisconsin Conservation Department and lumber or pulp companies.

Fig. 1 Badger Tree Planter[2]

[1] Wagler Equipment Co., Pewaukee, Wisconsin.
[2] Cost of machine $600 f.o.b., Milwaukee, Wis.

Main Features

Basic Construction: Planting unit is built around a single-bottom, trailing-type tractor plow, mounted on automobile wheels.

Furrowing Device: Middle-breaker plow, which precedes the trencher, provides a shallow furrow in sod or light brush. Plow shares need not be engaged for planting in cultivated soil or soil free of sod and brush. The plow is preceded by a full-swivel rolling coulter.

Trencher: Trencher has inclined-plane snout to elevate the soil from the trench and deposit it on the sides. Berms or cover plates behind the trencher push the soil back into the trench around the roots of the seedlings. The berms also serve as foot rests for the planter. There is no coulter operating at the depth of the trencher.

Packing Wheels: Packing wheels are assembled with the planter's seat on a trailer. The trailer assembly is hinged to the frame to permit vertical and horizontal swinging.

Hoist: Hydraulic hoist, operated by the assistant planter, forces the carrying wheels down (in relation to the frame) to raise the planting assembly suspended on them, or raises the carrying wheels to allow the planting parts to sink into the ground. The lever used to operate the hoist is located beside the assistant planter's seat in the middle of the frame.

Over-all Dimensions: Length 12 ft. (6 ft. 4 in. for body of machine plus 5 ft. 8 in. for trailer); width 4 ft. 4 in.

Weight: 1,000 lb.

Towing Equipment: Crawler tractor is most suitable. Heavy wheeled tractors may be used under favorable conditions.

Mobility: The chassis wheels are standard automobile wheels mounted with anti-friction bearings. They are equipped with 6.00 x 16 pneumatic tires. When the planting assembly is raised, these wheels support the machine for towing along the highway.

Parts Replacement: The penetrating snout on the trencher is replaceable.

Other Features

Safety hitch for coupling the machine to the tractor provides automatic release in case of overloads or obstructions.

Rack for tree boxes is located to the left of the assistant planter's seat.

Extra weights can be carried on the platform behind the planter's seat when more pressure is needed for packing the soil.

Alternate use may be made of the machine as a fire plow by the substitution of a middle-breaker plow for the tree planting assembly.

Operation

The planting crew consists of three men: the tractor operator; the planter, who sits facing forward on the seat attached to the packing wheel assembly; and the assistant planter, who sits, facing the rear, in the middle of the machine. As the machine is towed forward, the assistant planter operates the hydraulic hoist to lower the planting assembly to the proper depth in the soil. The middle-breaker plow opens a shallow furrow ahead of the trencher. The trencher elevates soil from the trench and deposits it on either side. The soil is forced back into the trench around the roots of the trees by the berms. The planter places the roots of a tree into the slot formed by the moldboards, moves the tree out of the slot, and releases it when the roots are firmly grasped by the soil which is being pushed back into the trench by the berms. The packing wheels pack the soil firmly about the roots of the tree.

The assistant planter raises the planting assembly at the end of each row before the machine is turned to begin planting on the next row. He sorts and hands trees to the planter and maintains the depth adjustment of the trencher. The most satisfactory rate of travel is 2 to 2-1/2 mph.

Advantages

The simple design of the Badger makes operation easy. The machine does a good job of furrowing where furrowing is desirable. Wearing parts are readily replaceable. The attachment of packing wheel assembly, which permits lateral movement of the packing wheels, provides for better packing and prevents the wheels from rolling over the seedlings when the planting rows are slightly curved or irregular. The job of trenching done by the Badger is considered by some foresters to be superior to that done by machines that make a vertical slit trench.

Limitations

The trencher may not penetrate to a sufficient depth in heavy soils. The machine is not as ruggedly constructed as some other machines. Tie rods must be used to prevent down-hill side-slipping of the packing wheels on steep slopes. The high center of gravity of the machine adds to the difficulty of planting steep slopes. Since the trencher is not protected by a coulter it is more subject to snagging on buried obstructions than are trenchers on other machines.

Comments on Field Use

1. Mr. George Kilp, Manager of Nekoosa-Edwards Paper Company woodlands operations, writes that he employs small caterpillar tractors, such as the International T-D6 and D-2 Caterpillar, to tow his planting machines. He operates two Badgers and one Lowther machine in the open areas of central Wisconsin where there is little stone in the soil, and one Lowther machine in northern Wisconsin in hilly country where the soil is stony and covered by much litter, including down logs. He has had excellent success with the Badger machine and prefers it to the Lowther in open country free from stone. The Lowther is preferred under the rough conditions in northern Wisconsin. He has experienced no difficulty with soil penetration and packing with the Badger in central Wisconsin.

He says that the three-man crew can plant 11,000 to 15,000 trees per day using four-year-old transplant stock ranging in height from 12 to 24 inches, and averaging 18 inches. Machine planting costs are much lower than bar planting costs, and survival of machine-planted stock is far better than that of bar-planted stock. Transplant stock survives much better than seedling stock under either method of planting, and the transplant stock is handled more easily than seedling stock on the machines.

2. The Regional Forester, North Central Region (Region 9), U. S. Forest Service at Milwaukee, Wisconsin,

in a letter to the author states that the Forest Service was provided with a Badger for experimental purposes. In a test of several hours' duration it was found that the plow would not run deep enough to throw out a furrow, and, consequently, that it was not possible to pack the dirt firmly about the roots of the trees. The opinion expressed was that the difficulty was due to faulty construction rather than to faulty design of the machine.

3. Trenk and Bruhn[1] published information supplied by Frank Fixmer, forester of the Mosinee Paper Company. Records showed the following costs for planting slightly less than 200 acres each year by hand and with one of the forerunners of the Badger, a second-hand rebuilt farm tractor plow:

	Costs per acre of 1,076 trees	
	1944 (Hand planting)	1946 (Machine)
Labor	$ 5.52	$ 1.76
Tractor rental and operation	1.67*	2.74
Depreciation on planting machine		.41
Adjustment for increasing labor costs from 1944 to 1946	1.93	
Total	$ 9.12	$ 4.91

*Presumed to be for furrowing prior to hand planting.

[1]F. B. Trenk and H. D. Bruhn. 1947. Design and Use of Mechanical Tree Planters. Jour. For. 45:408-413.

These figures do not include the cost of the planting stock, and figures for 1945 were omitted (by Smith) because no adjustment of labor costs was given in the article for that year. It is not known whether tractor depreciation costs are included in the above figures; if not, there would be less difference between machine planting and hand planting totals, but the totals would still be overwhelmingly in favor of machine planting. Trenk and Bruhn present further evidence from which they conclude that difference between machine planting and hand planting costs will be increased in favor of the machine when commercially manufactured machines are used.

A machine operator on a custom planting job increased his daily output by at least 20 percent by eliminating the turns at the end of each row. He began planting in the center of a forty-acre field with spiral rows around a circle 250 feet in diameter, and, while there was irregularity in spacing between the rows at the corners of the field, a fully stocked stand was provided.

In May 1946 an experienced planter of the Mosinee Paper Company set out 25,000 four-year-old Norway pine transplants in sandy soil. Although the planting was done during a pronounced spring drought, it was not possible to find a dead tree in the plantation the following September, and all trees had made most satisfactory growth.

Lowther Standard Planter

The Lowther Standard Planter was originally designed by J. E. Davis for planting cut-over lands in the South, but it has proved adaptable to a wide variety of planting conditions in many parts of the country. Many improvements have been made on the machine since the early production models were first used in extensive field planting operations.

Fig. 2 Lowther Tree Planting Machine
(Standard Model)[1]

[1]Photograph by courtesy of the manufacturer, Harry A. Lowther Co., Industry Ave., Joliet, Illinois. Cost of machine $750 f.o.b., Joliet, Illinois.

Main Features

Basic Construction: Machine is ruggedly constructed on a heavy rectangular frame supported at the front by standard automobile wheels with 6.00 x 16 heavy duty tires and at the rear by the 16-inch packing wheels.

Trencher: Special trencher plow and coulter assembly on free-floating beam is suspended within the frame and attached to it at the front. Straight vertical moldboards, spaced two inches apart, form the planting guides. Replaceable plow points are bolted to the shoe of the trencher. The trencher operates at a depth of eight inches, and the coulter preceding it operates one inch deeper (or nine inches). The 28-inch coulter will cut through roots up to 2-1/2 inches thick and will raise the planting assembly over obstructions it cannot cut through.

Packing Wheels: Packing wheels with 4.00 x 8 pneumatic tires are attached rigidly to the rear of the frame.

Hoist: Hand-operated hydraulic lift is used for raising the planting assembly. The control for the lift is located beside the planter's seat, which is located above and immediately behind the packing wheels.

Over-all Dimensions: Length 10-1/2 ft.; width 4 ft.; height without safety cab about 2-1/2 ft.; wheel base about 5-1/2 ft.

Weight: 1,300 lb.

Towing Equipment: Crawler tractor of 15 to 35 h.p. is generally used. Under favorable conditions the machine has been towed by a jeep.

Mobility: Ball and socket trailer hitch is used to tow the machine over the highway on the automobile wheels, the packing wheels being raised above the ground. The socket joint is built into the rear of the frame.

Parts Replacement: Standardization of parts and some changes in the design of the machine have made replacement of parts much easier for the later models than for the original models.

Other Features

Brackets for the planting stock boxes are located on either side of the frame just forward of the planter's foot rests.

Triangular towing bar is hinged at the front of the machine to permit vertical movement. It permits horizontal swinging from the tractor draw bar, to which it is coupled with a vertical pin.

Safety cab is available at extra cost.[1] Constructed of metal mesh it allows full visibility and protects the planter from brush when it is attached in the middle of the frame. It is equipped with the Burris depth gauge, which was designed for use in setting longleaf pine seedlings, the depth tolerance of which is very limited.

Scalper plows are available[2] for use where furrowing is desired. Bolted to the plow beam, they fit snugly to the coulter and provide a furrow of any desired depth. They are protected by the floating coulter action.

Operation

The planting crew consists of two or three men: the tractor operator, the planter, and the assistant planter (optional). The planter rides, facing forward, on the seat at the rear of the frame. The assistant planter sorts trees, packs the planting boxes with trees, and supplies the planter with trees. Where two or three machines are operated in adjacent areas, the assistant planter may supply trees for more than one crew. In some crews the planter and the assistant planter exchange jobs periodically during the day, and in some cases the assistant planter

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[1] $37.50 f.o.b., Joliet, Illinois.

[2] $25 f.o.b., Joliet, Illinois.

follows the machine to check the planting and reset the trees that were not planted properly.

As the machine moves forward, the planter trips the hydraulic lift so that the planting parts settle to the desired depth in the ground. The coulter cuts the soil ahead of the trencher, which lifts the soil upward and outward to open a narrow trench between the planting guides. The planter places the roots of a seedling between the guides, then moves the tree out of the guides, and releases it when the roots are firmly grasped by the sides of the trench, which are being forced back to their original position by the packing wheels.

When the scalpers are used, they turn back the sod to provide a furrow ahead of the trencher.

The depth gauge, which is used only in some situations, consists of a glove (minus fingers) on the end of a chain, the other end of which is attached to a rod hinged to the top of the safety cab. The planter wears the glove on his planting hand and pulls down against the action of a spring until the rod is stopped at the low position by an attachment on the safety cab. If the planter grasps all seedlings at the root collar, this device permits the setting of seedlings at a uniform depth. The length of the chain is adjusted so that the root collars of the trees will be at ground level.

Advantages

The simple, rugged construction of the Lowther Standard Planter makes operation easy and insures long service. The design of the planting parts permits minimum disturbance of the soil, a desirable feature in the South and anywhere that erosion is a problem. The action of the coulter in cutting small roots and raising the planting assembly over large underground obstructions permits planting of rough sites that could not be planted by some other machines, protects the plow from injury, and prevents clogging of the trencher with brush.

Limitations

The Lowther does not do as good a job of furrowing and ground preparation as machines especially designed for the purpose. Since this machine has two pairs of rigid wheels in contact with the ground at the time of turning, it is more difficult to turn than machines that have only one pair of wheels in contact with the ground at the time of turning. The double wheel base is also undesirable if the planting rows are slightly curved or irregular because the packing wheels may be thrown slightly to one side so that they roll over the seedlings and fail to pack the soil properly. The packing wheels often fail to pack properly in very wet soils. It is difficult or impossible to get the plow deep enough for planting in heavy clay soils.

Comments on Field Use

1. In 1947 and 1948 the author supervised crews using from one to three Lowther machines on National Forests in southern and northern Mississippi. The machine is well adapted to conditions in the southern part of the state, where longleaf pine was planted. The rolling ground was fairly rough with many stump holes, old stumps, and heartwood from longleaf pine tops. Most of the ground was burned over either early in the fall just prior to planting or in the winter one year prior to planting. Crawler tractors of 15 to 35 h.p., depending on availability, were used to tow the machines. Trees planted by skilled operators compared favorably in survival with those planted by bar crews. Unskilled operators had difficulty setting the trees at the proper depth, and since the depth of planting is such a critical factor with longleaf pine (see Depth of Planting in third section of report), the rate of survival was not as high as that obtained with bar planting. Machine planting costs were about 25 to 50 percent less than bar planting costs.

Machine use was limited by the following conditions, which would also limit the use of some of the other machines:

(1) In boggy areas or very wet areas immediately after a rain the packing wheels sank into the ground, became clogged with mud, and failed to pack properly. A day of planting time was

sometimes lost after heavy rains. The planting rows were laid out either to avoid boggy areas entirely, or to cross narrow strips of boggy ground in which case the planter stopped planting until reaching firm ground.

(2) To obtain proper packing of the soil, it was necessary to run the rows almost perfectly straight. On even slight curves the packing wheels were often thrown to one side so that they packed poorly and sometimes rolled over the seedlings. In irregularly shaped areas trees were planted along zig-zag rows; i.e., a series of straight rows joined by abrupt turns, in which the planter stopped planting. This practice was much more desirable than planting such areas as a series of short blocks because frequent turning around wasted much time, while making abrupt, partial changes in direction wasted little time. The most efficient planting was done in an area where rows were about one mile long. The supply of seedlings was kept at the middle of these rows. The operators got a load of trees, planted a row one-half mile long, turned and planted another row back to the supply of seedlings, where they reloaded with seedlings, finished the row, and returned along a third row to the starting point.

(3) Areas of heavy clay had to be avoided entirely because the plow would not run deep enough to provide a suitable trench in which to place a tree. Where small eroded clay spots or strips were intermingled with good soil, the planter ceased planting when the plow stopped providing a suitable trench.

(4) Light brush was no hindrance, but thick clumps, especially scrub oak thickets, had to be avoided because the planting parts or packing wheels would ride over the brush knocked down by the tractor and would fail to trench or pack properly.

The Burris depth gauge was used during the first week of the 1947-48 planting season. In open areas it worked fairly well. In areas covered by even light brush, the chain became snagged in branches, and use of the gauge had to be discontinued. The planters preferred not to use the gauge because it confined their hands. Several times the chain was torn loose when the planters caught their gloved hands under the packing wheels. The damage was more psychological than physical. While the gauge worked well on even ground, it did not permit any adjustment for irregularities, for which a skilled planter could allow when not using the gauge. A report from the author to the Forest Supervisor stated that the use of the gauge seemed impractical in most situations, but that it might be useful for training purposes the first few days of each season. The planters appeared to acquire the knack of proper depth setting more quickly when using the gauge for a few days in the 1947-48 season than they had without it in the previous season.

The Lowther machine was tested in northern Mississippi in the spring of 1948. It was found to be unsuitable for use there, since soil was largely heavy clay loam and topography was very hilly. Moreover, planting sites were small, irregular in shape, and scattered. Too much time was lost in turning at the ends of short rows. In dry clay the trencher functioned erratically. In wet clay the trencher often turned over a furrow, and the packing wheels became so clogged with mud that they would not pack properly. A metal wheel scraper welded to the frame of the machine failed to overcome this difficulty. Although the machine was used on the best planting sites, the survival of machine-planted stock was poor, and planting costs were about one-third more than those for bar planting on poorer sites.

This discussion indicates the limits of machine use. While the machine did not work well in northern Mississippi, it did a very good job in the southern part of the state where conditions were more favorable.

2. Mr. R. M. Millar, Timber Management Assistant, Mississippi National Forests, writes informally that costs of planting about three million longleaf and slash pine seedlings with six Lowther machines, each with a three-man

crew, on National Forest land in southern Mississippi in the 1948-49 planting season varied from $6.00 to $6.75 per thousand trees. These figures include all direct planting costs but not the cost of the seedlings. The rate of machine planting varied from 8,000 to 13,000 seedlings per eight-hour day, with an average of about 8,500 per day. Hand planting costs under somewhat less favorable conditions in another area were almost twice as high. All factors considered, he believes that one Lowther machine, with its three-man crew, is equivalent in planting production to about twelve hand planters.

Survival of trees planted by machine in the 1947-48 season was from 60 to 80 percent for longleaf and about 85 percent for slash.

3. Mr. A. K. Dexter, Division Forester for the International Paper Company at Canton, Mississippi, writes that he has planted longleaf, loblolly, and slash pines with a Lowther machine for the past two seasons. In Mississippi he uses a Ford-Ferguson tractor to tow the machine, while in Louisiana he has to use a BHD Oliver-Cletrac tractor. The cost of machine planting is less than the cost of bar planting, and under all conditions in which the machine operates satisfactorily, survival of machine-planted seedlings has been excellent. His two-man crew has planted 12,000 seedlings a day with the machine. Machine planting

is feasible in large areas but impractical in small areas of only a few acres, where hand planting is used. When the ground is too soft, planting by machine is postponed until conditions are suitable.

4. Mr. A. L. Shepard of the Gulf Naval Stores Company at Gulfport, Mississippi, writes that he has tested an attachment to the Lowther machine to prevent the sinking of the packing wheels in soft ground. He attached a pair of steel slides on either side of the frame opposite the planter's seat. The slides, set about an inch above the normal point of contact of the packing wheels, worked well to prevent the sinking of the packing wheels, but, being rigid, the slides made it difficult to maneuver around stumps and trash. He is planning to replace the slides with rubber-tired wheels similar to the packing wheels.

He also burned off about four inches of the rear end of the trencher and pulled in the planting guides so that they were spaced about one and one-half inches at the rear. This change, he found, made the sides of the trench start sooner to fall back into place, and helped to prevent the packing wheels from turning back the sod. The result was the provision of a more definite line in the trench by which the planter could judge the proper depth to set longleaf pine seedlings.

5. A forester for one large paper company[1] operating tree planting machines in the South furnished the following information for the 1948-49 planting season. Depreciation costs are based on amortization in three years for the motor equipment and five years for the planting machines.

