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# Evaluation of The Marden Model 200 Spot Planter



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# **Evaluation of The Marden Model 200 Spot Planter**

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## CONTENTS

|   | <u>Page No.</u> |
|---|-----------------|
| INTRODUCTION .....                        | 1               |
| EQUIPMENT DESCRIPTION AND OPERATION ..... | 1               |
| SITE DESCRIPTION .....                    | 3               |
| DATA COLLECTION .....                     | 3               |
| PERFORMANCE OF MARDEN MODEL 200 .....     | 3               |
| CONCLUSIONS .....                         | 8               |
| RECOMMENDATION .....                      | 8               |
| LITERATURE CITED .....                    | 8               |

## ILLUSTRATIONS

| <u>Figure No.</u> |   | <u>Page No.</u> |
|-------------------|---|-----------------|
| 1                 | Marden Manufacturing Company's self-contained hydraulic system spot planter, Model 200 .....  | 1               |
| 2                 | Model 200 planting on the Modoc National Forest .....   | 1               |
| 3                 | Model 200 planting on the Superior National Forest .....  | 1               |
| 4                 | The sharp angle of the packing wheel of the Model 200 was rounded off as shown in an attempt to improve packing and reduce the depression alongside the seedlings ..... | 5               |
| 5                 | Model 200 equipped with narrower packing wheel with a flatter angle .....   | 5               |
| 6                 | Original packing wheel made narrower by cutting off 2½ in (6.4 cm) .....  | 5               |

## TABLES

| <u>Table No.</u> |  | <u>Page No.</u> |
|------------------|--|-----------------|
| 1                | Marden Model 200 Spot Planter specifications ..... | 1               |
| 2                | Summary of tree planter operations .....           | 2               |
| 3                | Type and size of seedlings .....                   | 3               |
| 4                | Tree-planting quality results .....                | 4               |
| 5                | Field evaluation reliability failure summary ..... | 7               |

**INTRODUCTION**

Evaluation of the Marden Manufacturing Company, Inc., Model 200 Spot Planter (fig. 1) was conducted during April and May 1983 on the Big Valley Ranger District, Modoc National Forest, California, and the La Croix Ranger District, Superior National Forest, Minnesota. Two locations were used in order to evaluate the tree planter on different soil types. This *Project Record* provides USDA-Forest Service field units with operational characteristics and capabilities of the Marden intermittent-furrow tree-planting machine.

Past experience has shown machine tree planters reduce tree-planting costs and result in more successful and more uniform planting. Intermittent-furrow tree-planting machines should also cause less ground disturbance (resulting in lower soil erosion potential) and result in a planted site with a more natural, hand-planted look; require less intensive site preparation; and require lower energy inputs to reforest because there is no continuous furrow.

**EQUIPMENT DESCRIPTION AND OPERATION**

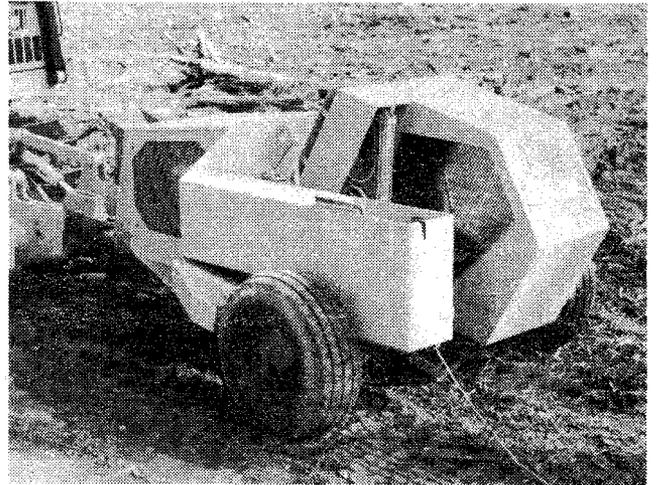
The Model 200 is a towed, single-row, intermittent-furrow, tree-planting machine (table 1 and figs. 1, 2, and 3) that has its own self-contained power system.

