# LABOR PRODUCTIVITY FOR MANUAL TREE PLANTING IN MANITOBA

A File Report

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## ABSTRACT

Labor productivity for manual tree planting was examined at six locations in Manitoba during the 1986 planting season. Study areas included both prepared (shear bladed and disk trenched) and unprepared sites where either bare-root or container seedlings were planted. Preliminary results, based on 286 sample lines and representing 34 different planters, showed wide variation in production rates. Average planter productivity (trees planted per hour) ranged from 138 for bare-root to 353 for container grown seedlings.

This report describes field methods used in the study and provides preliminary data summaries.

## ACKNOWLEDGEMENTS

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# INTRODUCTION

Efforts to regenerate burned or harvested forest lands to desired stocking levels of acceptable species are currently receiving high priority among forest management activities in Manitoba. These efforts are demonstrated by the increased number of seedlings planted throughout the province in recent years. For example, during the four-year period 1981-84, about 4.7 million seedlings were planted annually while during the previous four-year period (1977-80) annual plantings averaged about 1.6 million trees (Kuhnke and Brace, 1986; Annual Reports, Manitoba Natural Resources 1982-83 through to 1984-85). These plantings consisted of both bare-root and container grown stock although there appears to be a trend towards the greater use of containers. The majority of tree planting in Manitoba is done manually and represents considerable expenditures by forest management agencies.

Site preparation treatments promote seedling establishment and development as well as facilitate manual tree planting. Therefore the amount of labor required to reforest a particular site may be influenced by the degree and type of site preparation utilized. For example scalps created by the Bracke scarifier not only provide planting spots requiring little or no screefing, but also ensure that prescribed tree spacing is maintained, thus contributing to planting speed. Disk trenching prepares shallow trenches or furrows which, like the Bracke, eliminate or reduce the amount of screefing required. The trenches establish the layout of the plantation, creating an order or structure which may enhance planter productivity. On shear bladed sites, heavy slash has been pushed aside thus improving planter accessability. Vyse and Muraro (1973) reported substantial savings in planting costs could be realized from prescribed burning to reduce slash and duff cover. In general, planter productivity, expressed as trees planted per unit of time, is dependent on site conditions.

Within a forest management unit, planting conditions may range from sites receiving no treatment to sites completely cleared of slash and shrubs. Consequently labor requirements, and therefore costs, to reforest a particular site may vary substantially. Similarily, stock type, (i.e., bare-root or container seedlings), and/or planting tool may also impact on planter productivity. Estimating planting costs are difficult under these varying circumstances. Although historical records provide some indication of costs, such data are usually applicable to average planting conditions and may not be suitable to estimate costs to reforest a specific site. In addition, costs vary by region and economic climate further reducing the utility of

historical cost data. Knowledge of planter productivity would enhance the ability of forest managers to estimate costs, particularly when productivity estimates are related to site conditions.

This study was initiated in the spring of 1986 to determine costs of manual tree planting in Manitoba. Specifically, the purpose of this study is to describe how site conditions affect labor requirements to reforest specific sites. Data on planter productivity that reflect site conditions have several uses, viz:

(1) Assist forest managers in allocating resources among numerous potential silviculture activities;
(2) Facilitate labor cost estimation that reflects specific site conditions. Knowledge of labor requirements provides the flexibility of determining local labor costs applicable to the economic conditions prevailing at the time of planting;
(3) Assist private contractors in preparing realistic bids that reflect the difficulty of planting specific sites;
(4) Provide guidelines to managers when assessing contractor bids;
(5) Provide managers with comparisons of labor productivity on sites receiving different site preparation treatments. Such information may suggest alternative or varying intensity of treatment to reduce planting costs. For example, the extra expense of a particular treatment may payoff in lower planting costs; and
(6) Provide managers or contractors with labor productivity comparisons between different planting tools and different planting stock.

This study is part of Project C/M-7.2 entitled Economics of Intensive Forest Management and is funded by the Canada-Manitoba Forest Renewal Agreement. The purpose of Project C/M-7.2 is to develop economic guidelines, through determination of labor and/or machine productivity and costs, for a variety of silvicultural activities to ensure cost effective use of intensive forest management funds. In the preliminary stages of this project, only labor and machine times required to create a prescribed treatment are examined; later stages will address costs associated with the various treatments. To date file reports relating to Project C/M-7.2 have summarized data for pre-commercial thinning (De Franceschi and Steele 1986) and shear blade site preparation (Steele and De Franceschi 1986).