Old Field - 2 Lowther machines used 1,442 acres - 713 seedlings/acre	Cost of planting 1,027,000 seedlings per M	per acre
Heeling in	$ .07	$ .05
Planting labor @ $.65/hr.	1.13	.80
Depreciation on tractors @$1.00/hr.	.85	.61
Depreciation on machines @$.40/hr.	.34	.24
Fuel, oil and lubricants for tractors and machines	.21	.15
Tractor repairs	.16	.13
Machine repairs	.10	.07
Supervision	.26	.19
	$ 3.12	$ 2.24

Forest Land	Cost of planting 350,000 seedlings per M	per acre
Soil preparation (recorded on books as fire protection cost)		
Labor @ $7.20/day	$ .57	$ .38
Tractor (without depreciation) @ $8.10/day	.64	.42
Planting		
Labor @ $1.14/hr. (average)	2.60	1.72
Tractor (without depreciation) @ $1.08/hr.	1.83	1.22
Machine		
Amortization	.55	.37
Labor	.60	.40
Materials	.40	.26
Supervision	1.14	.75
	$ 8.33	$ 5.52

[1] The author was requested not to disclose the source of this information.

Old Field - 726/acre - Spacing 6' x 10'

	Cost of planting 379,800 seedlings per M	per acre
Heeling in	$ .13	$ .09
Tractor depreciation @ $.80/hr.	.44	.32
Machine depreciation @ $.30/hr.	.16	.12
Fuel, oil, and grease for tractor	.22	.16
Tractor repairs	.04	.03
Machine repairs	.03	.02
Planting labor @ $.68/hr. (average)	1.01	.73
Supervision	.16	.12
	$ 2.19	$ 1.59

Old Fields - 61 acres, spacing 8' x 8', 680 trees/acre
376 acres, spacing 6' x 10', 726 trees/acre

	Cost of planting 315,000 loblolly & slash seedlings per M	per acre
Heeling in	$ .09	$ .07
Tractor depreciation @ $.80/hr.	.83	.60
Machine depreciation @ $.30/hr.	.31	.22
Fuel, oil, and grease for tractor	.30	.21
Tractor repairs	.03	.02
Machine repairs	.01	.01
Planting labor @ $.67/hr. (average)	1.49	1.07
Supervision	1.02	.73
	$ 4.08	$ 2.93

Old Field - 738 trees/acre, spacing 6' x 10'

	Cost of planting 533,500 seedlings per M	per acre
Heeling in	$ .14	$ .10
Planting labor @ $.65/hr. (average)	1.16	.86
Tractor depreciation @ $1.20/hr.	.90	.66
Machine depreciation @ $.50/hr.	.34	.25
Fuel, oil, and lubricants for tractor and machine	.17	.13
Tractor repairs	.00	.00
Machine repairs	.10	.08
Supervision	.75	.55
	$ 3.56	$ 2.63

6. Mr. Carl M. Carpenter, forester for the Indiana Department of Conservation, writes that he has planted

white, red, scotch, shortleaf, virginia, loblolly, pitch, and jack pine, osage orange, black locust, black walnut, bald cypress, red maple, silver maple, and tulip poplar seedlings and transplants with a Lowther machine. His price for custom tree planting jobs is $15.00 per thousand for orders of 10,000 or over and $16.00 per thousand for small orders of 5,000 to 10,000 trees. Survival varies but has been as high as 95 percent under favorable conditions. He considers the lack of furrowing with this machine a considerable advantage in hilly country since even on slight grades furrows are inclined to wash severely, washing out the trees and even starting gullies. By keeping the machine moving, his crews have been able to plant consistently 1,500 to 1,800 seedlings per hour under good conditions. There is some difficulty keeping the packing wheels clean, but the packing wheel scraper on the later Lowther models has proved helpful. Mr. Carpenter likes the sturdy construction of the Lowther machine, which withstood rough treatment in planting 340,000 trees last year. He feels that the Lowther machine will operate in wetter soil than any other machine he has used or observed, and feels that it would be difficult to improve upon the machine.

7. See Comment 1 under the Badger machine.

Mr. Kilp writes that, while the Badger machine is preferred for planting under good conditions in Wisconsin, he prefers the Lowther machine under rough conditions. In regard to furrowing with the Lowther machine he writes: "The Lowther people have put on our machine a couple of small mold board arrangements together with points, but we have found that they are a hindrance in operating the machine, and, therefore, have taken them off."

8. The Forest Supervisor of the Lower Michigan National Forest, with headquarters at Cadillac, Michigan, writes that a Lowther machine was tested on the Manistee Forest, and gave generally satisfactory results. The scalping attachments were satisfactory under Manistee conditions, but it is questionable whether they would have been satisfactory under the rougher conditions of the Huron Forest.

9. The Regional Forester of the North Pacific Region, Portland, Oregon, writes that the Forest Service and the Weyerhauser Timber Company of Tacoma, Washington, operate the only two machines (Lowthers) he knows of in the Pacific Northwest. The Forest Service machine will be put into use where the topography is gentle to plant ponderosa pine on areas where there is scattered small brush and bunch grass. The machine can be towed by a Clarkaire or a small Oliver tractor on light soils, while a D-4 is needed on heavy soils. The tractor should be equipped with a bulldozer blade to ward off obstructions. He expects that

survival and cost will be about the same with either machine or hand planting methods. Only a limited amount of machine planting has been done in that region as yet.

10. Mr. Theodore R. Yocum, Silviculturist for the Weyerhauser Timber Company at Longview, Washington, sent the author a report of tests made with the Lowther machine in the Douglas fir type on the St. Helens Tree Farm near Longview. The report indicated that average production was about 3,500 trees per day, with a maximum of 3,700 trees per day. A heavy tractor, with a bulldozer blade for clearing brush and trash, was used to tow the machine. Because of stumps, down logs, and logging trash on the area, the tractor operator had to run irregular courses so that planting time was lost and many spots were left unplanted. The attempted spacing was 8 ft. x 8 ft., or about 680 trees per acre, but only 405 trees per acre were actually planted.

This test, along with the statement by the Regional Forester (Comment 7) that both the Weyerhauser machine and the Forest Service machine will be used in the ponderosa pine type, indicates that logged-over areas in the Douglas fir type are too rough to permit practical use of the Lowther Standard machine.

Lowther Hillside Planter

The Lowther Hillside machine was originally developed to plant trees under the rugged hilly conditions found on the Muskingum Watershed Conservancy District in Ohio by Forester H. P. Garritt, the Agricultural Engineering Department at Ohio State University, and an equipment company.[1]

Fig. 3 Hillside Planting Machine[2]

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[1] Harry A. Lowther Company.

[2] Photograph by courtesy of the manufacturer Harry A. Lowther Co., Industry Ave., Joliet, Illinois. Cost of machine about $1,100.

Main Features

Basic Construction: Frame is a modified tool bar carrier supported by two pneumatic-tired automobile wheels, which are attached to the frame by a linkage which permits independent raising and lowering of each wheel.

Trencher: The coulter and trencher are similar to those of the standard Lowther machine except that the plow beams are shorter and are attached to the frame with a king pin which permits horizontal swinging of the trencher from the front of the frame. A hold-down bar above the beams and a lift bar below them hold the trencher at the desired depth, but permit lateral movement of the beams.

Hoist: A gasoline engine mounted on the frame provides the power to operate hydraulic cylinders linked to each wheel. The wheels are lowered, with respect to the frame, to raise the planting parts and are raised to allow the planting parts to sink into the ground. Ropes are attached to the hoist control levers so that the tractor operator can control them from his seat on the tractor.

Packing Wheels: The packing wheels are mounted in an assembly with the planter's seat. This assembly is connected to the back end of the plow beams to permit both horizontal and vertical movement. A stop is provided so that this assembly is raised with the planting parts when the carrier wheels are lowered.

Over-all Dimensions: Length, about 10 ft.; width, about 4 ft.; height, in operation, about 3-1/2 ft.; height, with wheels lowered, about 5 ft.

Weight: Unknown, but probably over 1,500 lb.

Towing Equipment: Heavy crawler tractor is used.

Mobility: The automobile wheels support the machine for towing along the highway when the planting parts are raised.

Other Features

Planting stock boxes are located on the rear of the frame within reach of the planter.

Operation

The planting crew consists of the tractor operator, a planter, and an assistant planter. As the machine is towed forward, the tractor operator pulls the control ropes for the hydraulic hoists to allow the planting parts to sink into the ground. The uphill wheel is raised on hillsides to level the machine. The coulter cuts the soil and the trencher raises it slightly before spreading it laterally to form a trench. The planter places a seedling so that the roots are between the planting guides, moves the tree out of the guides, and releases it when the roots are grasped by the closing sides of the trench. The packing wheels force the soil at the sides of the trench back to its original position, relatively undisturbed, and pack it about the roots of the tree. In hilly terrain the tractor operator follows the contours. On curves the plow beam and the packing wheel assembly swing laterally so as to follow directly behind the tractor. At the end of each row the tractor operator pulls the hydraulic control ropes to raise the planting parts. He then turns onto the next row, lowers the planting parts, and relevels the machine. When the coulter encounters an obstruction through which it cannot cut, it raises the planting parts and the entire machine over the obstruction. The assistant planter keeps the planter supplied with trees.

Advantages

The Lowther Hillside Planter is better adapted for planting on steep hillsides, up to 40 or 45 percent slope, than any other planting machine. It is ruggedly constructed for long service. The short length of the planting parts and the hinging for horizontal movement permit planting on sharp curves. The power-operated hydraulic hoists permit quick leveling on hillsides and quick raising and lowering of the planting parts. Quick turning at the ends of the rows is possible because only the carrier wheels are in contact with the ground at the time of turning. The machine operates well on level sites at rates exceeding those achieved on hillsides.

Limitations

This is the most expensive planting machine produced commercially. There is no furrowing device on the machine. With the technique of planting employed by the designer of this machine, a special plow is required for furrowing prior to planting.

Comments on Field Use

H. P. Garritt, who designed this machine, also designed a special plow which he uses to furrow the planting sites the year before planting. The plow, like the planting machine, has gasoline engine-powered hydraulic hoists with which the plow can be leveled for plowing on steep hillsides.

The two-way, two-bottom plow throws two furrow slices downhill. The planting machine is run along these furrows with the uphill wheel in the furrow and the trencher in the turned up furrow slices, which have been allowed to settle during the winter before planting. The furrow ridges retard water run-off, increase water intake, and provide a double layer of top soil in which the tree roots may grow. According to Erwin[1] growth of the young trees is apparently stimulated under these conditions.

Mr. Garritt uses a special hillside hitch on the tractor to compensate for the tendency of the rear end of the tractor to slide downhill on steep slopes. Planting rates established by Mr. Garritt's crews were from about 7,000 per day on steep hillsides to as many as 10,000 per day on level ground, with an average of about 8,000 trees per day.

Mr. Garritt writes that he uses a TD-6 International or a D-2 Caterpillar crawler tractor in the 50-inch width with 16-inch pads for towing both the furrowing plow and the Hillside planting machine. The width of the planting machine is correlated with the widths of the furrow and the ridge so that the shoe will operate in the ridge when the uphill wheel of the machine runs along the furrow. The machine is designed for operation around curves with as short a radius as ten feet and on slopes up to 50 percent. It is his opinion that the quality of work done with the

[1]Robert L. Erwin. 1948. Machine Plants Trees on the Contour. Ohio Farm and Home Research, Vol. 33, No. 254 (September-October 1948), pp. 152-155.

machine is much superior to that done by crews of men using hand-planting methods. He has also pointed out that use of the machine does away with the need for large crews and much supervision because a few good men can be hired for the machine planting.

Mr. Garritt has furnished the following cost figures for planting on the Muskingum Conservancy District:

Basis of Costs

Wage rates
  Common labor $1.02/hr.
  Tractor operator $1.45/hr.
Initial cost of equipment
  Tractor, International TD-6, including freight and handling $3,676.75
  Plow, contour ridging, hydraulic, about $1,200
  Planting machine, about $1,100
Equipment operation rate
  Tractor and plow $1.00/hr.
  Tractor and planting machine $1.00/hr. (tractor @ $.82/hr.)

Comparative Costs

1. Hand planting without contour ridging (scalping with grub hoe) 6,000 trees or 7-1/2 acres

Labor 17.14 men - 350 trees/man-day	$ 139.86
Industrial insurance, 6.5 percent	9.09
Total	$ 148.95
Cost per acre	$ 19.86

2. Hand planting with contour ridging - 6,000 trees or 7-1/2 acres Two years

Contour ridging (6 acres per day)
  Labor

Tractor operator - 10 hours	$ 14.50
Industrial insurance, 6.5 percent	.94
	$ 15.44

2. Hand planting with contour ridging (continued)

Equipment	
Tractor and plow - 10 hours	10.00
Total	$ 25.44
Cost per acre	$ 3.39
Planting	
8.57 men - 700 trees/man-day - 68.57M/hr.	$ 69.94
Industrial insurance, 6.5 percent	4.54
Total	$ 74.48
Total cost	
Contour ridging	$ 25.44
Planting	74.48
Total	$ 99.92
Cost per acre	$ 13.32

3. Machine planting with contour ridging - 6,000 trees or 7-1/2 acres

Contour ridging	$ 25.44
Machine planting	
Labor	
Tractor operator - 8 hours	$ 11.60
2 planters - 8 hours	16.32
Industrial insurance, 6.5 percent	1.81
	$ 29.73
Equipment	
Tractor and planting machine - 8 hours	$ 8.00
Total	$ 37.73
Total cost	
Contour ridging	$ 25.44
Planting	37.73
Total	$ 63.17
Cost per acre	$ 8.42

The foregoing figures do not include depreciation on equipment. Mr. Garritt estimates that the savings achieved by contour ridging and machine planting will pay for the equipment in about two years with a total of 522 acres of planting.

Reforestator Planting Machine

The Reforestator incorporates several features of the Prairie States Forestry Project and Badger machines. It was designed by Lester E. Bell, Extension Forester and T. D. Stevens, Research Associate, both of Michigan State College, especially for conditions in Michigan, where furrowing or scalping is considered necessary prior to planting. It is best adapted for use on abandoned farm land but has been used extensively on other types of land.

Fig. 4 Michigan State Reforestator[1]

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[1] Photograph by courtesy of the manufacturer, L. W. Meriam Co., Elsie, Michigan. Cost of machine $635 f.o.b., Elsie, Michigan.

Main Features

Basic Construction: Machine is built around a standard farm implement "uni-carrier."

Furrowing Device: Right- and left-hand moldboard plows with 12-inch shares are attached to the tool bar of the uni-carrier and are preceded by an 18-inch fluted coulter. The depth of the furrow is controlled by the two lever arms at the front of the machine. The furrowing device may be removed where it is desired to plant without furrowing.

Trencher: Trencher is bolted between the plow beams and is preceded by a second 18-inch coulter. Two excavating fins open a trench 4 inches wide and 8 inches deep. The trencher is removable and may be replaced by a larger trencher for planting larger planting stock. Filling irons behind the trencher force the excavated soil around the roots of the seedlings and also serve as footrests for the planter. The machine is so designed that the trencher will always dig a trench 8 inches deeper than the furrow.

Packing Wheels: Packing wheels and planter's seat are attached to a sulky, which is hinged to the uni-carrier to permit vertical motion. A stop permits raising of the sulky with the planting parts.

Hoist: Mechanical power lifts, operated by forward motion, raise the planting assembly along with the sulky. Forward motion of about 6-1/2 feet is required to lift the planting parts completely out of the ground. The lifts are controlled through ropes from the tractor operator's seat. Each time the ropes are pulled the lift reverses so that the tractor operator can raise or lower the planting parts without leaving his seat on the tractor.

Over-all Dimensions: Length 14 ft.; width 5 ft.; height with levers up (machine not in operation) 6 ft.; height with levers down 3 ft.

Weight: 1,370 lb.

Towing Equipment: Crawler tractor is recommended. The heavier wheeled tractors may be used under favorable conditions.

Mobility: The machine is mounted on wheels equipped with pneumatic tires. When the planting parts are in raised position, these wheels permit movement of the machine from one planting site to another.

Parts Replacement: All wearing parts are replaceable.

Other Features

Spring hitch release on the device for coupling the machine to the tractor protects the machine in case the planting parts become snagged.

Two planting stock boxes, holding approximately 1,000 three-year-old coniferous transplants, are carried on a large rack on the frame forward of the planter's seat.

For contour planting on slopes up to 30 percent, one wheel of the uni-carrier may be raised and the other lowered to level the machine.

Alternate use may be made of the Reforestator as a fire plow by the removal of the trencher.

Operation

The planting crew consists of two men: the tractor operator and the planter. As the machine moves forward, the tractor operator, from his seat on the tractor, pulls the ropes to trip the power lift to allow the furrower and trencher to sink into the ground. He adjusts the levers at the front of the machine to obtain the desired depth of furrow. The furrowing device turns back the sod to either side, and the excavating fins on the trencher throw soil to either side to produce a trench 8 inches deeper than the furrow. The planter sets a tree in the trench and holds it until it is grasped firmly by the soil that is being thrown back into the trench by the filling irons. The planter controls the amount of soil thrown back into the trench by the pressure of his feet on the filling irons. The packing wheels press the soil firmly about the roots. Before turning at the end of each row, the tractor operator pulls the rope to engage the power lift, which raises the planting parts. The planter dismounts before the planting parts are raised.

If it is desired to plant without furrowing, the tractor operator adjusts the levers so that the furrower skims the surface of the ground.

Advantages

The power lift of the Reforestator provides for quick raising of the planting parts and the sulky at the ends of the rows so that little time is lost in turning. The machine provides a good furrow. Many foresters believe that tearing of the soil by the trencher is an advantage (See the discussion of trenching under Silvicultural Aspects). The Reforestator packs better on curves, in sandy soil at least, than some other machines. Moderate slopes are easily planted since one wheel can be raised and the other lowered to level the machine. The longer draft (distance from tractor draw bar to trencher) of this machine facilitates proper soil penetration by the trencher. The machine permits a greater range of adjustments than many other machines. Furrows made by the machine act as fire-breaks for several years after planting.

Limitations

Time may be lost in freeing the machine from obstructions unless some mechanism for hoisting is provided in addition to the power lift, which requires forward motion. Tearing of the soil is considered a limitation rather than an advantage under some conditions. Since the Reforestator is not as ruggedly constructed as some of the other machines, it does not withstand rough treatment as well. The comparatively complicated construction of the Reforestator makes it more difficult to adjust than most other machines.

Comments on Field Use

1. Lester E. Bell, Extension Forester, Michigan State College, states: "After using the Reforestator for several seasons, we are convinced that this machine does an excellent job of planting trees under a wide variety of planting conditions." He points out that where furrowing is necessary, no sites, except extremely small ones, are too small for efficient machine operation because a tractor and plow would have to be used to furrow prior to hand planting.