This tree planter is designed such that the only attachment to the prime mover is the tree planter drawbar. The self-contained power unit is powered by a 26-hp air-cooled diesel engine. With this feature, no special hydraulic power requirements has to be provided by the prime mover. This enables the planter to start work almost immediately after arriving on the planting site because no special equipment preparation time is required. The planting arm with the

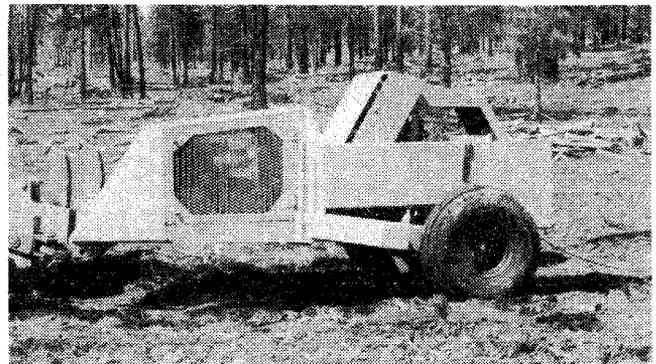
**Table 1. Marden Model 200 Spot Planter specifications**

Dimensions:

|  |                           |
|--|---------------------------|
| Overall length . . . . .                         | 12 ft 7 in (3.83 m)       |
| Height . . . . .                                 | 5 ft 8 in (1.73 m)        |
| Width (with wheels) . . . . .                    | 8 ft 2½ in (2.5 m)        |
| Wheels . . . . .                                 | 11 x 16.1                 |
| Tires . . . . .                                  | 14 x 16.1                 |
| Weight . . . . .                                 | 6,300 lb (2,850 kg)       |
| Hydraulic power system (on-board self-contained) |                           |
| Engine (2 cylinder, air-cooled) . . . . .        | Murphy<br>Model 302-2 MWM |
| Horsepower . . . . .                             | 26 hp @ 2,400 rpm (19 kW) |
| Hydraulic pump . . . . .                         | 16 gpm (60-1) @ 2,400 rpm |
| Hydraulic oil reservoir capacity . . . . .       | 40 gal (150-1)            |



**Figure 1. Marden Manufacturing Company's self-contained hydraulic system spot planter, Model 200.**



**Figure 2. Model 200 planting on the Modoc National Forest.**



**Figure 3. Model 200 planting on the Superior National Forest.**

planting dibble is hydraulically operated. The ejection of the seedlings into the furrow is also hydraulically operated.

The planter operator sits in the planter facing rearward. The operator manually loads a seedling into nylon planting fingers, depresses a foot switch that operates a solenoid

hydraulic valve causing the planting arm, with the dibble and packing wheel, to move downward. As the planter moves forward, the hollow dibble forms a furrow into which the seedling is planted. The ejector cylinder is triggered when the packing wheel comes in contact with the ground. A spring is depressed on the packing wheel mount of the

**Table 2. Summary of tree planter operations**

| Date                 | Trees planted (attempts) | Planting time | Planting rate (seedlings/hr) | Number of breakdowns/adjustments over 10 min | Repair or adjustment time | Remarks  |
|----------------------|--------------------------|---------------|------------------------------|--|---------------------------|--|
| <b>Modoc</b>         |                          |               |                              |  |                           |  |
| 4/11/83<br>Monday    | 1,272                    | 2 hr 8 min    | 524                          | 1  | 15 min                    | At start-up, 42 min planting and adjusting machine not included in planting time           |
| 4/13/83<br>Wednesday | 2,629                    | 4 hr 15 min   | 618                          | 2  | 1 hr 43 min               | One 12-min adjustment and 16 other adjustments of 10 min or less                           |
| <b>Superior</b>      |                          |               |                              |  |                           |  |
| 5/10/83<br>Tuesday   | 1,487                    | 2 hr 32 min   | 541                          | 2  | 29 min                    | Two adjustments and finger replacement. Two other adjustments at 10 min or less            |
| 5/11/83<br>Wednesday | 2,561                    | 4 hr 39 min   | 571                          | 3  | 42 min                    | Stuck two times for 48 min not included in planting time                                   |
| 5/14/83<br>Saturday  | 3,006                    | 3 hr 22 min   | 892                          | 3  | 2 hr 15 min               | Starter failure  |
| 5/17/83<br>Tuesday   | 4,275                    | 5 hr 13 min   | 819                          | 1  | 15 min                    | —  |
| 5/18/83<br>Wednesday | 6,240                    | 7 hr 55 min   | 788                          | —  | —                         | One short stop to let hydraulic oil cool   |
| 5/19/83<br>Thursday  | 4,797                    | 7 hr 39 min   | 627                          | —  | —                         | Two adjustments and hydraulic oil temperature reached 200° F. Stopped to allow oil to cool |
| 5/20/83              | 913                      | 59 min        | 928                          | 1  | 1 hr                      | Starter failure  |
| <b>TOTALS</b>        |                          |               |                              |  |                           |  |
| 7 days               | 27,202                   | 38 hr 42 min  | 702                          | 13   | 6 hr 39 min               |  |