This file report summarizes work completed to date in developing productivity estimates for manual tree planting. Study methods used to determine labor inputs are outlined and data summaries are presented from six areas planted in Manitoba during 1986.

## DESCRIPTIONS OF STUDY AREAS AND PLANTING OPERATIONS

Six different areas were sampled during the 1986 planting season. The extended container planting season allowed for a greater number of areas to be sampled for container systems than for bare-root planting. All sampled areas were planted on an operational scale by either hourly paid provincial employees or contract workers paid on a piece-work basis.

The following section provides descriptions of the planting sites along with some observations on methods used in the planting operation. At some areas, data were collected from more than one planting site. For these, descriptions are combined for that area with any differences between sites noted. General locations of study areas are shown in Figure 1. A brief summary of stand history and site conditions are presented in Table 1.

### AREA 1: LAC DU BONNET - EASTERN FOREST REGION

#### Site Description

The planting area is located near the northern boundary of the Agassiz Provincial Forest in Township 15, Range 9 EPM. The original jack pine/aspen (Pinus banksiana/Populus tremuloides) stand was destroyed by wild fire in 1979 and subsequently salvaged logged for firewood throughout 1981-84. During November of 1985, the area was site prepared with a TTS disk trencher. The treatment left generally well defined although somewhat shallow trenches due to the frozen ground conditions at the time of site preparation.

Soils on the area range from fine to coarse, almost gravel-like sands. Topography is flat to gently rolling with slopes not exceeding 5%. Vegetation cover was generally light although patches of aspen suckers 2-3 m in height interspersed with white birch (Betula papyrifera) up to 4 m tall were common. Since planting was restricted to the centre of the prepared trench, the light duff layer (approximately 5 cm thick) had no effect on planting rates. Where trenches were less defined, the light grass cover offered some resistance to planting however this could be considered a minor factor on this site. The fire and salvage logging eliminated all standing mature trees and left only minor slash cover.