2. The Forest Supervisor of the Lower Michigan National Forest, with headquarters at Cadillac, Michigan, has supplied the following information by word of mouth and by correspondence:

The Lower Michigan National Forests employ six Reforestators in field planting. Results of their use are very satisfactory. Crawler tractors are used exclusively to tow the machines. Machines will plant successfully through blueberry brush and also through scattered scrub oaks if care is taken to avoid the clumps. However, they do not plant successfully in aspen thickets. Plow points are broken easily in heavy brush. By agreement with the Michigan Department of Conservation all furrowing is limited to a maximum depth of four inches, which with the upturned soil on either side makes a total maximum soil height variation of eight inches. Machines used on the Huron National Forest have two extra cutting coulters on either side, ahead of the furrowing device, to cut the sod at the point where it will bend so that it will be sure to turn over and not fall back into the furrow.

Proper soil penetration by the planting parts has been secured without difficulty but the machines have seldom been operated on heavy soils. Little difficulty has been experienced in freeing the planting parts from obstructions. The rolling coulters, ahead of the plow and the trencher, lift the parts out of the ground when obstructions are encountered. Occasionally roots and brush must be removed by hand from the trencher and plow points. The machine has operated well with one wheel raised to level it for planting on hillsides, but costs are increased when it is used in this manner because an extra man is required to raise and lower the wheels.

Planting of 12,000 trees per machine per day has been achieved, but it is now limited to 8,000 trees per day because quality of planting was found to suffer at the higher rate. It is hoped that all planting of 150,000 acres will be completed in fifteen years. Machines will accomplish about 60 percent of the job, especially on lands acquired from the state, which were often burned for many years until recently put under fire protection. Hand planting will be used on the rougher areas.

The planting stock used in both hand planting and machine planting is 2-0 jack pine, 2-1 red pine, 2-2 white pine, and 2-2 white spruce. This stock is produced in Forest Service Nurseries at costs ranging from $3 per thousand for 2-0 jack pine seedlings to $8 per thousand for 2-2 white pine transplants. Cost of hand planting, exclusive of the cost of planting stock, averages $14.88 per acre when 912 trees are planted per acre. Similar costs of machine planting have been $6.50 per acre on the Huron Forest and $7.61 per acre on the Manistee Forest. Machine planting costs are based on charges of $.50 per hour for operation and repair of the Reforestator, and total charges of $1.50 per hour for operation, repair, and depreciation of a crawler tractor of 20 to 34 h.p.

. . .

3. Mr. A. C. Shaw of the Champion Paper and Fibre Company at Canton, North Carolina, writes that he has used

both the Reforestator and Lowther machines for planting loblolly and slash pine on level to rolling ground in the South Carolina Piedmont and the east Texas flatwoods. To tow the machines he has used caterpillar type tractors of 18 to 35 h.p., depending on availability of the tractors. He found that the Reforestator was not satisfactory for southern conditions because it "tears up too much soil." He has abandoned its use as a planting machine and has turned it into a fire plow.

TreeP Tree Planting Sled

The TreeP was designed by J. E. Davis (who helped to develop the Lowther machine) especially for planting on the stony soils and steep hills of New York State. The plow beam assembly and the action of the trencher are similar to those of the Lowther machine. The TreeP is manufactured by the same company[1] that used to produce the Simplex and Duplex machines, and it has been licensed under the original patents for those machines. It is said to be the only machine for planting trees under forest conditions that is protected by patents.[2]

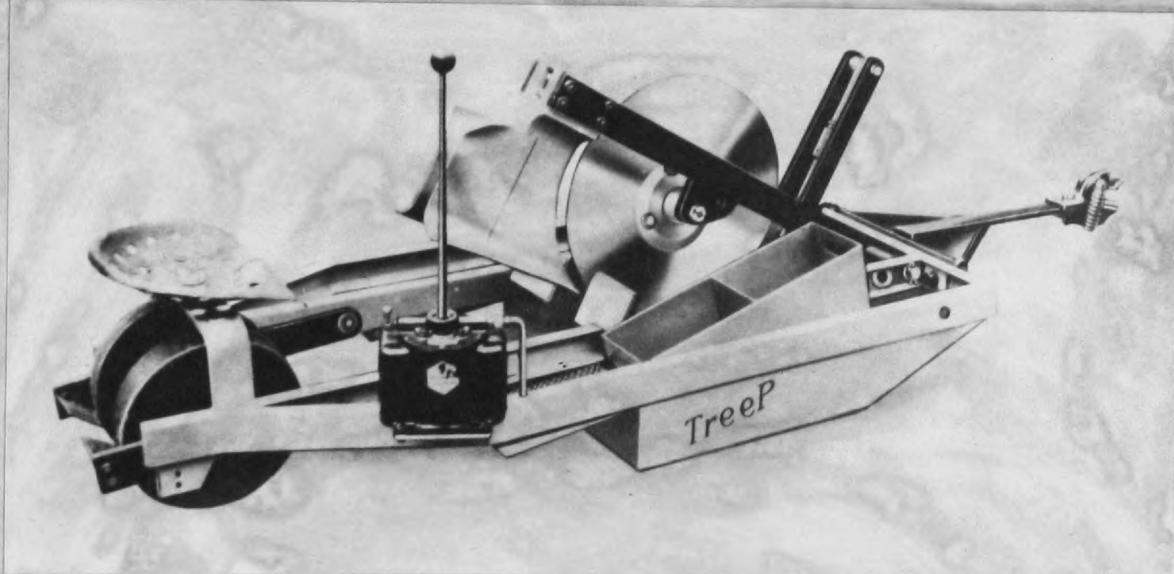

Fig. 5 TreeP Sled-Type Planter[3]

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[1]Champion Sheet Metal Company, Cortland, New York.

[2]A machine for planting trees in the Great Plains was patented prior to 1900.

[3]Photograph by courtesy of TreeP, P.O. Box 163, University Station, Syracuse 10, New York. Cost of machine $750 f.o.b., Cortland, New York.

Main Features

Basic Construction: The frame is mounted on a sled; two runners provide about 385 sq. in. of contact surface.

Trencher: Modified middle-breaker-type plow and coulter are mounted on a free-floating beam hinged at the front of the frame to permit vertical movement. Straight vertical moldboards behind the plow point form the planting guides. The trencher has no replaceable point as on the Lowther machine but is made of wear-resistant Z-metal. Two sizes of coulter are supplied for use in different soil types, and two adjustments can be made for each.

Packing Wheels: Heavy, free-floating metal packing wheels are hinged to the frame to permit vertical movement. Light wheels are available for use on blow sand and soft, light soil. The packing wheels may be locked to the frame by means of bolts inserted in the guide brackets to permit planting in soils where the wheels would otherwise sink into the ground. A scraper cleans mud from the wheels.

Hoist: Hand-operated hydraulic lift is employed to raise the planting parts. The pump lever is located beside the planter's seat.

Over-all Dimensions: Length 6 ft.; width 37 in.; height 15 in.

Weight: Gross weight fully equipped is 1,200 lb.

Towing Equipment: Crawler tractor is recommended. Heavy wheeled tractors may be used under some conditions.

Mobility: Two wheels with pneumatic tires and trailer hitch (including ball joint) are used to tow the TreeP over the road.

Parts Replacement: Castings can be ordered from the manufacturer, as can all other parts. Stock parts are of standard sizes and makes that can be purchased at equipment supply houses. Steel structural members can be repaired with standard welding equipment.

Other Features

Arch at rear of frame is 15 inches high, and can be built on special order up to two feet high to accommodate hardwood seedlings up to two feet tall.

Weights are provided to hold the plow at full depth in stiff soils and to force it back into the ground after it is raised.

Safety hitch for coupling the machine to the tractor protects the machine from damage in case the plow point becomes snagged. The hitch is designed for attachment to a draw bar at a height of 14 inches above the ground.

Hydraulic jack and jacking bar are provided for one-man removal and assembly of the towing wheels, and for attachment of the packing wheels to the machine.

Removable tree boxes hold 1,000 to 2,000 trees. They are carried on each side of the TreeP.

Accessories can be supplied at extra cost for two-man operation of the machine.

Operation

The planting crew consists of a tractor operator and a planter. A third man may be used to sort trees and to perform miscellaneous tasks. As the machine is towed forward, the planter trips the hydraulic lift to allow the plow beam assembly to sink into the ground. The coulter cuts the ground, cuts through small roots, and lifts the trencher assembly over large obstructions. The trencher lifts and spreads the soil to provide a trench for the trees, and permits it to fall back into place relatively undisturbed. The planter grasps a seedling at the root collar with thumb and forefinger, inserts it in the trench, moves his hand to the rear with his fingers at the ground surface, and releases the seedling as it is firmly grasped by the closing sides of the trench. The packing wheels pack the soil on either side of the planted seedling. The planter raises the trencher at the end of each row, by means of the hydraulic lift, before the tractor operator turns.

Advantages

The TreeP is ruggedly constructed and is the smallest machine of its type on the market. Small size is an advantage in planting odd areas and hillsides and in turning at the ends of the rows. Keels on the runners help to prevent side-slipping on hillsides. The sled-type construction provides better floatation in boggy soils, and the free-floating packing wheels, which can be locked to the frame, permit good packing under boggy conditions. If the trencher wears as well as the manufacturer anticipates, the lack of a detachable point will be an advantage because time is often lost on some other machines when the plow shares or plow bolts become loose or break.

Limitations

The lack of a furrowing device is a limitation in areas where furrowing is practiced. The sled may prove less adaptable than wheels to areas containing brush and stumps.

Comments on Field Use

1. Only a limited amount of information on field use is available at this time because the TreeP was first used commercially in the 1949 spring planting season. Information supplied by the manufacturer indicates that the machine was tried out successfully under a wide variety of conditions in New York State for one year before being put on the market.

2. Mr. Joe B. Davidson of the Department of Conservation, Springfield, Illinois, writes that the TreeP has done a good job of planting on black prairie-land soil and on southern Illinois clay timber soil. It has not been used by him on rocky soil, but has been used in dense sod and on slopes up to 20 percent. He likes the sled feature because it is exceptionally good for planting on slopes. The machine is pulled on his operations by practically any kind of farm tractor. Under good conditions 8,000 to 9,000 trees can be planted per eight-hour day. The TreeP is more mobile than the Lowther machine, and has quite a few features that are more desirable. However, the trencher, as it is now made, is too narrow to accommodate big planting stock, which can be accommodated by the Lowther machine.

OTHER TREE PLANTING MACHINES

This section treats briefly some of the new machines used for planting under forest conditions, machines used in the shelterbelt, machines used only in particular localities, and machines no longer in use.

Machines Operating on Power Lift of Wheeled Tractor

The machines described in this section are all relatively new. Other similar machines are probably in use, but their existence has not come to the author's attention. The Lowther Nursery and Shelterbelt Planter is similar to the machines described in this section, but it is described separately because it is particularly adapted for shelterbelt planting.

Common Features

Design: The Purdue Planter, the Illinois Central Planter, and the Whitfield Transplanter are all designed to operate on the power lift of a wheeled tractor. Each has a coulter, a trencher, packing wheels, and a seat for the planter. The technique of planting with these machines does not differ sufficiently from techniques used with machines already described to warrant explanation here. These machines will probably be used most effectively to plant the better sites and small areas, particularly on farms.

Advantages: Advantages common to these machines are low cost, light weight, small size and adaptation for use with light tractors available on farms. Depth of trenching is easily adjusted by the tractor operator. Small size and attachment to a power lift make the machines easier to turn than machines of other types. They can be operated efficiently on small and irregular planting sites. They are easily moved from one site to another attached to the tractor or carried on a pickup truck. Most of the parts are standard farm implement parts which can be obtained from local supply houses, and repairs can be made in any good machine shop. Costs of operation and maintenance are low. All adjustments of these machines are made by the tractor operator so that the planter has only to concentrate on setting the trees.

Limitations: Since these machines are attached to a wheeled tractor, their use is limited to areas in which such a tractor can operate effectively.

Purdue Planter

The Purdue Planter was designed by Professor Daniel DenUyl of the Department of Forestry and Conservation at Purdue University. The machine is expected to be available commercially in the fall of 1949.[1] It weighs 350 pounds,

[1]The Dearborn Motors Corporation, Detroit, Michigan. Estimated price $250.

is seven feet long and three feet wide. It is built on a modified double-bottom plow with the planting shoe attached to one beam. The packing wheels are hinged to permit vertical motion relative to the frame.

Professor DenUyl writes that the machine can be used on nearly all sites and soils and on slopes up to 30 percent. The coulter and moldboard plow operate as they do on a standard tractor plow. The machine has been used on the Ford tractor lift but is not limited to use with that tractor. It is expected to be manufactured so that the scalping attachment can be used only when needed. Field tests indicate that the machine does a good job of planting.

John G. Guthrie, Forestry Agent for the Illinois Central Railroad at Hattiesburg, Mississippi, writes that he used the Purdue Planter in its original form in eleven counties in southern Mississippi and found that it worked very well. Rough ground containing brush and stumps, and some scrub oak lands were planted. An average rate of planting of 1,000 seedlings per hour can be maintained. The rate is higher in old fields. The 14-inch moldboard turning plow is effective in clearing brush and trash on rough areas, thus leaving a clear planting bed. The furrows thus provided serve as fire breaks. The trencher breaks up the soil somewhat so that loose soil is placed around the roots of seedlings. Because the furrowing plow was not detachable on the original machine, it was not well adapted for planting of longleaf pine or for planting on hillsides.

More information should be available after the commercial models are used during the next planting season.

Illinois Central Planter

The Illinois Central Planter was developed from the Purdue Planter, by Illinois Central Railroad foresters, to operate under conditions existing in southern Mississippi and Louisiana. It has not yet been produced commercially, but the Railroad has constructed three machines in its machine shops and has blueprints from which others can be constructed in any good machine shop. Mr. P. R. Farlow, Agricultural Agent for the Railroad, writes that by the fall of 1949 several concerns will probably have on the market similar machines, which he expects to be somewhat better than the present models. He believes that the present machine is not strong enough to withstand operation in rocky ground.

The Illinois Central machine is about six feet long and three feet wide, and weighs about 400 pounds. It has a draw bar for attachment to a Ford or Ferguson tractor. Both the fluted coulter and the ordinary single-bottom breaking plow preceding the trencher are detachable. Wheelbarrow wheels with 4.00 x 8 tires, used for packing wheels, are attached to the trailer through a spring. The trailer,

Fig. 6 Illinois Central Machine[1]

equipped with tree boxes, footrests, and a seat for the planter, is hinged to the frame of the machine to permit vertical movement. The machine can be quickly dissassembled into three parts for hauling.

William W. May, Forestry Agent for the Railroad at Jackson, Mississippi, writes that the machine operates well through brush and briers, and in soil containing stumps. The machine will roll out of the ground if the coulter encounters rocks or roots too big to cut. The fluted coulter has been found particularly effective in

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[1]Photograph by courtesy of the Illinois Central Railroad.

brush and briers. The machine has been used with and without the moldboard furrower. On about 90 percent of the sites planted in Mississippi it was found desirable to plant without the furrower. Under average conditions a crew of moderate skill can plant about 12,000 trees per day.

Whitfield Transplanter

The Whitfield Transplanter is available commercially. It is constructed around a subsoiler with side plates to

Fig. 7 Whitfield Machine[1]

[1]Photograph by courtesy of the manufacturer, R. A. Whitfield Manufacturing Company, Route 4, Box 324, Atlanta, Georgia. List price through dealers $210 with one seat or $225 with two seats.

hold the trench open. It can be used as a subsoiler when the planter frame is removed. It is 65 inches long, 34 inches wide with one seat, 50 inches wide with two seats, and 50-1/2 inches high. It weighs 350 pounds. A wooden tree box is mounted behind the planter's seat. The packing wheels are mounted on ball bearings and equipped with 4.00 x 8, 4-ply tires. The machine can be adjusted for different depths of trenching by means of a turn-buckle on the top link or push bar.

The manufacturer writes that the transplanter can be used on the hydraulic lifts of the Ford, Ford-Ferguson, Ferguson, and Leader tractors, and on the Willys farm jeep equipped with the Monroe lift. At additional expense it can be attached to other tractors. In several different soil types in Georgia and Alabama survival of trees planted with the machine has exceeded 90 percent. The machine can be used to plant pines, kudzu, coastal Bermuda, multiflora rose, and bicolor. A watering attachment permits planting of some farm crops. Up to 3,000 trees per hour can be planted by two men and the tractor operator.

Forest Service Machines Used in the Shelterbelt[1]

As early as the late 1880's a man named Stratton and Dr. F. B. Fernow, early head of the Federal Division of

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[1]Most of the information in this section was obtained by correspondence with the Regional Forester, U. S. Forest Service, Denver, Colorado.

Forestry, designed and built a tree planting machine which was used for contract planting on timber claims in western Nebraska and elsewhere. The machine was later patented, and to the best of the author's knowledge, is the only true tree planting machine ever patented. Since the machine actually set the trees in the ground, it was the only machine which the U.S. Patent Office classified as a tree planting machine. The patented Simplex and Duplex machines and all machines in current use are not classed as tree planting machines by the Patent Office because these machines do not actually plant the trees, but merely open a trench into which the trees must be placed by hand.

Only two types of machines are now used in the Rocky Mountain Region by the U. S. Forest Service: the Naber machine, and a machine used on the Nebraska National Forest. Both of these machines are suitable for use only in light sandy soils or in cultivated land free from rocks, roots, and other buried obstructions. Both are towed by tractors. Survival of trees planted by both machines is fully equal to that of trees planted by hand.

Naber Machine

The original Naber machine was horse-drawn and was developed by the U.S. Forest Service for planting in the Nebraska sand hills. The present tractor-drawn model is constructed around a John Deere single-row, horse-drawn corn lister frame. The trencher is V-shaped, as viewed from above, and is mounted on a vertical bar attached to the frame. A seat for the planter is attached above the packing wheels on a trailer hinged to the frame to permit vertical movement. The space between the packing wheels is adjustable. The machine is light and can be used satisfactorily to plant hardwoods or conifers up to 15 or 18 inches in height.

Nebraska Planter

At the present time all planting on the Nebraska National Forest is being done by a machine which has been developed from a horse-drawn trencher plow developed about 1915 by Seward D. Smith of the Forest Service. Two views of the present model are shown on the next page. It has a coulter, a middle-breaker furrowing plow, a trencher, and packing wheels. Except for the design of the trencher and packing wheels, it resembles the Reforestator, described fully in a previous section. The present machine is very efficient for planting in light sandy or cultivated land. Costs of planting trees on good sites with this machine are about $5 per thousand trees for the actual planting operation, while costs of planting trees with a grub hoe on typical rough sites in the Rocky Mountain Region vary from $20 to $40 per thousand trees.