planting arm. This operates a switch that in turn activates a solenoid hydraulic valve that controls the ejector cylinder. This takes place when the dibble is at planting depth. The foot switch is held down until the packing wheel rolls past the planted seedling. When the foot switch is released, the planting arm and packing wheel lift and return to the load position. Total cycle time to load, lower the planting arm, eject, pack the seedling, and return the planting arm to the load position is 3½ to 4 seconds.

On the Modoc National Forest, California, a J.I. Case 1450B crawler tractor was used to pull the planter. On the Superior National Forest, Minnesota, a John Deere 450B crawler tractor was used.

### SITE DESCRIPTION

The tree-planting site on the Modoc National Forest was burned by wildfire in August 1977. A salvage sale and harvest was carried out in 1978 and in early 1983, the area was double-disked to eliminate grass in preparation for tree planting. The area was nearly level with only 2 to 3 percent slopes. This is a site of low rainfall, 20 to 25 in (50 to 63 cm) per year. Soil moisture was not near field capacity.

The tree-planting site on the Superior National Forest was harvested in 1972. Aspen, 1- to 2-in (2.5 to 5-cm) DBH, was growing on the site when it was single-drum roller-chopped in September 1982. At the time of planting,

the soil was very moist and some areas were near field moisture capacity.

### DATA COLLECTION

Planting time, planting quality data, repair time, other downtime, and number of seedlings planted were collected for each of the 7 days the tree planter was operated (see table 2).

### PERFORMANCE OF MARDEN MODEL 200

The criteria for performance is stated, followed by a discussion of the degree the planter meets the criteria.

1. Ability to plant both bare-root and most containerized stock, one or two rows at a time. When bare-root stock is planted, protection from roots drying out must be provided.

The Marden Model 200 is a single-row machine. The manufacturer has a containerized seedling attachment, but it was not used during this field evaluation because no containerized stock planting was done. See table 3 for information on type and size of seedling planted.

The planter has a large seedling storage compartment (4.8 ft<sup>3</sup> or 0.13 m<sup>3</sup>) on the left rear near the planter operator's compartment. During planting,

Table 3. Type and size of seedlings

| Type                                      | Stock |                    | Shoot length                | Root length                 |
|---|-------|--------------------|-----------------------------|-----------------------------|
| <b>Modoc National Forest</b>              |       |                    |                             |                             |
| Jeffery Pine<br>( <i>Pinus jeffreyi</i> ) | 2-0   | Range              | 6 to 13 in<br>(15 to 33 cm) | 7 to 12 in<br>(18 to 30 cm) |
|   |       | Mean               | 9.4 in (24 cm)              | 9.1 in (23 cm)              |
|   |       | Standard deviation | 2.2 in (5.6 cm)             | 1.2 in (3 cm)               |
| <b>Superior National Forest</b>           |       |                    |                             |                             |
| Jack Pine<br>( <i>Pinus banksiana</i> )   | 3-0   | Range              | 5 to 9 in<br>(13 to 23 cm)  | 3 to 6 in<br>(8 to 15 cm)   |
|   |       | Mean               | 6.5 in (16.5 cm)            | 5 in (12.7 cm)              |
|   |       | Standard deviation | .8 in (2 cm)                | 1 in (2.5 cm)               |
| White Spruce<br>( <i>Picea glauca</i> )   |       |                    |                             |                             |

seedlings were stored in this compartment in nursery bags and then transferred to the operator's compartment. As with most other planting machines, the method used to prevent the seedling roots from drying out is the responsibility of the operator.