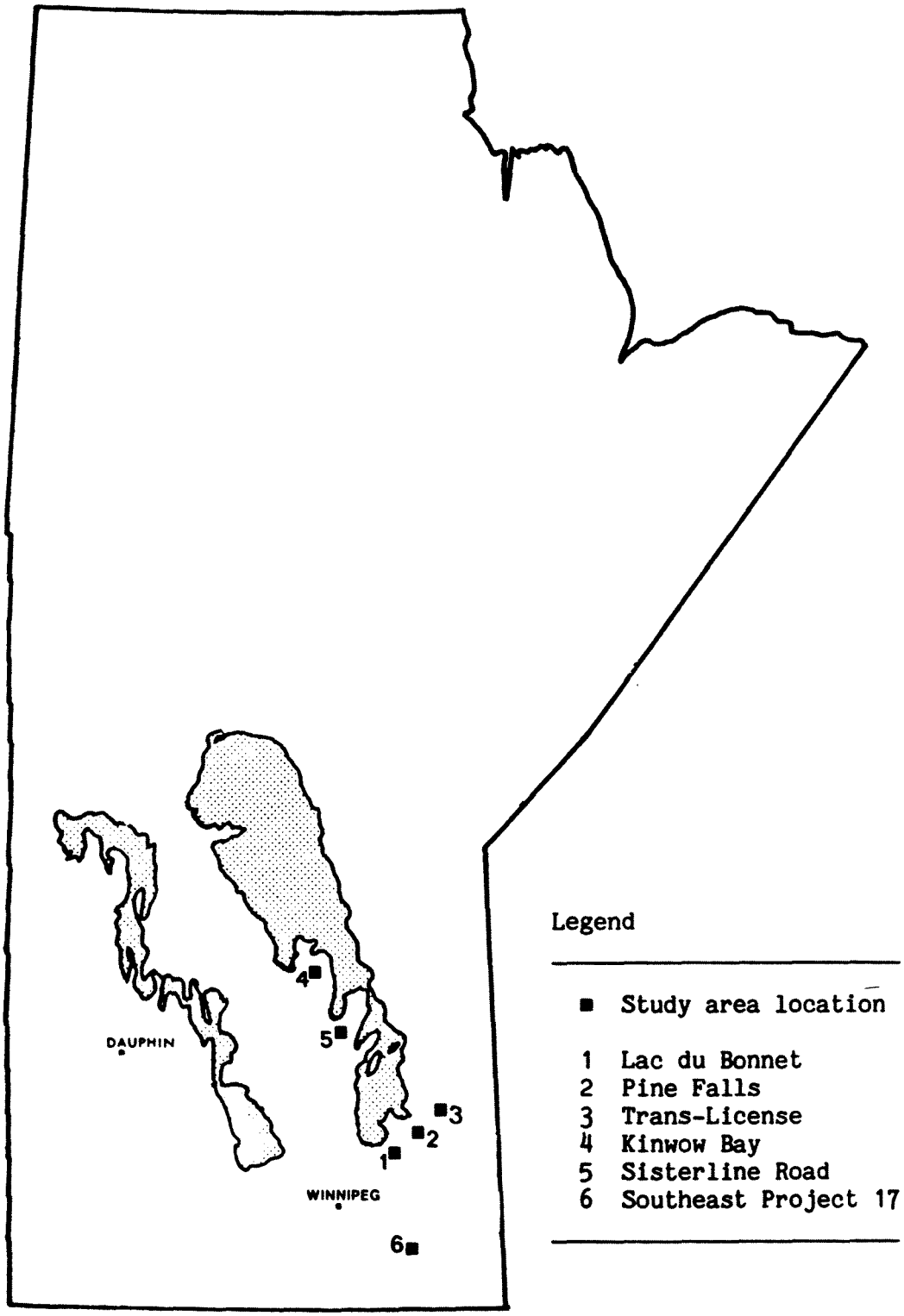


FIGURE 1. General locations of study areas of labor productivity for manual tree planting in Manitoba, 1986.

TABLE 1. Summary of stand history and site conditions of planting areas.

| Study area | Stand history: Original stand | Stand history: Disturbances | Stand history: Site preparation | Planting site conditions: Soil | Planting site conditions: Duff thickness (cm) | Planting site conditions: Slash | Planting site conditions: Vegetative cover | Planting stock type | Planting tool |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Jack pine/ aspen | Wildfire/ salvage logging | Disk trenching | Fine to coarse sand | 5 | Light | Light | Bare-root | Shovel |
| 2 | Spruce/ aspen | Logging | Shear blading/ herbicides/ disk trenching | Clay | NM* | Light | Heavy grass | Container | Shovel |
| 3 | Spruce/ aspen/ jack pine | Wildfire/ salvage logging | Shear blading | Silty sand | NM** | Light | Medium grass | Container | Shovel |
| 4 | Spruce/ aspen | not available | Shear blading | Silty sand | 10 | Light | Light | Bare-root | Shovel |
| 5 | Spruce/ aspen | Wildfire/ salvage logging | Shear blading | Silty sand | 5 | Light | Light | Container | Pottiputki |
| 6 | Spruce/ jack pine/ aspen | Logging | none | Sand | 20-45 | Heavy | Heavy | Container | Pottiputki |

* NM - not measured; seedlings planted into side of trench
** NM - not measured; shallow soil over bedrock

Planting Operation

The area was planted with 2-0 jack pine and red pine (Pinus resinosa) bare-root seedlings using shovels. Average seedling lengths were 43 cm for jack pine (16 cm tops and 27 cm roots) and 36 cm for red pine (17 cm tops and 19 cm roots) based on a random sample of about 120 excavated seedlings. During the observation period of May 5-9 1986, the planting crew consisted of 12 planters, one individual who kept planters supplied with seedlings, and a supervisor; all hourly paid employees of Manitoba Natural Resources. Seedlings were stored at a nearby location and distributed to planters via a small all-terrain vehicle. This meant planters were not required to leave their planting spot resulting in virtually no unproductive time other than scheduled rest breaks. Cool wet weather prevailed throughout the observation period.

AREA 2: PINE FALLS - EASTERN FOREST REGION

Site Description

Three separate sites within 5 km of each other were examined at this location. Since the sites were similar and planted by the same crew, site descriptions are combined with any differences noted accordingly.

The planting areas are located in Township 18, Range 10 EPM along the Bear River Road in the vicinity of what is locally known as the Maskwa Project. The original stands were mixed black spruce (Picea mariana) and aspen. The black spruce component had been logged during 1978-79. Subsequent treatments on the three sites varied and are as follows:

Site 1:
The area was shear bladed in January 1982 and slash piled in windrows 40 to 60 m apart. 2-4-D herbicide was applied in May of the same year. A second herbicide treatment (Roundup) was applied in August 1984 and followed by site preparation with an M&M disk trencher in July 1985.

Site 2:
The area was shear bladed in February 1980 and slash piles burned. No evidence of the slash piles remain other than at the fringes of the cutover. Roundup herbicide was applied in August of 1980 and 1984. In

May 1986, a few days prior to planting, the area was treated with a Donaren disk trencher.