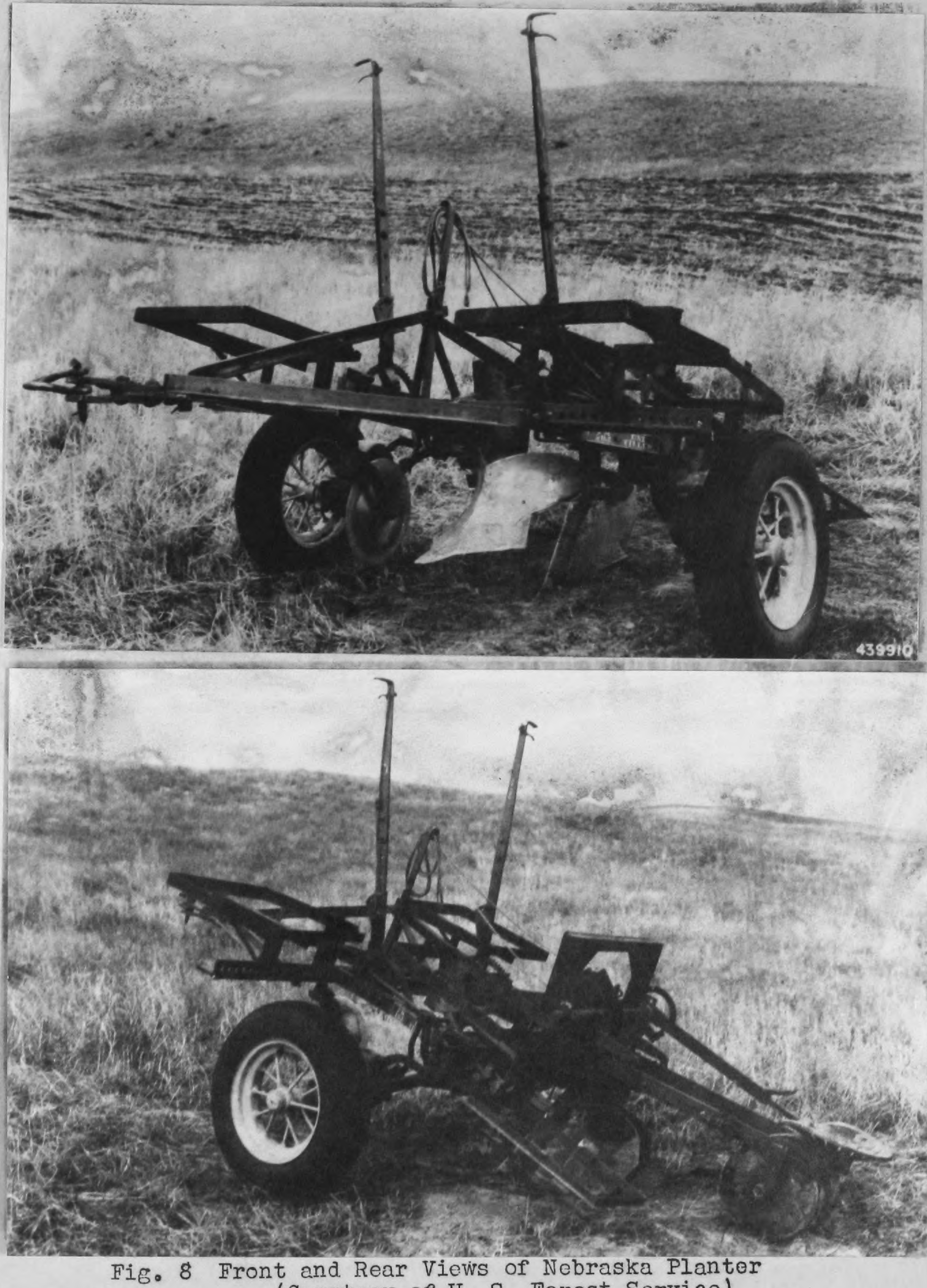

Fig. 8 Front and Rear Views of Nebraska Planter
(Courtesy of U. S. Forest Service)

Soil Conservation Service Machines[1]

Complete descriptions of 19 different tree planting machines are on file in the Soil Conservation Office in Lincoln, Nebraska. However, only three main types of machines are used by the S.C.S. at the present time. These three machines operate very satisfactorily in the Great Plains. All S.C.S. planting is done on prepared ground; sodded land is summer fallowed for at least one year before planting. Many species of coniferous and hardwood trees, and shrubs are planted by the S.C.S. Records show that survival of machine-planted trees is slightly better than that of hand-planted trees.

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P.S.F.P. Machine

Construction of the Prairie States Forestry Project machine was started by Sidney S. Burton and later carried on by Henry L. Lobenstein, both of the Prairie States Forestry Project of the U.S. Forest Service. When the Prairie States Forestry Project was transferred to the Soil Conservation Service in 1942, the S.C.S. received fifteen of these machines in all stages of construction. The S.C.S. now has forty modified P.S.F.P. machines in use.

The P.S.F.P. machine is built around a farm implement uni-carrier with two 6.00 x 16 pneumatic-tired wheels.

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[1]Most of the information in this section was obtained by correspondence with the Chief, Regional Forestry Division, Soil Conservation Service, Lincoln, Nebraska.

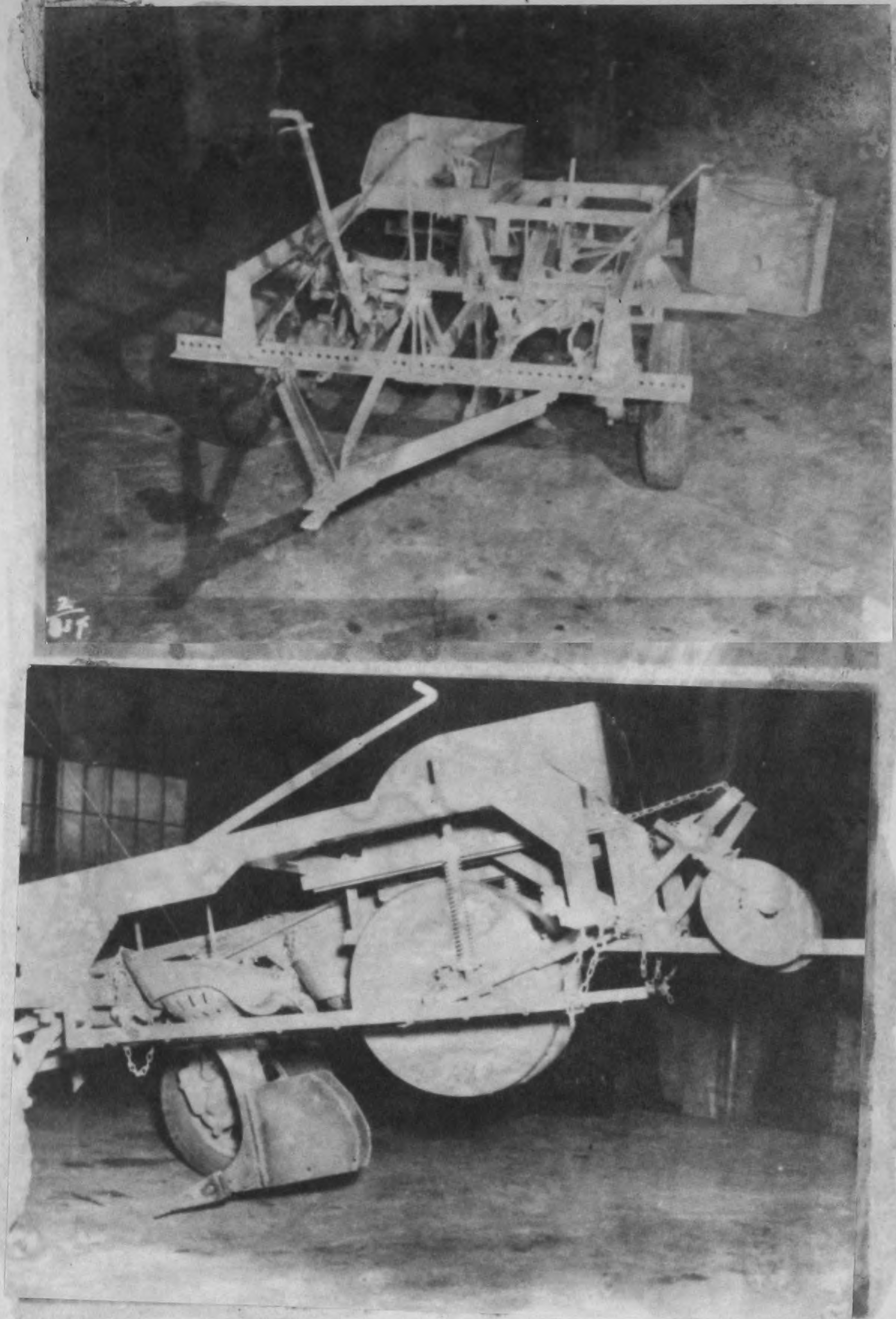

Fig. 9 Front and Side Views of
Improved P.S.F.P. Machine[1]

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[1]Photograph by courtesy of Soil Conservation Service.

Many standard equipment parts are used in its construction. The present model has many improvements over the original models. The operation of the uni-carrier is similar to that of the uni-carrier of the Reforestator; and many features of the present Reforestator were copied from the P.S.F.P. machine. The P.S.F.P. machine is about 13 feet long and about 5-1/2 feet wide. The wedge-type trencher is preceded by an 18-inch rolling coulter and followed by two 22-1/2-inch steel spring-mounted packing wheels. Two disc hillers are used to fill the grooves left by the packing wheels. The machine is equipped with seats for two planters, who sit facing the rear. Tree trays are mounted on each side above the packing wheels within easy reach of the planters. Some of the machines are provided with timing attachments to indicate when a tree should be planted. The planting parts may be removed so that other equipment may be attached to the uni-carrier for other work.

The machine is towed by a wheeled or a crawler tractor. The planters must dismount before the machine is raised for turning. A tongue can be attached for towing the machine backwards from one planting site to another. With one exception[1] this machine is not produced commercially. The S.C.S. Farm Forestry Handbook has full instructions for operation and maintenance of this machine and the machine described in the following paragraph.

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[1]Essentially the same machine is made by a small machine shop in Wahpeton, North Dakota, which produces from 12 to 20 machines each year.

Heavy S.C.S. Planter

The heavy S.C.S. Planter was developed by the S.C.S. from the Simplex machine, but now has few features of the original Simplex machine. The special frame is supported at the front by automobile wheels with 6.00 x 16, 6-ply tires and at the rear by the 23-inch steel packing wheels. The machine is about 12-1/2 feet long and 7 feet wide. The trencher is preceded by a 16-inch fluted coulter. The packing wheels are mounted on an arch at the back of the frame with a king pin, which permits lateral swinging. Chains on each side, hooked to the frame, restrict the lateral swinging of the packing wheels as the machine moves along the rows. The chains are removed at the end of each row so that the wheels can swing laterally when the machine is turned. Two discs fill in the grooves made by the packing wheels. The machine is equipped with two seats for the planters, who sit facing forward. It is towed by a suitable wheeled or crawler tractor. The rear end of the machine is raised and mounted on tandem wheels when the machine is towed from one planting site to another. The machine has held up well under all conditions of planting, including planting in heavily glaciated areas. It is capable of planting 1,000 trees per hour while in actual operation. It is not produced commercially. The models now in existence were constructed in S.C.S. shops.

Light S.C.S. Machine

The S.C.S. developed a light machine, built on a uni-carrier frame for one-man operation. Several machines of this type were built and are now in use. The newest model developed is designed for operation on the power lift of a wheeled tractor. It is similar in operation to other machines of this type already described and has many of the advantages of those machines. It is about 5-1/2 feet or 6 feet long and about 5 feet wide. The wedge-type trencher is followed by 24-inch steel packing wheels, which are connected to the top of the frame through springs. Discs following the packing wheels fill in the grooves made by the packing wheels. Two seats are provided for the planters, who sit facing the rear with their feet on footrests beside the packing wheels. Brackets for the tree buckets are attached to the frame near the packing wheels. This machine can be attached to any tractor with a hydraulic lift. The machine is being constructed in machine shops throughout the Great Plains, about twenty of them having been made during the last winter. It is also produced commercially as the Lowther Nursery and Shelterbelt Planter.[1]

Minnesota Machine

The Department of Conservation of Minnesota designed

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[1]Harry A. Lowther Company, Industry Ave., Joliet, Illinois. Price $350.

a two-man tree planting machine especially for operation in the sand plains. Five models produced[1] under the supervision of Raymond Clement weigh from 750 to 900 pounds. The machine has no furrowing device but employs a heavy coulter, a trencher, packing wheels, and a hand-operated hoist for raising the planting parts. A two-wheeled platform trailer is used for moving the machine from one planting site to another. Rudolf[2] states that field trials of this machine in 1945 indicated that the tractor operator and two planters could plant 1,500 trees or more per hour of operation.

The Director, Division of Forests, Department of Conservation, writes that the machines have been used on recently logged-off areas about half covered with trees six and seven feet tall, but that best results are obtained in light soils and in old fields. Over a 21-day period 2,500 to 3,000 trees were planted per acre at a cost of $2.41 per thousand trees. Bar planting costs under similar conditions are estimated at $6 to $10 per thousand trees. Survival of machine-planted trees apparently exceeds that of bar-planted trees. Survival of machine-planted trees in a wet year was found by actual count to be 98 percent, while in a dry year survival was 92 percent.

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[1] Cost of last machine produced was $495.

[2] Paul O. Rudolf. 1947. Machines for Forest Planting. Canadian Pulp and Paper Association, Woodlands Sect. Index No. 943 (F-2).

The machine is not adapted for planting in rocky soils or on rough terrain.

Valdosta Machine

Foresters of the International Paper Company designed the Valdosta machine to plant trees on old fields in the South. The original machine was constructed in a Georgia machine shop,[1] but the author has been unable to find out either whether the machine is being produced commercially or whether the original machine was used at all after the first trials.

The frame is supported at the front by pneumatic-tired automobile wheels and at the rear by large metal packing wheels mounted on a king pin, which permits lateral swinging of the packing wheels. The rolling coulter, the trencher, and a pair of covering discs are mounted on a beam hinged to the front axle. The 20-inch coulter is set to cut the ground to a depth of two inches below the bottom of the trencher to prevent snagging. The trencher, a plow point with parallel moldboards, makes a trench three inches wide. The perforated metal covering discs throw soil around the roots of the planted trees and the large packing wheels pack the soil firmly. The trencher can be raised by means of a foot pedal or by hand. The seat for

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[1] Waldon Howard Machine Shop, Valdosta, Georgia.

the planter is located on the left side of the machine opposite a point just forward of the covering discs. The operator sits facing forward.

The machine is equipped with a 100-gallon water tank and a measuring wheel. The measuring wheel rings a bell to indicate when a tree should be planted and at the same time opens a valve to squirt water into the trench. The water tank and measuring wheel are optional equipment. The machine is 6 feet long and has an 8-foot wheel base. It weighs 1,600 pounds with the water tank empty. It can be towed on prepared ground by a 16 h.p. wheeled tractor. The usual rate of travel is 2 mph. The arrangement for watering may be an advantage in some instances, but the heavy weight of the machine is apt to be a disadvantage.

Lowther Special Planter

The Lowther Special Planter is essentially a standard Lowther machine, adapted for transplanting nursery stock or other stock with large roots. The principal changes are enlargement of the planting box, i.e., the space between the moldboards which form the planting guides, from two inches to four inches in width and a change of the rear end of the frame to provide a 36-inch arch over the packing wheels. Two planters' seats are provided, one on either side of the frame. A large bucket to hold stock is located forward on the frame.

Hesselschwerdt[1] describes the use of the Lowther Special Planter for setting out multiflora rose transplants for game cover in Illinois. While one man can set out only about 500 transplants a day by hand, it is not unusual to plant 1,300 transplants per hour by machine. He states that this machine plants at the equivalent rate of at least sixteen men.

Joiner[2] states that the use of the Lowther machine has transformed the Illinois game cover restoration project from a dream into a reality. The machine was given successful tests in all types of Illinois soil.

Simplex and Duplex Machines[3]

The Simplex and Duplex machines were patented in 1934 by Ralph Royal Walling. Neither of them has been used in recent years, but their design is of interest in view of more recent developments in other tree planting machines.

The Simplex machine is designed for one-man operation and is horse-drawn. The planting parts are located along the center line of the machine. The seats for the planter and the driver, both of whom sit facing forward, are on the left side of the machine. The frame of the machine

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[1]R. E. Hesselschwerdt. 1948. The Lowther Planting Machine. Illinois Wildlife, Vol. 3, No. 4, p. 4.

[2]Dick Joiner. 1948. Asiatic Shrub Seen Perfect Game Refuge. Chicago Daily Tribune. Wednesday, January 7, p. 29.

[3]These machines were formerly manufactured by the Champion Sheet Metal Company, Cortland, New York. Prices in 1930 were $300 for the Simplex and $500 for the Duplex.

is supported by the packing wheel in the rear, a wheel on the left of the machine, and the drums attached to the coulter. A wheel at the right front of the machine, of smaller diameter than that on the left, operates only when it comes in contact with an obstruction, whereupon it lifts the machine over the obstruction. A bell mounted on the packing wheel, which is six feet in circumference, rings every time the wheel makes a complete revolution to indicate that a tree should be planted.

The Duplex machine is designed for two-man operation and is tractor-drawn. Two sets of planting parts are aligned along the outside edges of the machine, which is supported at the rear by the two packing wheels and at the front by the coulter drums on either side. The wheels mounted on the outside ends of the front axle each have a central hub and an eccentric hub. When mounted on the central hubs, they do not bear on the ground except when obstructions are encountered and when the machine sinks into soft ground. When mounted on the eccentric hubs, they are normally turned toward the rear so that their weight holds them in a position in which they skim the ground. If an obstruction is encountered, or if for some other reason it is desired to lift the machine, the wheel is rolled to the forward position so that cleats on the outside of the wheel on the side most distant from the eccentric hub engage the ground. Forward motion then causes the machine to be lifted as the long radius of the wheel passes under the hub. The planters sit side by side, facing forward, near the center of the machine within reach of the tree buckets between them and the planting trenches on their respective sides. The planter on the right plants with his right hand, while the planter on the left plants with his left hand. A timing device is located on a wheel towed by a universal joint behind the middle of the rear of the frame.