2. Capable of planting from 700 to 1,800 seedlings per hour in hilly, rocky terrain that is strewn with logging debris, where intensive site preparation has not been done. In addition, the planter must be able to operate in muddy conditions. Also, seedling spacing as close as 5 ft (1.52 m) is desired.

The average production rate of the planter for the 7 days of use on both Forests was 702 seedlings/hr of planting time. Instantaneous production rates were measured at 691 seedlings/hr on the Modoc and 1,125 seedlings/hr on the Superior. The reason for the difference was because the tree spacing on the Modoc within rows was 10 ft (3 m), while on the Superior, the spacing within rows was the closest spacing possible, approximately 7.4 ft (3.3 m). Also, the prime mover speed on the Superior was faster at 1.82 mph (2.93 km/hr) vs. 1.48 mph (2.38 km/hr) on the Modoc. Site preparation was intensive on the Modoc. On the Superior, site preparation was not intensive as the ground was almost covered with small diameter (1 to 2 in [2.5 to 5 cm]) aspen. The site was muddy. The tractor and planter became stuck in the mud several times, causing a loss in production time.

The mud also caused packing problems around the seedlings.

The closest spacing that could be achieved with the planter when traveling at 1.8 mph (3 km/hr) was 7.4 ft (3.3 m). The reason for this is the dibble must stay in the ground longer than is required to plant the seedling. The packing wheel is mounted on the planting arm and the packing wheel must roll past the seedling and pack it before the planting arm can be raised.

3. Consistently plant the seedling 10-in (25-cm) deep with 75 percent of the seedling's root collar between ground level and 1 in (2.5 cm) below the ground; when planting bare-root stock, the seedling should be inserted vertically (not more than a 30-degree lean, 25 percent of the time) with no "J" roots (25 percent or less). There should not be more than 20 percent skips or no-plant. Overall successful planting should be 75 percent or greater.

The criteria deals with planting quality and successful planting. Table 4 shows percentages of successful and unsuccessful planting and cause or contributing cause(s) of unsuccessful planting attempts.

Quality was a great concern to the Forest silviculturists. On the Modoc, the Marden Model 200 plantings were inspected by qualified forestry technicians using the same inspection procedures as hand-plantings. The plantings received a planting quality rating of 46 percent. For a

**Table 4. Tree-planting quality results**

| Sample size (attempts)                              | Percent successful | Percent unsuccessful | Cause or contributing causes of unsuccessful attempts (%) |                    |                 |       |                 |
|---|--------------------|----------------------|---|--------------------|-----------------|-------|-----------------|
|   |                    |                      | No tree planted   | Inadequate packing | Lean (over 30°) | Depth | "J" or "L" root |
| <b>Modoc National Forest</b>                        |                    |                      |   |                    |                 |       |                 |
| 30  | 47                 | 53                   | 33  | 0                  | 10              | 0     | 7               |
| <b>Superior National Forest</b>                     |                    |                      |   |                    |                 |       |                 |
| 40  | 55                 | 45                   | 5   | 10                 | 18              | 13    | 10              |
| <b>Combined Modoc and Superior National Forests</b> |                    |                      |   |                    |                 |       |                 |
| 70  | 51                 | 49                   | 17  | 6                  | 16              | 7     | 10              |

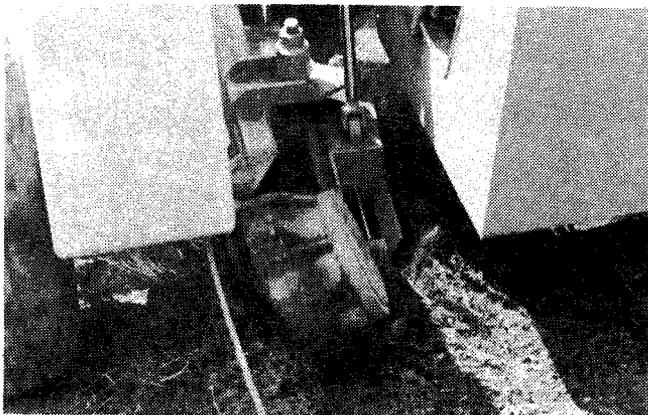
hand-planting contractor to receive payment for tree planting, a rating of 90 percent or more must be achieved. The Modoc silviculturists were not pleased with the planting quality and did not want to continue planting. Tree planting was discontinued after 2 days.