Site 3:
Stand history and pre-1986 post logging treatments are not available for this site however it appears the site had undergone a sequence of events similar to sites 1 and 2. This area was also prepared with a Donaren disk trencher a few days before the 1986 planting.

All three sites had been previously planted, however low seedling survival necessitated replanting.

Soils on these areas are a heavy clay and topography is flat. The previous herbicide applications had eliminated virtually all aspen suckers and shrubs however a heavy grass cover is still evident. Trenching produced by the disking treatment was prominent. The poor drainage in the area resulted in trenches filling with water which in places was up to 30 cm deep. The overturned sod layer created by the treatment commonly occured in soft mounds and seemed to hamper the planters' movements.

## Planting Operation

The area was planted with black spruce grown in 313 styroblock containers. The planting stock was reared during the summer of 1985 and kept in cold storage until planting in May 1986. Seedling size ranged from 12 to 18 cm in length and were planted with shovels. Planters were instructed to plant seedlings into the edge of the trench on the side where the trencher deposited the sod clumps. During the observation period of May 12-16, 1986, the planting crew consisted of about 12 planters and two supervisors. The planting crew, employees of Abitibi-Price, were paid on a piece-work basis for the planting operation but were to return to hourly paid duties at the paper mill at the completion of the planting season. All were experienced planters.

Seedlings were delivered daily to the planting site in cardboard boxes containing 450 seedlings in plastic-wrapped bundles of 25 trees. These were then forwarded to a central location via a small all-terrain vehicle where planters took up to 250 seedlings at a time and proceeded to their assigned areas. They returned to the central location to replenish their seedling supplies as required and it was at this time that lunch and rest breaks were usually taken. During the observation period at sites 1 and 2, warm sunny weather prevailed, while at site 3, temperatures turned cool.

## AREA 3: TRANS-LICENSE - EASTERN FOREST REGION

### Site Description

Two planting sites 2 km apart were examined in this area. They are located about 40 km northeast of Pine Falls in Township 20 Range 13 EPM in the Trans-License area of Abitibi-Price.

The original stands on both sites were destroyed by wildfire in the autumn of 1983 and had contained a mixture of spruce, aspen and jack pine. A portion of the fire-killed timber was subsquently salvage logged for fuelwood. In 1984, the sites were shear bladed and planted the following spring. Low survival rates necessitated replanting in 1986.

Shallow soils overlying bedrock are predominant on the planting areas and rock outcrops are common throughout. Topography is generally flat with slopes of 5-10% occurring near the rock outcrops. Upslopes usually supported a heavy grass cover while low lying areas ranged from marshy conditions containing up to 15 cm of water to dry grass-free patches. The shear blade treatment of 1984 piled slash into randomly spaced windrows with slash piles generally occurring on the unplantable rock outcrop areas. These areas which were avoided by the shear blade treatment contained standing remnants of the fire while plantable areas were free of slash and standing trees. Slash piles and standing trees presented obstacles to the planters only when those areas were crossed to get from one plantable area to the next. Some natural regeneration and seedlings surviving the 1985 planting were also present.

### Planting Operation

Planting was conducted by the same crew as in Area 2 using the same operational methods and planting stock as previously described. One difference which likely affected planter productivity was the absence of prepared trenches. Trenches provide pathways for planters to follow as well as facilitate planting. The absence of trenches along with the presence of established seedlings (both natural regeneration and survivors from the 1985 planting) may reduce planting rates. In addition, the occurrence of unplantable areas, (i.e. rock outcrops and slash windrows) required planters to spend more time walking and searching for suitable planting sites. In contrast to Area 2, where planters worked independently along rows, the nature of

these planting areas required planters to work in groups of two or three persons within a small plantable patch. This likely reduced planting rates since individuals were required to watch for seedlings planted by co-workers. During the observation period of May 21-23, 1986, the weather was hot and may have increased planter fatigue.

## AREA 4: KINWOW BAY - INTERLAKE FOREST REGION

### Site Description

The planting site is located in Township 30 Range 1 WPM. The original spruce/aspen stand was shear bladed during the winter of 1985-86 in preparation for planting. That treatment piled slash in windrows averaging 7.8 m apart and left planting areas clear of slash.

Soils on the area are silty sands and topography is flat to gently rolling with duff depth about 10 cm. At time of planting, water had accumulated in low lying areas.