Since the design of the planting parts on each machine is very similar, only the planting parts of the Simplex machine are described in this paragraph. Two drums are attached to the coulter, one drum on each side. This assembly is mounted on a short axle, the ends of which are held by vertical arms attached at the top to the tongue bars. The arms are free to turn with the tongue about the axle. The coulter drums bear on the ground, partially support the weight of the machine, and drive the coulter. The trencher has a vertical shank attached to the plow beam, the front end of which is supported by, but free to turn about, the axle and the rear end of which is supported between the sides of a divided bar, which permits vertical adjustments. The forward edge of the trencher conforms approximately to the shape of the coulter but is spaced behind it so that the toe of the trencher is nearer the coulter than any other part. The trencher has a flat shoe, pointed at the front end. The sides of the shoe slope upward toward the shank of the trencher. The trencher proper is very similar in design to that of the present Lowther Standard machine. Vertical parallel guides, built onto the rear end of the trencher, are connected by a piece of metal across the bottom so that the planting slot is entirely enclosed except at the top and the rear. The bottom of the trencher has a slight incline from front to rear, while the bottom of the planting slot slopes down toward the rear so that the bottom of its rear end is on approximately the same level as the toe of the trencher. Since both the coulter and the trencher are adjustable, the distance between them is variable. The action of the coulter and trencher is very similar to that of the Lowther Standard machine in cutting, lifting, and spreading the soil to open the planting trench. The split packing wheel rotates in a vertical plane, unlike the two packing wheels of the Lowther machine, which are toed in at the bottom. The two halves of the packing wheel straddle each tree and pack the soil on either side. The planter, seated to the left of the planting parts, sets the trees in much the same manner that they are set on the Lowther machine. Other features of the Simplex machine are not described here.[1]

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[1]Patent No. 1,972,281, September 4, 1934, describes both the Simplex and Duplex machines in full. The patent can be obtained from the U.S. Patent Office, Washington, D. C., at a cost of $.25

On each side of the Duplex machine planting parts are arranged in much the same way as on the Simplex machine. Toed-in heeling wheels at a suitable distance behind the planting slot are an added feature of the Duplex which could be incorporated in the Simplex machine. The heeling wheels are mounted on an arm which permits adjustment of the force which they exert against the ground. They start forcing the sides of the trench back into place and the split packing wheel finishes packing the soil. The only other major change in the planting parts is that the plow beams are pinned to the front and rear axles and are not adjustable. However, the pitch of the trenchers can be adjusted by placing the rear bolt, which holds the shank of the trencher to the plow beam, in different holes in the rear of the shank. Other features of the Duplex machine are not described here.

These machines were much used, particularly in New York State between the late 1920's and the early years of World War II, when their use was discontinued. Toumey and Korstian[1] state that, according to records of the New York Conservation Department for 1930, 4,764,454 trees were hand-planted at a cost of $6.17 per thousand, while 593,465 trees were machine-planted at a cost of $2.40 per thousand.

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[1]James W. Toumey and Clarence F. Korstian. 1942. Seeding and Planting in the Practice of Forestry, Third Edition. New York: John Wiley & Sons, Inc., p. 485.

SILVICULTURAL ASPECTS OF MACHINE TREE PLANTING

There is a difference in the planting done by the various types of machines because of differences in machine design. Furthermore, planting done in different localities by similar machines varies because of differences in soil, slope, and ground cover. All machine planting differs in some respects from hand planting. Since all machines open a continuous trench into which the trees are set, ground prepared by machine methods is different from that prepared by hand methods. Since machines are towed at the rate of two to three mph., machine planters do not have the time to do the precise planting done by bar or mattock planters. Some of the variables which are inherent in machine planting and which affect the survival and growth of the planted seedlings are discussed in this section.

Site Preparation

Site preparation, as discussed here, should not be confused with soil preparation, which involves cultivating techniques similar to those used in farming. Soil preparation is necessary in the shelterbelt, but is not discussed here.

Furrowing and burning are two methods used to prepare sites for planting. The desirability of either method is largely determined by regional conditions, and in many areas no site preparation is made.

In the Lake States, and in certain parts of New England and the Central States, furrowing has long been considered essential in planting operations. Its purpose is to eliminate competition from sod and other plant growth while the seedlings are becoming established. Furrows are usually made just deep enough to remove the sod and brush cover. Where planting is done by hand, a tractor and plow are used to furrow prior to planting. Where machine planting is done, the furrow is usually made by a part of the machine preceding the trencher. In most cases the trees are planted in the bottom of the furrow. Where furrowing is essential, survival of machine-planted trees is dependent upon the use of machines with efficient furrowing devices. Machines especially designed for furrowing are generally most satisfactory. One advantage of furrowing, in addition to reducing competition, is that, following planting, the furrows act for several years as firebreaks. One disadvantage of furrowing, more than compensated for by the advantages, is that the topsoil is thrown to either side of the trench so that the roots of the seedlings are placed in the less fertile layers of soil beneath. Baxter[1]

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[1]Dow V. Baxter. 1943. Pathology in Forest Practice. New York: John Wiley & Sons, Inc. p. 183-184.

reports that trees planted in furrows may be more subject to frost heaving because there is no sod to protect them.

In areas where erosion is a problem, even within regions where furrowing is the usual practice, typical furrowing with a planting machine is undesirable. In such areas furrows are apt to wash severely so that the roots of the planted trees are exposed. Sheet and gully erosion are apt to start in furrows in such areas.

An unusual system of furrowing is practiced in the hilly country in Ohio. During the fall prior to planting, furrowing is done along the contours with a special plow, which throws two furrow slices downhill. The furrow slices settle during the winter, and in the spring the Lowther Hillside machine is used to plant along the ridge formed by the furrow slices. With this technique the roots of the trees go into a double layer of topsoil, and the furrows along the contour help to prevent erosion. H. P. Garritt of the Muskingum Conservancy District reports better growth of seedlings planted by this method.

Although some furrowing has been done for planting site preparation in the South, it is not considered essential and is not the usual practice in most sections. In some cases, particularly in the planting of longleaf pine, such disturbance of the soil is considered bad practice. In the case of longleaf pine, any silting in the bottom of the furrow is apt to kill or damage the trees.

The site preparation used especially in the longleaf type, and somewhat in other southern pine types, is that of burning over the planting site. Burning, done either in the winter one year before planting or in the early fall prior to planting, accomplishes three things: (1) it reduces the rough so that the planting operation is more easily accomplished; (2) it tends to reduce brown spot infestation; and (3) it reduces the fire hazard in case there is a wild fire subsequent to planting. Light, controlled burning for brown spot control is often necessary in the second or third year after planting. Such a fire will do less damage to the seedlings if the rough has been reduced by fire prior to planting. Some plant growth after the fire and prior to planting is desirable as an aid in preventing frost heaving of trees planted during the fall and winter.

Trenching

Three basic types of trenchers were described fully under "Principles of Machine Design" in the section on "COMMERCIAL FOREST TREE PLANTING MACHINES." The wedge type of trencher works satisfactorily in light sandy soils in open areas typical of the shelterbelt. It will not be discussed here because it is not suited for use in the planting of typical rough forest sites, which are being discussed here.

Advantages are claimed for both of the other types of trenchers. One type of trencher, which for convenience will be referred to as the Lowther type, lifts and spreads the soil at the same time so that it falls back into place relatively undisturbed. The other type, which will be referred to as the Badger type, lifts soil out of the trench and forces it back in again so that it is thoroughly torn and mixed.

As previously stated, minimum soil disturbance is desirable in the planting of longleaf pine, the depth tolerance of which is critical, and in the planting of areas subject to erosion. In such situations the Lowther type of trencher is definitely superior.

If the Badger type of trencher were not preceded by a furrowing device, it would mix fertile topsoil with the other soil that is packed about the roots of the seedlings, but this type is seldom used without the furrowing device.

Advocates of the Badger type claim that thorough pulverizing and mixing of the soil is an advantage because the roots never have to penetrate a compact vertical plane. The author knows of no experiments designed specifically to test this theoretical advantage. However, some experimental findings are indicative.

Schantz-Hansen[1] planted 2-2 stock of red pine, white

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[1]T. Schantz-Hansen. 1945. The Effect of Planting Methods on Root Development. Jour. For. 43:447-448.

pine, jack pine, and white spruce in sandy soil at the Cloquet Experiment Station in 1937. The methods of planting used were the inverted v, the shovel slit, the regular planting bar method, the mattock slit, and careless planting by the slit method. No significant differences in survival or root spread were found after two growing seasons. He reports that, in slit planting of jack pine and red pine, Rudolf found greater root spread in the plane of the slit than at a right angle to it.

Wakeley[1] found in experiments with longleaf and slash pines in Louisiana that there was little significant difference in survival of trees planted with different tools. Among the poorest in survival were trees planted by mattock, a method in which the soil structure was more disturbed than by any other method. He has informed the author that articles relative to side-hole versus center-hole planting present arguments in favor of planting with minimum soil disturbance. Advocates of side-hole planting claim that water supply is better through soil of undisturbed structure. The author has been unable to find the literature referred to, but it is mentioned here as a possible source of further evidence.

Young[2] found in Michigan that seedling stock of

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[1]Philip C. Wakeley. 1948. Unpublished data of Southern Forest Experiment Station.

[2]Leigh J. Young. 1928. Growth and Cultural Experiments on the Saginaw Forest. Papers of the Michigan Academy of Science Arts and Letters, Vol. IX, pp. 541-594.

several species planted by the slit method on soil previously cultivated survived much better than stock planted by the grub hoe method on uncultivated soil. The prior cultivation may give somewhat the same effect as thorough pulverizing of the soil at the time of planting by a Badger type trencher.

There is some, though not conclusive, evidence from ponderosa and Austrian pines planted in Michigan that growth is better in trees planted by the center-hole method than in those planted by the slit method.[1] Since the Badger machine method is similar to the center-hole method and the Lowther machine method is similar to the slit method, it might be expected that growth of trees planted by the Badger type trencher would be better than growth of those planted by the Lowther type trencher. More investigation is necessary before conclusive statements concerning the advantages of either type of trencher will be justified.

Depth of Setting Seedlings

Depth of setting is an important factor in machine planting because the planter cannot set the seedlings consistently with the root collars at the soil surface.

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[1] G. David Bauch. 1944. An Experiment on the Effect of Root Pruning on Planted Coniferous Stock. Unpublished master's thesis on file in the Forestry Library, University of Michigan.

The author found in Mississippi that the best planters averaged only about 90 percent in successfully setting seedlings at the proper depth, and many planters averaged between 70 and 80 percent. It was customary on some jobs to have the assistant planter follow the machine to raise the deep-planted seedlings and to replant the shallow-planted ones. The author was not convinced, however, that the number of seedlings thus saved justified the expense of a man for this purpose.

The depth at which seedlings are set in the ground is critical for at least two southern pines. Wakeley[1] found in experiments with slash and longleaf pine planted in Louisiana in the 1935-36 and the 1936-37 planting seasons that "setting seedlings too high, even 1/2 inch, resulted in very significantly poorer survival than setting them normally or at any excessive depth up to and including 2 inches." Survival at the end of the first growing season was the basis of comparison.[2] The author conducted an experiment with longleaf pine in Mississippi, the results of which generally confirm Wakeley's findings with respect to longleaf.[3] Baxter[4] states that deep planting

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[1]Wakeley, op. cit.

[2]These findings are in opposition to earlier recommendations by Wakeley (1935. Artificial Reforestation in the Southern Pine Region. U.S.D.A. Tech. Bul 492) that longleaf seedlings be set with root collars 1/2 inch above the ground to prevent damage from silting.

[3]A full report of this experiment is included in the Appendix.

[4]Opus cited. p. 183.

causes losses and poor growth of seedlings planted in the Lake States.

While Wakeley found that survival of deep-planted seedlings was very significantly better than that of shallow-planted seedlings and in one case[1] significantly better than that of trees set properly, it is not safe to recommend setting longleaf seedlings deep. The basis of comparison in all cases was survival at the end of the first growing season, and it is not known whether longleaf seedlings with buds below the ground surface will ever start growing in height. There is some evidence that covering of longleaf buds by silting at least delays growth, if it does not kill the trees. Unfortunately Wakeley's experimental plantings were damaged by hogs before other checks could be made to determine subsequent growth of deep-planted seedlings. The author intends to report at a later date on the subsequent growth of deep-planted seedlings in the plots he established, and further experimentation would be justified.

Longleaf pine plantations established by machine planting are consistently reported as being successful; so it may be concluded that the defect in depth setting does not prevent successful establishment of longleaf pine plantations by this method. However, it is likely that

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[1] In one of Wakeley's experiments the survival of trees planted one inch deep significantly exceeded survival of trees with the root collars at the ground surface.

plantations would be much improved if a method were devised to set all or most of the seedlings at exactly the proper depth.[1]

<u>Packing of Soil about Roots of Seedlings</u>

There has been much speculation as to whether the soil is properly packed about the roots of machine-planted seedlings. Wakeley's experiments[2] with longleaf and slash pine provide a partial answer to the question. Several allegedly incorrect planting practices, including one in which the bottom of the planting slit was left open, were tested. Longleaf pine was much more adversely affected than slash by failure to close the bottom of the planting slit. Wakeley concludes: "Failure to close the hole at the bottom had a negligible effect on survival. No treatment excelled this 'defective' treatment significantly, and it excelled (though not significantly) two of the three checks. This rather gives the lie to the emphatic statements in planting manuals and leaflets concerning the importance of firm closure of the planting slit. It also suggests that the closure obtained in machine planting may be entirely adequate, even though not quite as tight as in the most skillful hand planting." This conclusion is substantiated by reports that survival of machine-planted stock is satisfactory. The author knows

[1]A recommendation by the author for a device that would actually set the trees in the ground at the proper depth is included in the Appendix.

[2]Opus cited.

of no similar planting experiments in other parts of the country, but again, reports of survival indicate that machine planting is satisfactory.

Root Pruning

Southern pines, which grow rapidly the first season, are often root-pruned incidentally in the nursery bed by the blade used for lifting the seedlings. In other areas older seedlings and transplant stock are often root-pruned to check the growth. Root pruning is discussed here because of its connection with the depth of the planting trench and with the ease with which trees are handled by the planter. The factor to be considered is whether root pruning or extra root pruning is desirable because of its effect on the survival and growth of planted trees, aside from the considerations mentioned above.

The author found in Mississippi that longleaf pine seedlings planted with the Standard Lowther machine often had L-roots; i.e., the tip of the root was often bent horizontally along the bottom of the trench. A correctly planted seedling is shown in Fig. 10a. L-roots can result from planting of extra long seedlings (Fig. 10b) or from planting a seedling of standard length when the trencher is running above the standard depth in the soil (Fig. 10c). The latter case is apt to occur when the machine runs through a pocket of heavy soil. Extravagant statements have often been made about the detrimental

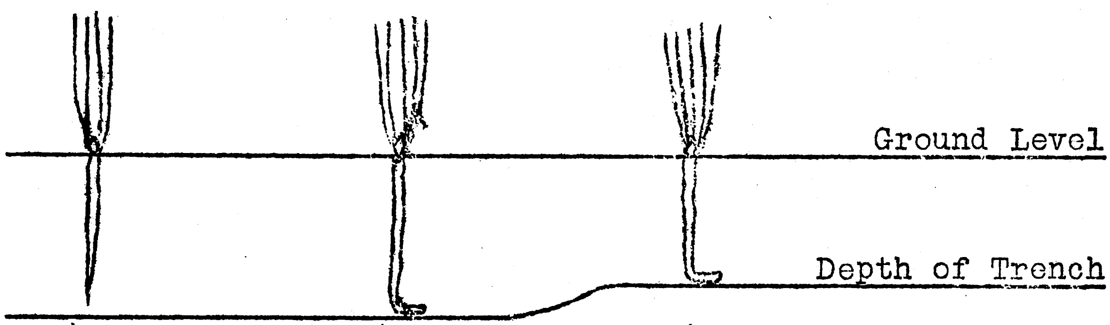

Fig. 10a Fig. 10b Fig. 10c

effects of planting trees with roots doubled up (U-roots). However, Wakeley[1] has found with Southern pines that little difference in first-year survival results from planting trees with the roots doubled up. He writes the author that he has seen seedlings, probably planted with U-roots, in which the roots have developed in the manner illustrated in Fig. 11a, but that probably a higher proportion

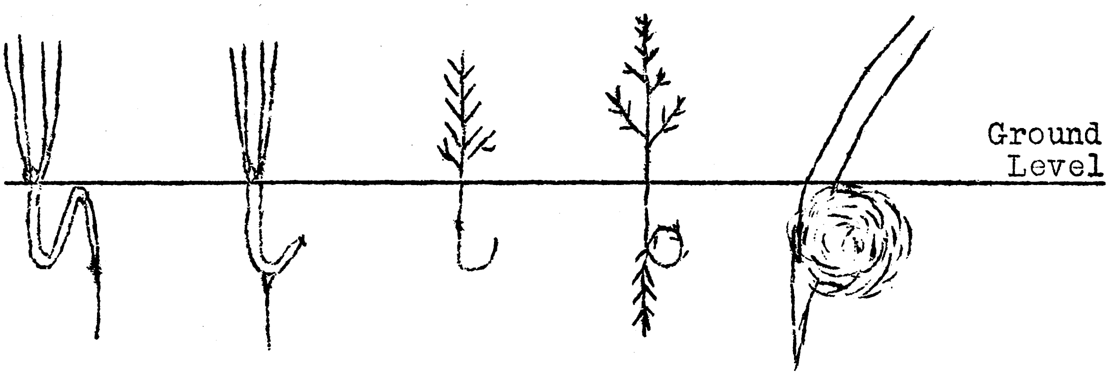

Fig. 11a Fig. 11b Fig. 11c Fig. 11d Fig. 11e

[1]Opus cited.

put down a new main root from the bottom of the "U", as shown in Fig. 11b. He writes also that slash pine planted with U-roots may develop as shown in Figures 11c, d, and e. The ball of roots shown in Fig. 11e may be as big as a man's head, and trees with such roots are subject to windfall in wet weather. Baxter[1] reports a similar deformity of slash pine caused by improper planting. He also states that trees planted with U-roots may be subject to drought damage even many years after planting.

The indications are that, while doubled roots may not be extremely harmful, it is much safer to plant trees with the roots in the normal vertical position. L-roots may not be as harmful as U-roots. If these conclusions are correct, is it, then, desirable to prune the roots so that it will be easier to plant the pruned seedlings in the correct manner?

Wakeley's findings[2] are indicative. In further experiments with longleaf and slash pines in Louisiana, seedlings with roots pruned to lengths of 2, 3, 4, 5, 6, 7, 8, 9, and 10 inches were planted. Wakeley found that there were no significant differences in survival after the first growing season for trees with root lengths from 5 to 10 inches. A similar experiment the following year confirmed these findings, with the exception that seedlings

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[1] Opus cited.

[2] Opus cited.

with 10-inch roots for some reason showed significantly or very significantly poorer survival than any others except those with 2- and 3-inch roots.

In another experiment longleaf and slash pines were planted on good and poor sites, 2 blocks per site, with root lengths of 2, 4, 6, 8, and 10 inches. Each length was tested with lateral roots removed and with laterals intact, plus one treatment with tap root pruned to 3 inches and the remaining laterals pruned to 8 inches (actually not much pruning of the remaining laterals was necessary to get them within this size) -- a total of 11 treatments. All lengths with laterals on plus the treatment with a 3-inch tap root and the remaining laterals pruned to 8 inches very significantly excelled in survival at the end of the first growing season all treatments with laterals removed. Longleaf survived much better than slash when laterals of both species were removed. With the laterals on in all cases these results confirm those of the root pruning experiments discussed in the preceding paragraph, with the exception that seedlings with 10-inch roots were superior in survival to seedlings of all other treatments. The adverse effects of stripping off the lateral roots proved worse on the poor site than on the good site. Wakeley concludes that with laterals removed, "for every length of root except 10 inches, the survival of any given root-length on the poor site was very significantly lower than that of the same root-length on the good site," while "with the side roots left on, as with tap roots pruned to 3 inches and the remaining laterals to 8 inches, survival of a given root-length on the good site (means of both species combined) in no case significantly excelled that of the same root-length on the poor site."