On the Superior, after four separate inspections by Forest personnel of a total of 622 planting attempts, 76 percent were considered successful, meeting the criteria of 75 percent.

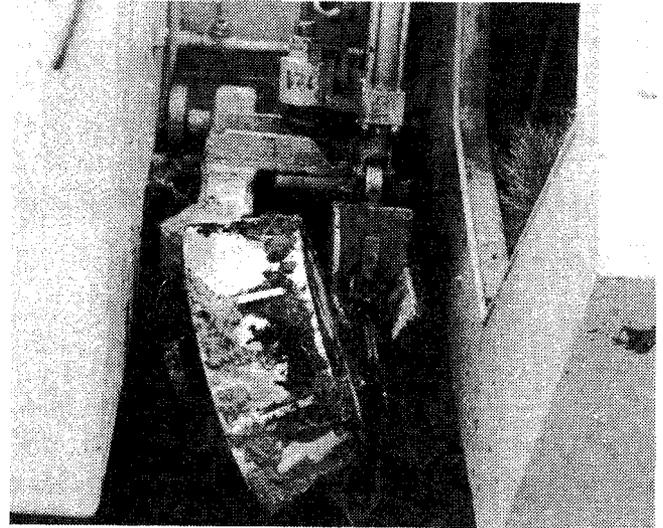
4. Should close the planting hole with adequate packing (no air pockets), but not overcompact the soil and thereby restrict water infiltration inhibiting root growth.

The packing system on the Model 200 has only one packing wheel which has a very sharp angle in order to move the dirt sideways against the seedling roots. This resulted in a very large depression alongside the seedlings. On the Modoc, the packing wheel was modified by reducing the sharp angle (fig. 4), but results were not improved enough for the silviculturist to want to continue to plant. Seventeen attempts were made to adjust the packing wheel and packing wheel pressure on the day the modified packing wheel was operated. While results were greatly improved with the modified packing wheel, they were still judged unsatisfactory.

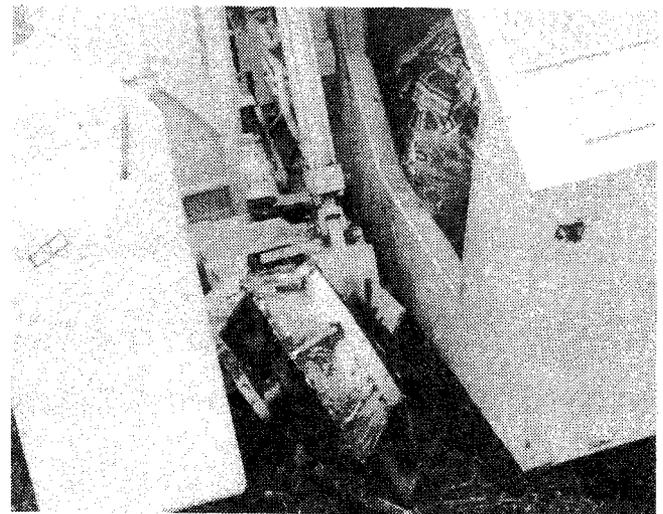
For the evaluation on the Superior, a narrower packing wheel with a flatter angle (fig. 5) was made available by the manufacturer. This packing wheel appeared to work better, but the required number



**Figure 4. The sharp angle of the packing wheel of the Model 200 was rounded off as shown in an attempt to improve packing and reduce the depression alongside the seedlings.**



**Figure 5. Model 200 equipped with narrower packing wheel with a flatter angle.**



**Figure 6. Original packing wheel made narrower by cutting off 2½ in (6.4 cm).**

of adjustments and results were far from satisfactory. The original packing wheel was made narrower (fig. 6), but results were also not completely satisfactory.

5. Should attach to and be operated by a "small" prime mover—preferably a crawler tractor in the 10,000-15,000-lb (4536- to 6804-kg) range and require only two operators (one on the tractor and one on the planter)—or, if cost effective, have an automatic feed system so the planter operator is not needed. Also, if cost effective, the unit could be an integral, self-propelled, special-design

machine. If the tree-planting machine plants two rows at a time (which is desirable for increased production), the tree planter may require (and probably will require) two operators.