Bauch[1] concluded from experiments with ponderosa pine and Austrian pine planted in Michigan that pruning 2-0 ponderosa pine seedlings and 2-2 Austrian pine seedlings to a length of 6 inches is quite practical, but that severe pruning (to a length of 4 inches) is bad practice. He also found some evidence that height growth of unpruned stock exceeded that for pruned stock, but the evidence was not conclusive because of the design of the experiment.

It may be concluded that for machine planting, pruning of roots to lengths of from 6 to 8 inches to facilitate proper placement of the roots in the ground is justified. Further experiments designed specifically to test survival and growth of machine-planted stock with various degrees of root pruning, within the sizes easily handled by the machine planter, would be worthwhile. Severe pruning of roots not only makes it difficult for the planter to handle the trees, but probably has an adverse effect on growth and survival after planting. Stripping of lateral roots is definitely harmful and should be avoided.

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[1] Opus cited.

Seedling Size

Within the limits of root length, already discussed, and with tops no longer than 12 or 15 inches (sizes normally planted), the large seedlings are more easily handled by the machine planter than small ones. "Size" here refers to the diameter of the seedlings at the root collar as well as to length. Seedlings smaller than 1/8 inch in diameter at the root collar are hard to grasp. Since the larger seedlings are usually more rigid, they can be placed in the trench more readily and released sooner as the soil is packed about the roots. Wakeley writes the author that during the 1920's and early 1930's large seedlings consistently survived better than medium-sized or small ones in the South. Since about 1936 the small and medium-sized seedlings have survived better than large ones. He writes that the problem is one of physiological versus morphological grade.[1]

It is possible that nursery techniques may be developed so that seedlings of a large size, easily handled by machine planters, will survive well when planted.

Transplant stock of a size easily planted by machine planters is usually planted in the Central and Lake States.

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[1]A paper by Mr. Wakeley on this subject was read at the 1948 meeting of the Society of American Foresters and is being published in the Proceedings of the Society. It is not available to the author at the time of writing.

The problems are the same as those already discussed.

Conclusions

Trees are not set as precisely by machine planting methods as they are by hand planting methods because the present techniques of machine planting do not permit great precision. However, the measure of success in planting is the cost of establishing stands of trees that will grow to produce satisfactory quantities of merchantable timber. Reports indicate that initial survival of machine-planted trees is satisfactory, and usually compares reasonably well with survival of hand-planted trees. In some cases machine-planted stock is reported to survive better than hand-planted stock. Not enough time has elapsed since the first extensive forest plantations were established by machine planting to show that the final results will be better than those for hand planting, but there is no evidence at present to indicate otherwise. On the basis of costs and initial survival, there is every indication that under suitable conditions, machines can be used to reforest land satisfactorily at total costs (including the cost of seedlings) averaging 2/3 to 3/4 of hand planting costs. Under conditions not favoring machine use, hand planting will still have to be employed. New developments and techniques, some of which have been outlined in this section, may be expected to speed machine planting and to improve the quality of plantations established by machine.

A P P E N D I X

Planting Machines Used in Different Forest Service Regions[1]

1. Northern Region, Missoula, Montana[2]
None

2. Rocky Mountain Region, Denver Colorado
Mountainous section - none
Plains area - Naber
Forest Service machine
P.S.F.P. machine
Soil Conservation Service machines
Lowther Special (plantings for wildlife purposes)
Probably others made locally

3. Southwestern Region, Albuquerque, New Mexico
None

4. Intermountain Region, Ogden, Utah
None

5. California Region, San Francisco, California
None

6. North Pacific Region, Portland, Oregon
Lowther Standard

7. Eastern Region, Philadelphia, Pennsylvania
TreeP
Reforestator
Simplex and Duplex (from the late 1920's until the early 1940's)

8. Southern Region, Atlanta, Georgia
Lowther Standard
Purdue
Illinois Central
Valdosta

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[1] This list includes machines used by all classes of users (federal, state, and private). Standard Forest Service Regions are the basis for grouping the machines by areas.

[2] Headings show region number, name, and headquarters.

8. Southern Region (Continued)

- Whitfield
- Reforestator[1]
- Others made locally

9. North Central Region, Milwaukee, Wisconsin

- Reforestator
- Badger
- Lowther Standard
- Lowther Hillside
- Purdue
- Illinois Central
- TreeP
- Minnesota
- Lowther Special (wildlife plantings)
- Others made locally

10. Alaska Region, Juneau, Alaska

- None

Tropical Region, Rio Piedras, Puerto Rico

- None

[1]It is not known whether the Reforestator has been used in the Southern Region since it was first tested there.

Tree Planting Devices

The devices discussed briefly here are not actually planting machines, but the techniques of their use are improvements over plain hand planting. Undoubtedly there are many such devices and techniques, not described here.

Miller Mechanical Planter

Mr. S. L. Miller of the Oregon State Forestry Department has developed a planting bar which makes the hole and plants the tree in one operation. The planter places a tree in the hollow, wedge-shaped blade while walking from one planting spot to the next. After inserting the blade in the ground, he pulls a trip on the handle to force the tree out of the side of the bar into the planting slit. Only small seedlings can be planted with this tool. Since the roots must be wrapped with cloth or paper, effectiveness of the tool depends upon economical wrapping. As many as 2,400 seedlings have been planted per man per day with this device. Further information can be obtained from the State Forester, Salem, Oregon. The tool is described fully in two magazine articles.[1]

Tree Planting Spade

Foresters of the New York State Conservation Department have developed a technique of planting with a spade attached to a crawler tractor. A piece of metal attached to the tractor tread gouges a hole in the ground. A crew of planters follows the tractor to set the trees in the holes by hand. Using this technique a crew of fourteen men can plant about 2,000 trees per man-day. The device and the technique of its use are fully described in a magazine article,[2] and further details can be obtained from the New York State Conservation Department, Arcade Building, Albany 7, New York.

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[1]Anon. 1945. Tillamook Planting Scheduled. Timberman, Vol. 47 (November 1945), p. 112.
Anon. 1946. No Squat, No Stoop with Mechanical Tree Planter. Pop. Sci. 148:98-99.

[2]Grant M. Powell. 1948. A Tree Planting Spade for a Crawler Tractor. Jour. For. 46:278-281.

Syracuse Forestry Plow

Professor Svend O. Heiberg of the New York State College of Forestry developed a tractor-drawn plow with middle-breaker plow points to turn back the sod and spring teeth to mix up the soil to a depth of 8 or 9 inches along the furrow. A crew of 5 to 8 men plants trees with dibbles or similar tools in the ground thus prepared. Each man can plant 1,000 to 2,000 trees per day. Trees thus planted are reported to survive and grow better than those planted by the usual hand methods. Further details can be obtained from an article[1] or from Professor Heiberg at the New York State College of Forestry, Syracuse, New York.

Pellet Planting by Airplane[2]

Dr. Lytle S. Adams has developed a technique for planting seed from an airplane. The seeds are formed into pellets, about 4 seeds per pellet, with clay, fertilizer, and rodent repellent. The pellets are planted by means of a multi-barreled centrifugal planter, which shoots them from an airplane. Seeding of 1,000 acres per hour with a small plane was reported to be possible. This method of planting was to be used principally for reseeding burned areas in the West, but no information has reached the author to indicate the effectiveness of the technique in large operations.

[1] G. E. Knapp. 1946. Gair Woodlands Planting Operation Testing Syracuse Forestry Plow. Mechanization Manual, Southern Pulpwood Conservation Association, No. 7.

[2] Harold J. Ashe. 1946. Trees Planted from Air. Nation's Business 34:47.

Longleaf Pine Depth Setting Experiment

Problem

With the present techniques it is not possible to plant longleaf pine (Pinus pa lustris) with the Lowther tree planting machine so that the root collars of all seedlings are exactly at ground level. Twenty or 30 percent of the seedlings are planted too shallow or too deep; i.e., they are set so that parts of the roots are exposed above the ground surface or the buds are beneath the ground surface. Wakeley[1] conducted experiments which showed that longleaf seedlings planted slightly too deep showed better survival at the end of the first growing season than those planted shallow. However, it is not known whether seedlings with buds below the ground surface will ever grow out of the grass stage. It is known that some seedlings will survive one growing season when planted one to two inches shallow, but it is not known what percentage will survive or how they will develop after the first growing season. This study has two purposes: (1) to show how depth of planting affects survival of bar-planted and machine-planted seedlings; and (2) to compare survival of bar-planted and machine-planted seedlings.

Design and Execution of Experiment

Location and Site: Approximately 2,000 longleaf pine seedlings have been planted in eight blocks on the Leaf River Ranger District of the DeSoto National Forest on two different sites within the Double Branches Plantation, T1S R13W, St. Stephens Meridian, about 16 miles southwest of Brooklyn, Mississippi. Blocks D-1, D-2, D-3, and D-4 are located on a wet site in Section 27 adjacent to block 9A of the experimental plots of the Southern Forest Experiment Station (see map). Blocks D-5, D-6, D-7, and D-8 are located on a dry site in Section 21 adjacent to blocks 3B and 9B of S.F.E.S. planting. The soil on both sites is loamy. All of the ground is gently sloping and had not

[1] Philip C. Wakeley. 1948. Unpublished data of Southern Forest Experiment Station.

been burned over for at least one year at the time of planting. A double plowed line enclosing the depth planting blocks and the larger experimental plots of the S.F.E.S. provides a fire break which will probably be maintained for several years. The ground between the plowed lines was burned off in February as an additional precaution. The site was covered about twenty years ago by good stands of virgin longleaf pine. Sheep, hogs, and fire have helped to prevent establishment of a new stand. The area is now fenced, cows being the only livestock allowed inside the fence.

Design: Each block consists of ten rows spaced four feet apart. Seven of the rows in each block were planted by bar and three by machine. The bar rows each contain 25 seedlings spaced four feet apart. The machine rows each contain approximately 25 seedlings spaced approximately four feet apart (see Table 2). All of the seedlings in any one row were planted as nearly as possible at the same depth. The seven bar-planted rows represent planting from 1-1/2 inches deep to 1-1/2 inches shallow at 1/2-inch intervals. It was impossible to be entirely accurate with the machine, but the intention was to plant one row correctly, one row shallow, and one row deep in each block. Table 2 shows the actual measurements taken on the machine rows the second day after machine planting. All ten treatments are represented by one row in each block. Table 1 shows the arrangement of rows, which was randomized separately for each block.

A creosoted 6 x 6-inch post, 12 to 18 inches high and scribed with the block number, marks one corner of each block, as shown on the map. Rows are numbered from 1 to 10, row 1 being nearest the post. Creosoted stakes about 15 inches high mark the ends of each row. The machine-planted seedlings were marked with wire pins with orange-painted loops 9 to 18 inches above the ground. The pins were set at approximately 4 inches from the seedlings, on the north side of east-west rows and on the east side of north-south rows. Rows on the wet site are numbered from east to west and on the dry site from north to south.

Planting Stock: Seedlings used in the experiment came from three bundles taken from the same part of one bed in the Ashe Nursery. The seed was from lot number 4-46, collected in Mississippi. It was sown in the fall of 1946. Seedlings showed some brown spot disease at the time of lifting on February 2, 1948. They were bundled and watered regularly until planted. They received normal treatment from the time of seed sowing to the time of planting in the field.[1]

Conduct of Planting: The machine planting was done on February 13, 1948, by C. A. Seal, the most skilled machine planter on the Leaf River Ranger District. J. H. Daughdrill, an experienced man and planting foreman, drove the Cletrac HG-10 tractor pulling the Lowther tree planting machine. The author walked beside the planter calling out numbers to help the planter space the trees. Fairly accurate spacing was achieved. The machine-planted trees cover approximately the same amount of ground in each row as the bar-planted trees. All but four of the machine-planted rows have exactly 25 trees on them; the others, D-1 rows 5 and 10, D-3 row 10, and D-6 row 3, have 28, 26, 23, and 24 respectively, as shown in Table 2. The depth of planting was controlled entirely by the ability of the planter (See Table 2 for record). The order of planting was D-1, D-2, D-3, D-4, D-8, D-7, D-6, D-5. Light and heavy showers immediately preceded the actual planting, came at irregular intervals during the planting, and lasted fairly steadily from the completion of the job about 2:30 p.m. until about 7:00 p.m. The temperature was approximately 32 degrees the night after planting.

The bar planting was done on February 14, a clear, cool day (40-55 degrees estimated), by five experienced planters as shown in Table 3. Table 3 also shows the direction in which each row was planted. Three planters did most of the work while the regular planting foreman, Mr. Mack Lambert, and the author gave close supervision. The standard bar-slit, one-man method was used except with respect to depth of planting.[2] The order of planting was

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[1]The night before planting E. R. Ferguson of the S.F.E.S. and the author tied a piece of 3/32-inch twine around the needles three inches above the root collar of each seedling to be planted deep by machine. These and other (plain) seedlings were then tied in bunches of 30 to facilitate handling. The bunches, of course, were taken apart before planting. The string on the deep-planted seedlings was intended to serve as a gauge of the actual depth after planting, but the strings slipped with the result that an accurate check on these seedlings was impossible. The strings were slipped off over the ends of the needles on February 15 by the author.

[2]After the first three rows had been planted by bar, a check revealed that a few trees had U-roots. As many as seemed likely to have U-roots were checked and replanted properly. The men were cautioned, and it is believed that extreme care by the planters and close inspection by the

D-1 through D-8 in order. The rows were planted in numerical order with no attempt to assign any particular man to any particular row. Checking was quite close on this part of the job, and it is believed that all seedlings are accurately set to the nearest 1/4 inch. Seedlings were measured with a special stick having 1/2-inch graduations, and any seedlings found to vary more than 1/4 inch from the intended depth were replanted at the correct depth. D-3 was completed before lunch at 12:45 p.m., and the other plots were completed after lunch before 5:20 p.m.

Examinations

The plots were examined by the author on April 17, 1948. As Table 4 shows, many of the shallow-planted trees and a few of the others already were dead or dying. The second examination (See Table 5) was made after the first full growing season in February, 1949, by Robert Allen of the S.F.E.S. The total number of seedlings by treatments and vigor classes is shown in Table 5.

Analysis of Results after First Growing Season

Table 5 shows the different depth treatments on the left side and the vigor classes across the top. Column 1 shows the total number of trees planted in each class. Column 2 shows the total number of seedlings in classes 1, 2, 3, and 4; class 5 (missing) is eliminated from the calculations, and all percentages in columns 3-9 are based on totals in column 2. Columns 3-6 show total trees and percentages individually for classes 1-4. Column 7 shows totals for classes 1 and 2 (vigorous and doubtful); all trees in this grouping are conceded a chance of survival. Column 8 shows totals for classes 3 and 4 (dead and dying), the opposite of column 7; all trees in column 8 are expected to die. Column 9 shows totals of classes 1, 2, and 4 vigorous, doubtful, and dying), all trees still alive after one full growing season.

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supervisors prevented a recurrence. Unusually long roots (10-12 inches) were the chief cause of this difficulty. The trees were accepted as bundled at the nursery, and many of them had roots 10 inches long. Since the blades of the planting bars were only 10 inches long, it was difficult to make the planting slits deep enough to accommodate the seedlings; however, since the ground was soft it was possible to force the bars to the proper depths.

No complicated tests of variance are deemed justified at this time. The measure of success for any particular treatment is the number of trees that will grow to produce merchantable timber. It is quite possible that the deep-planted seedlings will never begin height growth, even though they survived one growing season. Thorough analysis will be made when a majority of the trees have started height growth.

For the present, analysis of the totals by treatments, classes, and groups of classes shown in Table 5 is deemed ample. The chi-square test of significance is used. For each test of significance it is assumed that the survival percentage of the standard treatment (R or MR) would be expected for all other seedlings except for differences in depth treatment. The survival percentage of the standard treatment is used as the basis, and variations from this are tested for significance. This test should be conclusive since the trees are either dead or alive, or they are expected to live or not expected to live. Adjusted chi-square is computed as follows (after Snedecor[1]):

$$\chi^2 = (|X_1 - m_1| - 0.5)^2/m_1 + (|X_2 - m_2| - 0.5)^2/m_2$$

Significant $\chi^2 = 3.841 +$ (5% level)

Very significant $\chi^2 = 6.635 +$ (1% level)

From Col. 7 + 8, D1½ vs. R, χ^2 is computed

$$\chi^2 = \frac{(37.5 - 78.7 + 0.5)^2}{78.7} + \frac{(62.4 - 21.3 - 0.5)^2}{21.3}$$

$$= 99.1$$

The difference is very significant; i.e., the variation in survival would not be expected by chance and is very probably due to the difference in treatments. The results of similar tests for all treatments is summarized below. Actually a glance at Table 5 indicates strong trends in survival and vigor, but the significance test adds weight to the findings.

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[1]George W. Snedecor. 1946. Statistical Methods. (Fourth edition). The Iowa State College Press: Ames, Iowa.

<u>Differences -- vigorous or doubtful and dead or dying (Col. 7 and col. 8)</u>

Not significant
$D\frac{1}{2}$ and MR vs. R

Very significant
All other treatments vs. R
MD and MS vs. MR

<u>Differences -- Living and dead (Col. 9 and col. 5)</u>

Not significant
All deep treatments and MR vs. R
MD vs. MR

Very significant
All shallow treatments vs. R
MS vs. MR

<u>Differences -- Vigorous and all other classes (Col. 3 and totals of columns 4, 5, and 6)</u>

Not significant
$D\frac{1}{2}$ and MR vs. R
MD vs. MR

Significant
MD vs. R

Very significant
$D1\frac{1}{2}$, D1, and all shallow treatments vs. R
MS vs. MR

Findings

1. Survival and vigor of longleaf pine seedlings properly set by machine does not differ significantly at the end of the first growing season from survival and vigor of seedlings set properly with a planting bar.

2. Shallow planting, even 1/2 inch shallow, very significantly reduces survival of longleaf pine at the end of the first growing season.

3. Deep planting, up to 1-1/2 inches deep, does not significantly reduce survival of longleaf pine by the end of the first growing season.

4. Planting of longleaf 1/2 inch deep does not significantly affect the vigor of the seedlings at the end

of the first growing season, probably because, with the root collar at a depth of 1/2 inch, the bud is often left uncovered, and the top of the bud may be above the ground surface. (The author observed at the time of planting that there was very little difference in appearance between correctly planted seedlings and those planted 1/2 inch deep.)

5. Planting deeper than 1/2 inch significantly reduces the vigor of longleaf pine seedlings by the end of the first growing season.

6. Wakeley[1] concludes from similar experiments with depth of setting of longleaf pine and slash pine (Pinus caribaea) in Louisiana that:

"1. Depth of setting has an important effect on initial survival.

2. If seedlings cannot be set at the exact depth at which they grew in the nursery, they should be set deeper rather than higher.

3. Except possibly under extraordinary conditions, longleaf should not be 'set up' even 1/2 inch higher than it grew in the nursery as a precaution against injury by silting."

The findings of this experiment generally verify those of Wakeley's experiments. However, the conclusions of this author (next paragraph) differ slightly with respect to point 2.

Conclusions

With skilled planters and proper supervision machine planting should compare favorably with bar planting under conditions which permit efficient operation of the machines. Within the variations in depth of setting that are common in machine planting, shallow planting of longleaf pine has a more adverse initial effect on the seedlings than deep planting. Although it is probably better practice to set

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[1] Philip C. Wakeley, 1948. Unpublished data of Southern Forest Experiment Station.

the seedlings 1/2 inch deep than 1/2 inch shallow, planting deeper than 1/2 inch cannot be recommended because it is not known whether seedlings planted with buds below the ground surface will ever start to grow in height. Several growing seasons must elapse before the final effects of setting seedlings at improper depths can be determined. Meanwhile, every effort should be made to set longleaf pine seedlings with the root collars exactly at ground level.

Table 1

TREATMENTS

Row	1	2	3	4	5	6	7	8	9	10
Block:										
D-1	D½	S1½	D1	S½	MD	MR	D1½	S1	R	MS
D-2	MR	S½	D½	S1½	S1	MD	D1½	D1	MS	R
D-3	R	D1	D1½	D½	S1	MR	S1½	MD	S½	MS
D-4	D1½	MR	S1	D½	MD	D1	MS	S1½	S½	R
D-5	MR	S1½	D1	MS	D½	S½	R	D1½	S1	MD
D-6	S½	MS	MD	D½	D1½	S1	R	S1½	MR	D1
D-7	S1	D1	MD	MR	R	S½	D½	MS	D1½	S1½
D-8	MD	MS	S1	D1	S½	S1½	R	D1½	D ½	MR

Bar-planted rows

D1½ Deep 1½ inches
D1 Deep 1 inch
D½ Deep ½ inch
R Correct depth
S½ Shallow ½ inch
S1 Shallow 1 inch
S1½ Shallow 1½ inches

Machine-planted rows

MD about 1 inch deep
MR supposedly correct depth
MS about 1 inch shallow

Table 2

ACTUAL DEPTHS OF ROOT COLLARS OF MACHINE-PLANTED TREES
ON FEBRUARY 15, 1948 (inches)

Block No.	D-1			D-2			D-3		
Row No.	5	6	10	1	6	9	6	8	10
Treatment	MD	MR	MS	MR	MD	MS	MR	MD	MS
Direction of Planting	E	W	E	N	S	N	S	N	S
Tree No. in Row									
1	D1	0	S½	0	D1	S1	0	D1	S1
2	D1½	0	S1	0	D1	S1½	0	D½	S1
3	D1½	0	S1	0	D1	S½	0	D1	S½
4	-	0	S1½	0	D1	S½	0	D1½	S1½
5	-	0	S1½	0	D2	S½	0	-	S1
6	-	0	S2	0	-	S1	0	-	S½
7	-	0	S2	0	-	S1	0	-	S1
8	-	0	S1	D½	-	S1	0	-	S1
9	D1	0	S½	0	-	S1	0	-	S1
10	-	0	S1½	0	-	S½	S½	-	S1
11	-	0	S1	0	-	S½	0	-	S1½
12	D½	0	S1	0	-	S½	0	D1	S½
13	D1½	0	S1	0	-	S½	0	D½	S1½
14	D½	0	S1½	0	-	S½	D½	-	S1½
15	-	0	S1½	0	-	S1	0	D½	S½
16	-	0	S1	0	-	S½	0	-	S1
17	-	0	S2	0	-	S1	0	D½	S1½
18	-	0	S1½	0	-	S½	S½	-	S½
19	-	0	S1	D½	-	S1½	0	-	S½
20	-	0	S2	D½	-	S1	S½	-	S1
21	-	0	S1	S½	D1½	S½	0	D1½	S½
22	-	D½	S½	0	D1	S1	0	D1½	S½
23	-	0	S½	0	D1	S1½	D½	D2	S1½
24	D2½	0	S1½	0	D1½	S1	0	D1½	X
25	-	D½	S1	0	D1½	S½	0	D1	X
26	D1½	X	S1½						
27	-	X	X						
28	D1	X	X						

Block No.	D-4			D-5			D-6			D-7			D-8		
Row No.	2	5	7	1	4	10	2	3	9	3	4	8	1	2	10
Treatment	MR	MD	MS	MR	MS	MD	MS	MD	MR	MD	MR	MS	MD	MS	MR
Direction of Planting	N	S	N	E	W	E	E	W	E	E	E	W	E	W	E
Tree No. in Row															
1	0	D1½	S½	S½	S1	-	S1	D2	0	-	0	S1	D2½	S1	0
2	0	D2	S1½	0	S½	-	S1	D1½	0	-	0	S½	D½	S½	0
3	0	D1½	S1	S½	S1	-	S½	D1½	S½	-	0	S1	D1	S1½	0
4	S½	D½	S½	0	S1½	-	S2	D1½	0	-	0	S1½	-	S1	0
5	0	D1½	S1	0	S1	D1	S1½	-	0	-	S½	S1½	-	S1½	0
6	0	-	S1	0	S1	D½	S1	-	0	-	0	S1	-	S2	0
7	D½	D½	S½	0	S1½	-	S1½	-	0	-	S½	S1½	-	S1½	0
8	0	-	S1	0	S1½	-	S1½	-	D½	-	0	S1	-	S1	0
9	S½	-	S½	0	S1	-	S1	-	D½	-	0	S½	-	S1½	0
10	0	-	S½	0	S1	D1	S1½	-	0	-	0	S1	-	S1½	0
11	0	-	S1	0	S1	D1½	S1	-	0	-	S½	S1	-	S1	0
12	0	-	S1	0	S1	-	S2	-	0	D½	0	S1	D½	S1½	0
13	0	-	S1	0	S1½	D1½	S1	D½	0	-	0	S1	-	S½	0
14	0	D½	S1½	0	S1	-	S1	-	D½	-	0	S1	-	S½	0
15	0	-	S½	0	S½	D1½	S½	-	0	-	S½	S½	-	S1	S½
16	0	-	S1	0	S½	-	S1	-	0	-	0	S1½	-	S1	S½
17	0	-	S1	D½	S1½	D1	S1½	D1	0	-	0	S1	-	S½	S½
18	0	-	S½	0	S½	-	S2	-	S½	-	0	S½	-	S1	S½
19	0	-	S½	0	S½	-	S1	-	0	-	S½	S1	-	S½	0
20	0	D½	S1	0	S1	-	S1	-	D½	-	S½	S1	0	S1	S½
21	S½	D1	S2	0	S1	-	S1½	-	D½	-	0	S1	-	S1½	0
22	0	D1½	S1	0	S½	D1½	S1	-	0	-	0	S½	-	S1	0
23	S½	D2½	S½	0	S1	D1½	S½	-	S1	-	0	S1	-	S½	0
24	0	D½	S1	0	S1½	D1	S1½	-	S½	-	0	S1	-	S1	0
25	S½	D1½	S1	S½	S2	-	S1½	X	0	-	D½	S1	-	S1	0

\- Root collars below ground surface but actual depth not checked.
0 Root collars at ground surface.
X No tree planted.

Table 3

BAR-PLANTED ROWS

(Table shows initials of planter followed by letter to indicate direction of planting.)

	Block Number							
Row No.	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-8
1	WM-W	-	WM-N	GS-N	-	GS-E	GS-E	-
2	GS-W	WM-N	GS-N	-	WM-E	-	WM-E	-
3	RM-W	RM-N	RM-N	RM-N	GS-E	-	-	GS-E
4	WM-E	GS-N	WM-S	WM-N	-	WM-E	-	WM-E
5	-	RM-S	GS-S	-	RM-E	RM-E	RM-E	RM-E
6	-	-	-	MS-N	MS-E	MS-E	MS-E	GS-W
7	RM-W	WM-S	RM-S	-	GS-W	GS-W	GS-W	ML-W
8	GS-E	GS-S	-	GS-S	RM-W	WM-W	-	WM-W
9	GS-W	-	WM-S	RM-S	WM-W	-	WM-W	RM-W
10	-	RM-N	-	WM-S	-	RM-W	RM-W	-

- indicates machine-planted row

Planters

WM - Willie C. McCardle
RM - Richard L. McCardle
GS - Garvis Seal
ML - Mack C. Lambert
MS - McClain B. Smith, Jr.

Direction

N - North
E - East
S - South
W - West

Table 4

SUMMARY OF RESULTS TWO MONTHS AFTER PLANTING

(Examination made April 17, 1948 by M. B. Smith, Jr.)

Treatment		Vigor Classes							
	(1) Total Trees	(2) 1		(3) 2		(4) 3		(5) 4	
		#	%	#	%	#	%	#	%
D1½	200	185	92.5	-	-	1	0.5	14	7.0
D1	200	184	92.0	-	-	3	1.5	13	6.5
D½	200	185	92.5	1	0.5	4	2.0	10	5.0
R	200	180	90.0	3	1.5	3	1.5	14	7.0
S½	200	139	69.5	7	3.5	22	11.0	32	16.0
S1	200	133	66.5	11	5.5	29	14.5	27	13.5
S1½	200	95	47.5	2	1.0	65	32.5	38	19.0
MD	202	193	95.5	1	0.5	1	0.5	7	3.5
MR	200	166	83.0	10	5.0	7	3.5	17	8.5
MS	199	87	43.7	15	7.5	55	27.6	42	21.1

Treatments

Bar planting
- D1½ Deep 1½"
- D1 Deep 1"
- D½ Deep ½"
- R Correct setting
- S½ Shallow ½"
- S1 Shallow 1"
- S1½ Shallow 1½"

Machine planting
- MD about 1" deep
- MR supposedly correct depth
- MS about 1" shallow

Vigor Classes

1 Vigorous - green
2 Doubtful - yellow
3 Dead - brown
4 Dying - 1/2 brown

Table 5

SUMMARY OF RESULTS AFTER FIRST GROWING SEASON
(Examination made in February 1949 by Robert Allen)

Treatment	(1) Total Trees	(2) Total 1,2,3,4	Vigor Class (3) 1 #	(3) 1 %	(4) 2 #	(4) 2 %	(5) 3 #	(5) 3 %	(6) 4 #	(6) 4 %	(7) 1-2 #	(7) 1-2 %	(8) 3-4 #	(8) 3-4 %	(9) 1-2-4 #	(9) 1-2-4 %
D1½	200	189	63	33.3	8	4.2	42	22.2	76	40.2	71	37.5	118	62.4	147	77.8
D1	200	193	101	52.3	6	3.1	39	20.2	47	24.3	107	55.4	86	44.6	154	79.8
D½	200	197	134	68.0	13	6.6	32	16.2	18	9.1	147	74.7	50	25.3	165	83.8
R	200	193	128	66.3	24	12.4	40	20.7	1	0.5	152	78.7	41	21.3	153	79.3
S½	200	192	86	44.8	25	13.0	79	41.1	2	1.0	111	57.8	81	42.2	113	58.9
S1	200	190	82	43.1	28	14.7	77	40.5	3	1.6	110	57.9	80	42.1	113	59.5
S1½	200	190	64	33.7	17	8.9	107	56.3	2	1.1	81	42.6	109	57.4	83	43.7
MD	202	197	109	55.3	11	5.6	33	16.7	44	22.3	120	60.9	77	39.1	164	83.3
MR	200	198	118	59.6	36	18.2	43	21.7	1	0.5	154	77.8	44	22.2	155	78.3
MS	199	196	59	30.1	19	9.7	116	59.2	2	1.0	78	39.8	118	60.2	80	40.8

Treatments

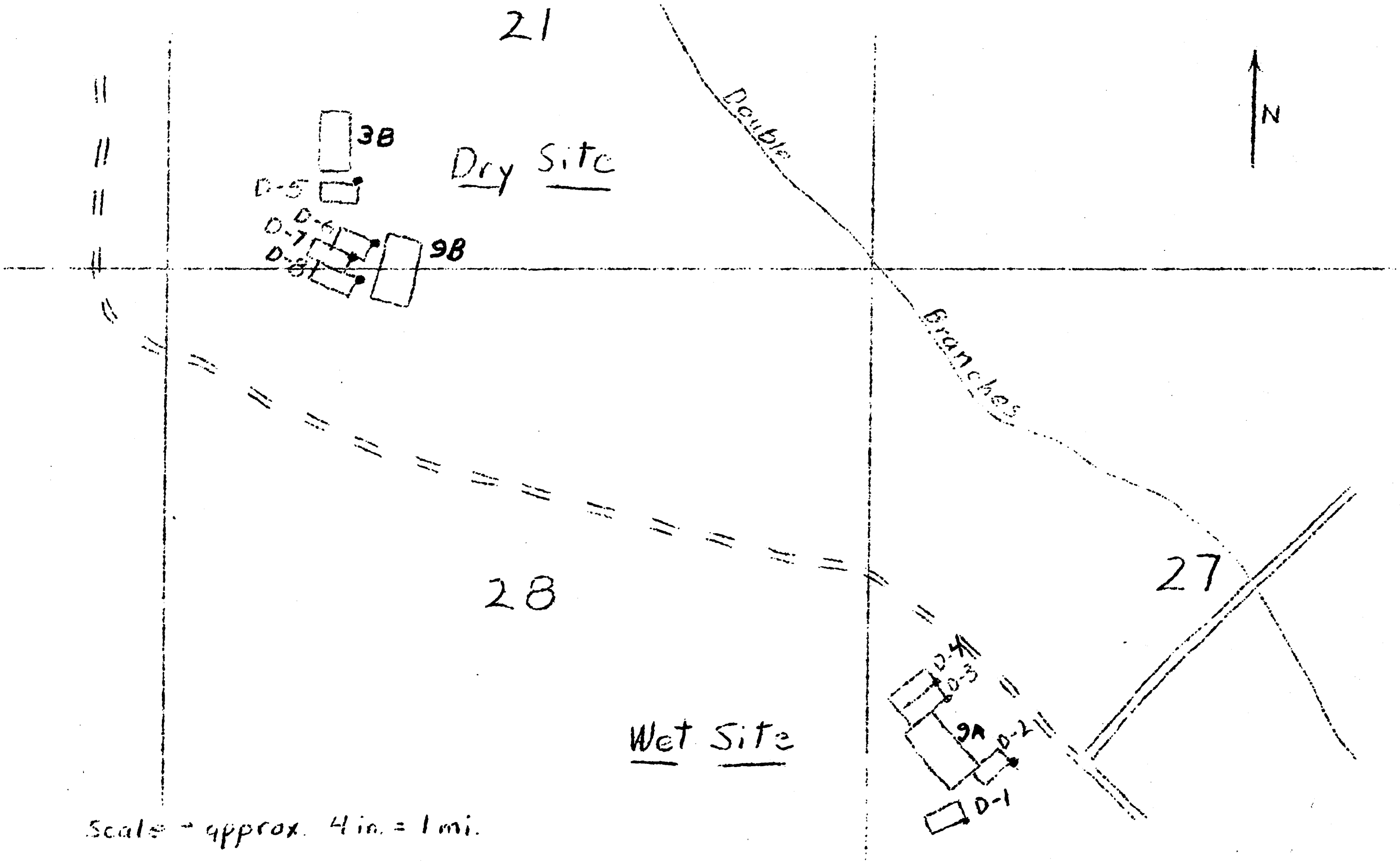
Bar planting
- D1½ Deep 1½"
- D1 Deep 1"
- D½ Deep ½"
- R Correct setting
- S½ Shallow ½"
- S1 Shallow ½"
- S1½ Shallow 1½"

Machine planting
- MD about 1" deep
- MR supposedly correct depth
- MS about 1" shallow

Vigor Classes

1 Vigorous - green
2 Doubtful - yellow
3 Dead - brown
4 Dying - 1/2 brown
5 Missing

Sketch Map to Show Location of Depth Experiment Blocks
Leaf River Ranger District, DeSotó National Forest
Forrest County, Mississippi St. Stephens Meridian



3B, 9A, & 9B - S.F.E.S. Plots
• Posts on Depth Experiment Blocks

M. B. Smith, Jr.
June 5, 1948

Seedling Setter

For Use with Slightly Modified Lowther Standard Planting Machine

Copies of the following sketches[1] and explanatory material were submitted to the Harry A. Lowther Company by the author. They are results of work the author has done in an attempt to improve the quality and increase the speed of planting with machines with which he carried on extensive field planting for the U. S. Forest Service in Mississippi.

Problem

It is difficult to set seedlings, especially longleaf pine seedlings, at the proper depth quickly and accurately. Many longleaf seedlings are lost with hand setting on the machine when they are set too deep or too shallow. The machine must proceed at low speed to permit the planter to set the trees accurately.

Proposed Solution

It is proposed with the seedling setter, described below and sketched in the accompanying drawings, to set the trees quickly and accurately by machine. It is believed that such a device would increase accuracy of setting from an average of 70 or 90 percent to 95 percent, and, more important, that it would double the planting speed.

Summary of Design and Operation[2]

Briefly the seedling setter consists of a double sheet metal frame supporting eight sprockets on which run a pair of chains lined on the inside with rubber tubing. The planter places a seedling upside down in a guide where the two chains converge to grasp the tree. The tree is

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[1] Sketches accompany only the first three copies of this report.

[2] The seedling setter is not actually in existence, but is described here as if it were.

carried around the two forward sprockets, the roots entering the trench. As the chains reach the level of the ground, their motion relative to the ground ceases, i.e., the principle of operation is the same as that of a tractor tread. The tree is held in the trench by the chain until the forward motion of the main planting machine closes the trench and packs the soil around the roots. As the packing wheels clear the tree, the chains diverge to release their grasp on the tree. The chains continue separated around the two pairs of rear sprockets until they converge again just beneath the guide to grasp another tree.

What advantage has this chain device over a similar device with a wheel? Different soils and different spots on the same site are of such varying nature that the point of closure of the trench varies from an inch or two behind the trencher to a point immediately between the packing wheels. A wheel setter would come in contact with the ground at only one point, and it would have to release the tree at this point. If the trench closed too soon, the tree would be torn from the wheel, possibly damaged, and set too high. If the trench closed too late, the tree would be dropped into the trench at a deep setting if it stood upright at all.

The chain setter holds the tree at the proper setting for 12 inches from the point where it enters the trench to the point where it is released immediately behind the packing wheels. The only drawback in the use of such a device, if it could be manufactured, would be the cost. However, depreciation and maintenance of the planting machine make up not more than 10 percent of the cost of planting, and even if the machine cost twice as much with this device included, the better survival and faster planting would easily make the setter worth the added initial investment in equipment. The planter should be able to set the trees in the guide at least twice as fast as he can set them in the ground because, in the latter case, he must lean over to place the tree in the planting box, move it to the rear, gauge the depth by eye, and hold the tree until it is grasped by the soil. Using the setter, the planter merely grasps a seedling, sets it in the guide slot, and lets go immediately.