On the Modoc, the planter was pulled by a 28,000-lb (12,700-kg) J.I. Case 1450B crawler tractor without any problems. On the Superior, it was pulled by a John Deere 450B crawler tractor weighing 14,500 lb (6,570 kg). In the opinion of the tractor operator and authors, the John Deere 450B crawler tractor is the smallest size that should be considered for pulling the planter.

Drawbar pull was measured from 2,000-lb (8,900 N) to 5,000 lb (22,000 N), the 5,000-lb pull occurred when the dibble was in the ground.

On the Superior National Forest the unit became stuck at times.

6. The tree planter must be affordable. That is, it must be able to be operated on a sound economical basis when operated by force account and at a profit when operated by a contractor. The purchase price that will allow the planter to be affordable is very much dependent on the production rate.

From the methodology developed in an economic analysis (1), the maximum purchase price you can afford to pay for a tree-planting machine can be found by the following equation:

$$X = -91,300 + 1,560 (\text{HPC}) (\text{MPR})$$

Where

X = Maximum economical purchase price of a tree planter

HPC = Hand-planting cost per seedling in dollars

MPR = Machine production rate in seedlings/hr.

This equation has been adjusted for the labor and tractor rates found on the La Croix Ranger District, Superior National Forest.

Using FY 83 hand-planting costs in Minnesota, and average production rate of the Model 200 on

the Superior, the maximum affordable planter cost is found:

$$X = \$91,300 + 1,560 (\text{HPC}) (\text{MPR})$$

$$X = -91,300 + 1,560 (\$.145) * (720)$$

$$X = \$67,500$$

\*Hand-planting cost includes contract cost, COR costs, contract administrative costs, and inspector.

The actual purchase price of the Marden Model 200 is \$21,000; therefore, this is an affordable tree-planting machine provided it meets reliability, availability, maintainability, and tree-planting quality criteria and is able to be operated at the assumed field efficiency of 80 percent. Data indicates actual field efficiency of about 65 percent. Some reasons for the field efficiency not being 80 percent may be: Short rows, wet and cold weather, adverse terrain, logistics delays, and insect nuisance to planting crew.

7. Have high system reliability, with a minimum mean-cycles-between-failures (MCBF) of 12,000, and a minimum inherent availability of 85 percent, which will require a high degree of maintainability.

Reliability (2)—mean-cycles-between-failures (MCBF)—was 2,092 MCBF which is far below the desired 12,000 MCBF.

Inherent availability (2)—percent of uptime as compared to uptime plus active repair time—was 85 percent.

Maintainability (2)—mean time to repair (MTTR)—was 31 minutes.

Breakdown or adjustments requiring over 10 min to repair or adjust were considered a failure for reliability, availability, and maintainability calculations (table 5). The 46 percent of the failures or adjustments (6 out of 13) were adjustments related to the dibble, packing wheel arm, and packing.

In addition to the six reliability-related failures, there were many other adjustments to the dibble and packing wheel arm of less than 10 min. On

**Table 5. Field evaluation reliability failure summary  
(Breakdown or adjustments over 10 min)**

| <b>Date</b>                     | <b>Failure</b>                                     | <b>Time to repair or adjust</b> |
|---------------------------------|--|---------------------------------|
| <b>Modoc National Forest</b>    |  |                                 |
| 4/11/83                         | Packing wheel and dibble adjustment                | 15 min                          |
| 4/13/83                         | Packing wheel and dibble adjustment                | 12 min                          |
|                                 | Broken packing spring bolt                         | 1 hr 31 min                     |
| <b>Superior National Forest</b> |  |                                 |
| 5/10/83                         | Finger replacement                                 | 11 min                          |
|                                 | Adjust packing wheel spring nut                    | 18 min                          |
| 5/11/83                         | Adjust packing wheel psi and repair throttle cable | 14 min                          |
|                                 | Adjust packing wheel psi                           | 13 min                          |
|                                 | Leaking hydraulic fitting replacement              | 15 min                          |
| 5/14/83                         | Adjust packing wheel psi                           | 18 min                          |
|                                 | Hydraulic and engine oil leak                      | 57 min                          |
|                                 | Starter failure                                    | 1 hr                            |
| 5/17/83                         | Leaking hydraulic gage (replaced)                  | 15 min                          |
| 5/20/83                         | Starter failure                                    | 1 hr                            |
| <b>TOTAL</b>                    | <b>13 failures or adjustments over 10 min.</b>     | <b>6 hr 39 min</b>              |

one day there were 16 adjustments. These many adjustments being required to the dibble and packing wheel arm indicate a problem area and a need for further development.