Details of Design and Operation

Figures 1, 2, and 3 are sketches of three views, at a scale of approximately one square per inch, of the standard Lowther planting machine and the seedling setter. These three figures are intended to show only the relationship between the parts of the planting machine and the setter. Not all parts are shown. The standard machine parts are shown in pencil. The seedling setter parts are shown in red. The only intended change in the standard Lowther machine involves modification of the rear end of the frame. The relationship between the various planting parts of the standard Lowther machine is not to be changed, although changes may have been made inadvertently in the sketches, since accurate drawings of the machine were not available. To avoid complicating the sketches the planter's seat is not shown. It is suggested that the seat be set at an angle astride the right rear frame so that, facing the left front, the planter could rest one foot just over the right packing wheel on a rest projecting from the bar holding the packing wheel, and the other foot on a similar rest outside the frame. In this position he could reach trees from the tree box at his left rear and place them in the setter guides. The frame could be extended to the rear if necessary to provide more room for the planter. It is suggested that the seat be mounted on a stiff spring which would absorb some of the shocks of high-speed operation without allowing the planter to bounce sufficiently to prevent accurate setting. The frame holding the setter assembly and the gears driving the chains on each side are not shown.

Figure 1 - Top view; tree box and setter guides not shown.

Figure 2 - Side view

Figure 3 - Rear view showing only the rear parts of the standard machine; depth setter draw bar is not shown.

Figure 4 shows a type of chain which might be made to bend in two planes if none of the available chains were capable of making the sharp turns required. The shaded portion is a lengthwise section of rubber tubing attached to the button on the large link of the chain.

Figure 4a - Top view of separate pieces of chain about 1-1/2 times actual size.

Figure 4b - Side view of 4a.

Figure 4c - Top view of linked chain about 1/2 actual size.

Figure 4d - End view of large link to show attachment of rubber tubing (about 1/2 actual size).

Figures 5, 6, 7, and 8 are detailed sketches respectively of side, top, rear, and front views of the seedling setter at a scale of approximately two squares per inch.

Only the relevant planting machine parts are shown, and not all setter parts are shown in each figure. Colors explained in the legend are used to make some of the parts stand out more clearly. The parts are numbered to correspond to numbers used in the discussion which follows.

The frame (1) of the setter is supported at the front by the depth gauge wheels (2) and at the rear by a bar (3), which rests on the flange of the beam (4) of the main machine frame. The depth gauge wheels are set wide to avoid disturbance by the raised sides of the planting trench. The axles (5) of the depth gauge wheels and the rear support bar (3) should be mounted with a screw device to permit minor adjustments. (Such adjustments might not be necessary.) The sprockets (shown in ink) are mounted on roller bearings on axles attached to the setter frame (1). To make them stand out clearly the sprockets are shown wider than they would actually be. The chain, sprockets, and frame could all be made narrower than shown on the sketches; they are shown in these wide positions for clarity in the small-scale sketches. The top forward sprockets (6) on each side should be mounted with a screw device to adjust the tension of the chains (green).

The whole setter is towed along with the machine by draw bars (7), on each side, attached around the axles of the depth gauge wheels at 8 and to the frame (4) of the main planting machine by a pin at 9. The two halves of the frame are held together by metal bars (10, brown) welded to the setter frame halves. Each frame half is bent along a line (11), with the pivot rollers (red) at each end of the bend line.

Power for driving the chain (green) is obtained from a gear (12) attached to the right depth gauge wheel (2) and concentric with, but free of, the axle (5). This gear is connected with a gear (13) by a gear linkage (not shown), so designed that the chain is driven at a speed exactly the same as that of the planting machine, so that there is no relative motion between the ground and the portion of the chain at the bottom of the cycle, nearly in contact with the ground. The gear (13) is mounted on a rolling axle, which is also the axle for the right lower forward sprocket. No cogs are shown on any of the sprockets and no gear teeth are shown on any of the gears.

The left chain is driven by the right chain through gears with angled teeth on an axle (14) extending from one side of the setter frame to the other. These gears and the axle are not shown in Figure 6. The angle-toothed gears are connected to gears (15) concentric with, and attached to, the top rear sprockets. This point of transferring power from the right to the left chain is the only point where the cross axle (14) will not interfere with the movement of the seedlings. It is necessary that the chains on each side be driven by the same source of power so that they will both move at exactly the same speed.

The planter grasps a tree with his fingers at the root collar and inserts it, upside down, in the chain by moving his hand forward along the slotted guide (16, orange). The guide consists of two flat metal plates attached to the setter frame (1, brown) just above the pivot rollers (red), so that there is a one-inch slot between the two plates. The top of the plates is at the same distance above the top of the chains that the ground is below the bottom of the chains, so that if the seedling is properly placed in the guide slot, it will be set at exactly the proper depth in the ground. The guide plates should be mounted on screws to permit minor adjustments. The chains are converged by the top pivot rollers, so that the chains grasp the tree firmly to convey it to the planting trench. The chains are diverged around the bottom pivot rollers to release the tree immediately after the packing wheels (17) have packed the soil about the roots. The chains are lined on the inside with rubber tubing, which is not shown in Figures 5, 6, 7, or 8. Figure 9 (cross-sectional views) shows how the rubber tubing grasps the seedlings. Figure 9a shows the position of the tubing without a seedling. Figure 9b shows how the tubing grasps a thin-topped seedling. Figure 9c shows hot it adjusts to grasp a thick-topped seedling. Figure 5 shows seedlings (18) in various positions in the setter, and planted as well (19).

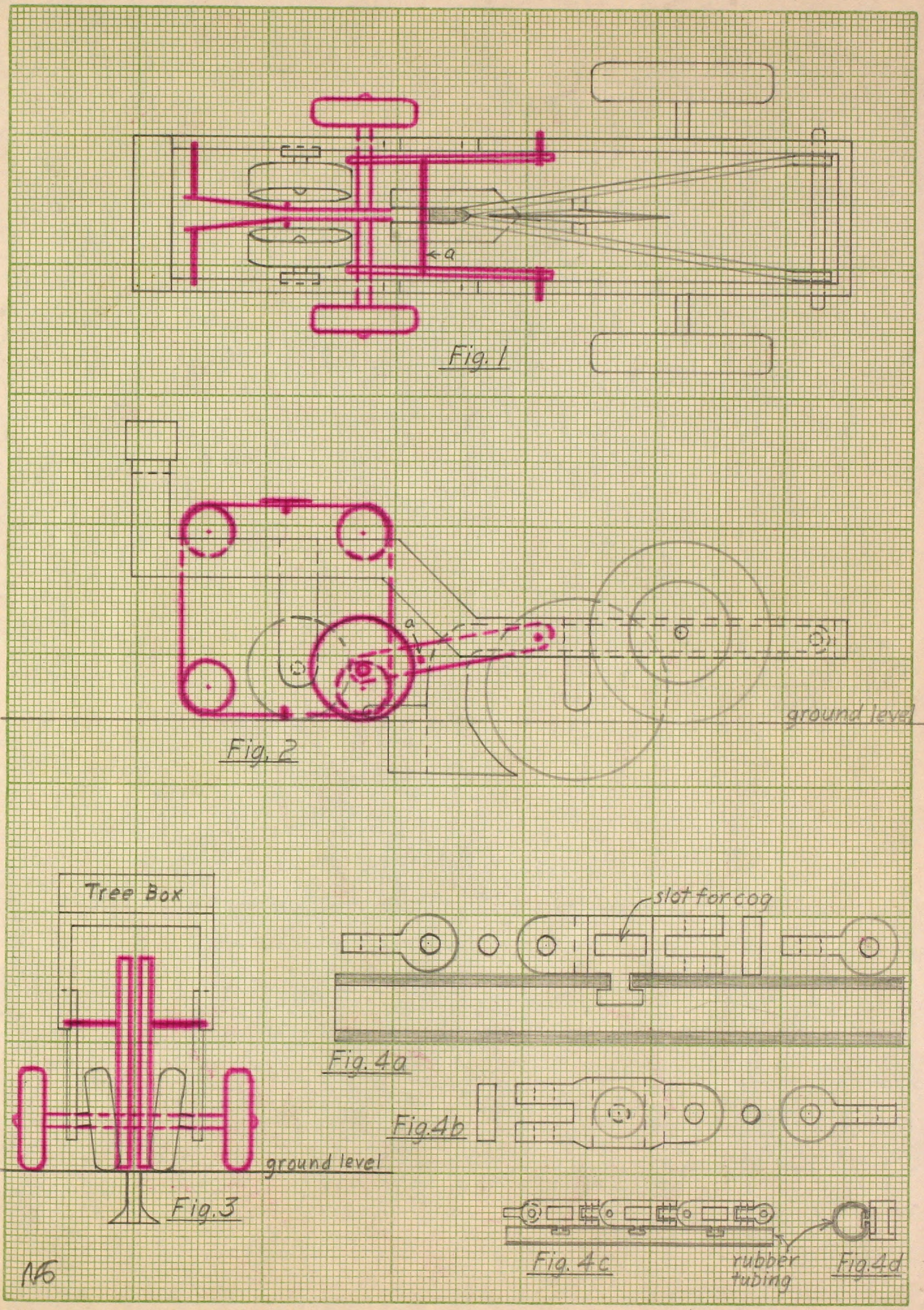
A lift bar (a on Figures 1 and 2; not shown on other sketches), connecting the two draw bars (7) enables the setter to be lifted above the ground on top of the trencher guides as the trencher assembly is raised. This feature protects the setter against injury. If necessary, a stop bar (20, Figure 5) could be provided so that the back end of the setter would be lifted. It might be necessary to cut a slot out of the machine frame beam just above the rear support bar (3) to allow the support bar to pass through the flange of the beam when the setter is raised.

It might be more feasible to use a second pair of depth gauge wheels to support the rear end of the setter instead of supporting it on the support bar (3).

It might be necessary to increase the distance between the bottom of the chain and the ground, increasing the distance between the top of the chain and the planting guides (16) by the same amount.

SEEDLING SETTER

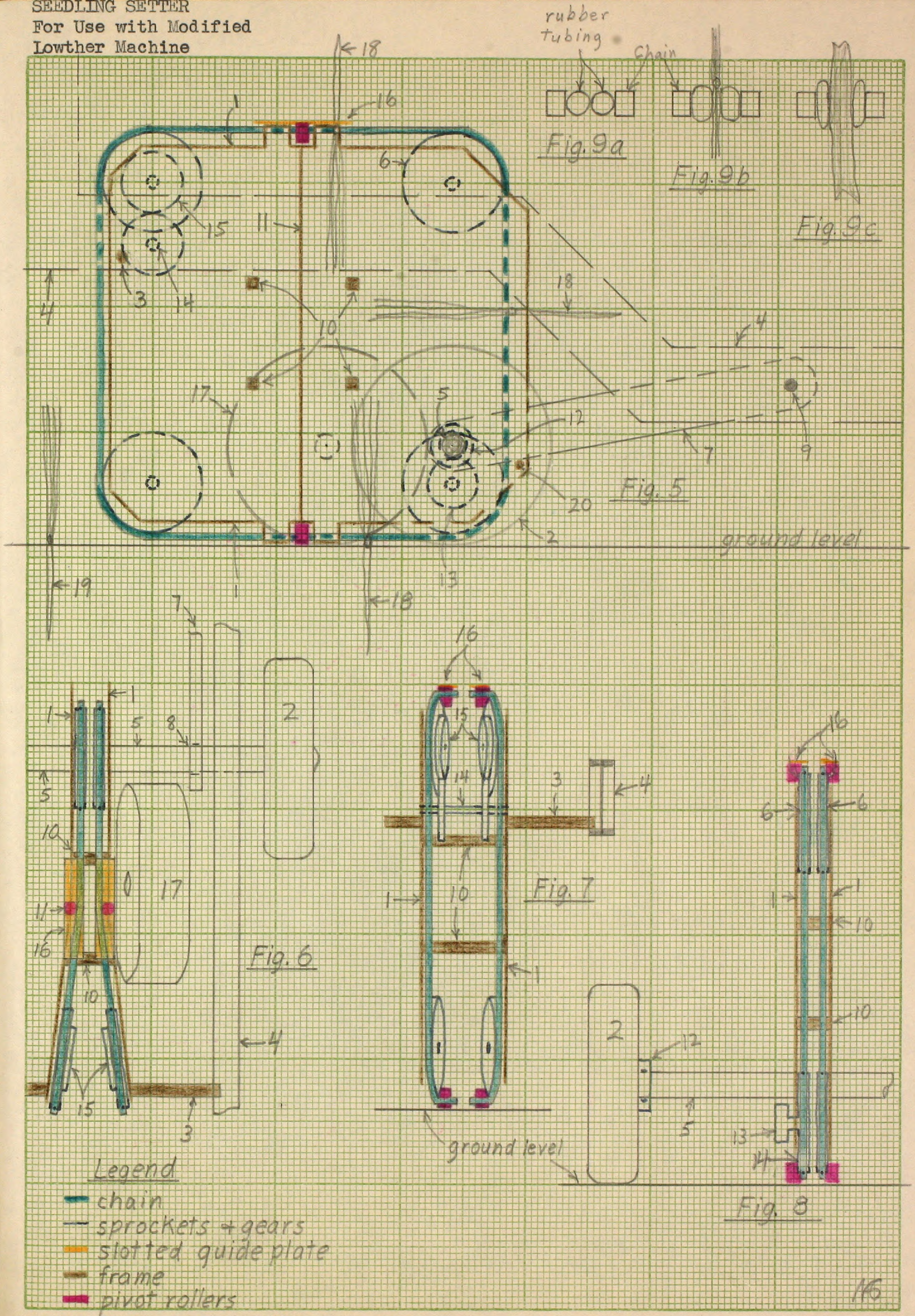
For Use with Modified Lowther Machine



Drawn by McClain B. Smith, Jr.

April 28, 1949

SEEDLING SETTER
For Use with Modified
Lowther Machine



Drawn by McClain B. Smith, Jr.   April 28, 1949

BIBLIOGRAPHY

Anon. 1948. Hillside planter levelled with hydraulic system. Forestry News. S.A.F. Washington, D. C., Vol. 3, No. 9, p. 8

Anon. 1946. Machine plants 9,000 seedlings in eight hours. West Coast Lumberman. 73(9):66,102.

Anon. 1948. Mechanical planting cheaper. Forestry News. S.A.F., Washington, D. C. Vol. 3, No. 11, p. 6.

Anon. 1931. New machine eliminates much labor from forest planting. Forest Leaves 23:28-29.

Anon. 1947. New tree planter. Southern Lumberman 175(2195-Sept.):64.

Anon. 1946. No squat, no stoop with mechanical tree planter. Pop. Sci. 148:98-99.

Anon. 1945. Tillamook planting scheduled. Timberman 47 (Nov. 1945):112.

Anon. 1930. Tree planting machine cuts planting cost in half. Jour. For. 28:1004-1005.

Anon. 1942. U.S. Forest Service devises tree planting machine. Jour. For. 40:60.

Ashe, Harold J. 1946. Trees planted from air. Nation's Business 34 (Jan.):97.

Bauch, G. David. 1944. An experiment on the effect of root pruning on planted coniferous stock. Unpublished master's thesis on file in Forestry Library, University of Michigan.

Baxter, Dow V. 1943. Pathology in forest practice. New York:John Wiley & Sons, Inc.

Bruhn, H. D. and F. B. Trenk. 1947. The fundamentals of mechanical tree planter design and performance. Agricultural Engineering 28:387-390, 396.

Cheyney, E. G. 1927. The effect of position of roots upon the growth of planted trees. Jour. For. 25:1013-1015.

Davis, J. E. 1947. New Lowther tree planting machine. Jour. For. 45:746-8.

Duchaine, William J. 1949. Tree planting machines. Amer. For., Vol. 55, No. 4, pp. 23,40.

Emerson, Arthur W. 1946. Soil conservation tree planters ready for commercial production. Mechanization Manual So. Pulpwood Cons. Assoc., No. 5, 4pp.

Erwin, Robert L. 1948. Machine plants trees on the contour. Ohio Farm and Home Research, Vol. 33, No. 254, pp. 152-155.

Hepting, George H. and Albert A. Downs. 1944. Root and butt rot in planted white pine at Biltmore, North Carolina. Jour. For. 42:119-123.

Hesselschwerdt, R. E. 1948. The Lowther planting machine. Illinois Wildlife, Vol. 3, No. 4, p. 4.

Hardee, Jay H. Mechanical tree planting in the sandhills of North Carolina. Jour. For. 46:608-609.

Jackson, Lora Z. 1944. Planting a tree a second. Amer. For. 50:170, 191, 192.

Joiner, Dick. 1948. Asiatic shrub seen perfect game refuge. Chicago Daily Tribune. Jan. 7, p. 29.

Knapp, G. E. 1946. Gair Woodlands planting operation testing Syracuse forestry plow. Mechanization Manual. So. Pulpwood Cons. Assoc., No. 7, 2pp.

Knapp, G. E. 1946. Lowther tree planter. Mechanization Manual. So. Pulpwood Cons. Assoc., No. 21, 3pp.

Knapp, G. E. 1946. Valdosta tree planter. Mechanization Manual So. Pulpwood Cons. Assoc., No. 3, 2pp.

N.Y. Cons. Dept., Albany. 1931. 20th Annual Report for 1930, pp. 95-100.

Powell, Grant M. 1948. A tree planting spade for a crawler tractor. Jour. For. 46:278-281.

Priaulx, Arthur W. 1946. Tree planter. Amer. For. 52: 120-121, 138, 139.

Rudolf, Paul O. 1937. Lessons from past forest planting in the Lake States. Jour. For. 35:72-76.

Rudolf, Paul O. 1947. Machines for forest planting. Canadian Pulp and Paper Assoc., Woodlands Sect. Index, No. 943(F-2).

Schantz-Hansen, T. 1945. The effect of planting methods on root development. Jour. For. 43:447-448.

Snedecor, George W. 1946. Statistical methods. (Fourth edition). The Iowa State College Press: Ames, Iowa.

Stevens, T. D. and L. E. Bell. 1946. Michigan State College reforestator. Mechanization Manual So. Pulpwood Cons. Assoc., No. 6, 3pp.

Toumey, James W. and Clarence F. Korstian. 1937. Foundations of silviculture upon an ecological basis, second edition. New York: John Wiley & Sons, Inc.

Toumey, James W. and Clarence F. Korstian. 1942. Seeding and planting in the practice of forestry, third edition. New York: John Wiley & Sons, Inc.

Trenk, F. B. and H. D. Bruhn. 1947. Design and use of mechanical tree planters. Jour. For. 45:408-413.

Trenk, F. B. and H. D. Bruhn. 1947. Homemade tree planter saves time and labor. Pop. Mechanics, Vol. 83, No. 129 (April), p. 129.

Wakeley, Philip C. 1935. Artifical reforestation in the southern pine region. U.S. Dept. of Agriculture. Tech. Bul. 492, 114pp.

Williams, R. A. 1944-45. A quarter-billion trees against the wind. Timberman 46 (6) (April 1945): 62-63, 65.

Young, Leigh J. 1928. Growth and cultural experiments on the Saginaw Forest. Papers of the Michigan Academy of Science Arts and Letters, Vol. IX, pp. 541-594.