8. The tree planter shall be energy efficient.

Total fuel use per acre rates were not obtained because acres planted at one location were unknown and at the other, two tree planters were planting in the same area. Data indicates the Model 200 engine uses about 0.6 gal/hr of fuel.

The hydraulic oil temperature during operation ranged from 140° F (60° C) to over 200° F (93° C). At times, planting operations had to be slowed or stopped to allow the oil temperature to cool. This would indicate energy is being wasted in the hydraulic system. In reviewing the operation of the hydraulic system, it was learned that the output from the pump is relieved by a relief valve when the packing wheel is in contact with the ground. This generates heat in the hydraulic system, wasting energy.

9. The tree planter must be safe to operate. If no automatic feed, a safe and comfortable operator station and rollover protection must be provided.

No injuries were reported during this field evaluation. However, there were some areas of concern related to safety:

- Need shielding on bottom of planter to prevent limbs, saplings, and other debris from coming into contact with the planter operator.
- Need shielding around hydraulic hoses and fittings to keep the operator from being sprayed with hot hydraulic oil if a large leak or break should occur.
- Need for an emergency exit on the left side of the operator's compartment.

Limbs and saplings entered the operator's compartment, but did not cause any injuries. A hydraulic fitting leak, located at the top of the hydraulic planting cylinder sprayed hydraulic oil on the planter operator. The planter was shut down and the fitting was changed. To enter the operator's position, the operator must climb over the packing wheel and planting arm. This is not considered a good arrangement. There is no other way in or out of the operator's position. An exit could be placed on the left side of the machine which would eliminate this problem. If a hydraulic line broke, spraying hot (200° F)

(93° C) hydraulic oil and blocking the normal exit, the operator could get out on the left side if there were an exit on the left side.

## CONCLUSIONS

Based on the performance criteria, the tree planter performed adequately in the following areas:

- Stock type—The planter was able to plant bare-root stock one row at a time.
- Production factors—The overall production rate was 702 seedlings per hour.
- Planting factors—Seedlings could be consistently planted at 10-in depth.
- Planter configuration—The planter could be pulled adequately with a 14,500-lb (6,576-kg) crawler tractor.
- Affordable—At the production rate observed of 702 seedlings per hour, and a list price of \$21,000, the Marden Model 200 is an affordable tree-planting machine provided tree-planting quality, reliability, availability, and maintainability are also acceptable.
- Planter performance—The inherent availability was 85 percent and maintainability was 31 min MTTR (mean-time-to-repair).

The tree planter was unsatisfactory in the following areas:

- Site characteristics and planting quality—The planter had difficulty operating on a site that was double-disked, and also on wet and muddy sites. Only 51 percent of the attempts to plant a seedling were judged to be successful.

- Spacing—The planter could not plant seedlings with a within-row spacing of 5 ft (1.52 m). Within-row spacing of 7.4 ft (3.3 m) was about as close as could be achieved.
- Reliability—Reliability was far below the desired reliability (mean-cycles-between-failures, MCBF), desired being 12,000 MCBF and demonstrated being 2,092 MCBF.
- Safety—The planter needs some shields added for safety on the bottom to prevent limbs and saplings from entering the operator compartment, and shielding around the hydraulic hoses and fittings to keep hot hydraulic oil from spraying on the operator if a hose or fitting is broken.

Also needed is an emergency exit on the left side of the operator compartment.

Overall, the Model 200 performance on the Modoc and Superior National Forests must be judged unsatisfactory for the following reasons:

- Only 51 percent successful planting
- Low demonstrated reliability
- Need improvements in planter safety
- The machine could not achieve a within-row seedling spacing of 5 ft (1.52 m).

## RECOMMENDATION

If significant improvements are made to the planter by the manufacturer that will result in better planting quality and improved reliability and safety, the unit should be reevaluated.