### Planting Operation

The area was planted with 3-0 white spruce (Picea glauca) and 2-0 black spruce bare-root stock using shovels. Seedling lengths averaged 30 cm tops and 25 cm roots. The area was planted by private contract with workers paid on a piece-work basis. Planters worked either singly or in two-person teams planting in an S-pattern between slash windrows. Seedlings were stored at a central location from where planters took up to 200 seedlings at a time in burlap sacks and proceeded to their planting areas. The hot weather (in excess of 30 degrees C) that occurred during the observation period noticeably affected the workers' productivity.

## AREA 5: SISTERLINE ROAD - INTERLAKE FOREST REGION

### Site Description

The planting area is located in Township 27 Range 2 EPM adjacent to what is locally known as the Sisterline Road. The original black spruce/aspen stand was destroyed by fire in 1972 and subsequently salvage logged. In January of 1986, the area was shear bladed and

slash piled in windrows 7 to 12 m apart. During the shear blade operation, local residents salvaged downed timber from the windrows. The site preparation treatment and subsequent salvage of firewood left planting areas clear of slash.

Soils in the area are stone-free sands and silts and topography is flat. Duff thickness ranged from 5 to 10 cm although the shear blade treatment left occassional patches of exposed mineral soil. Sheared aspen sucker stubs less than 1 m in height were common between windrows however these, as well as the large sheared stumps, appeared to have little effect on planter productivity.

### Planting Operation

The area was planted with black spruce Can-Am No.1 container grown stock using a pottiputki planting tool. Seedlings ranged from 10 to 18 cm in length (top to root collar). A small all-terrain vehicle transported seedlings from a nearby camp to strategic locations throughout the planting area where planters collected 128 seedlings at a time and worked up and down cleared strips parallel to slash windrows. The site was planted by a four-person crew working on a contract basis. Weather during the observation period was cool and overcast.

## AREA 6: SOUTHEAST PROJECT 17 - SOUTHERN FOREST REGION

Two planting sites are located in this study area. Since both sites are similar and planted by the same crew, their descriptions are combined.

### Site Description

The planting areas are located in Township 6 Range 10 EPM in the Sandilands Forest Reserve of the Southern Forest Region. The original stands containing a mixture of black spruce, jack pine, aspen and white birch were logged during the winter of 1985-86. No site preparation was conducted prior to planting therefore slash and vegetation cover was heavy. Standing mature trees and windfalls were common throughout the planting area.

Soils in the area are generally sandy and topography flat although the terrain is somewhat humocky with a 20-45 cm thick duff layer.

Planting Operation

Black spruce reared in Can-Am No.1 containers were planted using the pottiputki planting tool. Seedling lengths ranged from 10 to 18 cm from top to root collar. During the observation period the planting crew consisted of 6 planters, one person who distributed seedlings to planters, and one supervisor; all were hourly paid provincial employees. Planters worked both singly or in two-person teams. Since one individual kept planters supplied with seedlings, workers were not required to leave their planting position therefore vitually all work time was productive other than scheduled rest breaks. Weather during the observation period was cool and cloudy.

## STUDY METHODS

Field observations were conducted to determine time requirements for manual tree planting and to measure site characteristics which may affect planting rates. A prime consideration in collecting field data was to minimize distruption to the planters thus allowing them to work in their normal manner and reduce bias in time measurements.

### Sampling Procedure

The general method of field observation was to measure the time required to plant seedlings along a sample line and obtain appropriate measurements which describe site characteristics and planting quality. Rather than establish sample lines of fixed length, planting productivity was determined for a specified time period therefore resulting in variable line lengths.

Casual observations suggested that within five minutes, at least 15 trees could be planted in a row over a distance where site characteristics (i.e. ground conditions including slash and standing trees or shrubs) would remain relatively uniform. Therefore the planter was timed for approximately five minutes and the distance travelled was determined. This travel line constituted the sample plot on which subsequent measurements were collected. The predetermined time approach was favoured over a fixed length approach because:

(1) Where planters are not restricted to a prepared pathway, such

as that produced by a disk trencher, difficulties may arise in pre-selecting the planter's line of travel. Although planters could be asked to follow a particular line, this would likely introduce bias in the worker's performance.

(2) Use of a fixed length line requires markers to indicate end points. These markers may influence the planter's work pattern, particularly seedling spacing, as the line's end point is approached; and

(3) The five minute time span could easily be adjusted to accommodate unforeseen situations as they occur. For example, time measurements could cease at any point without loss of data already collected for that line.

Table 2 presents summary statistics for sample lines by study area.

During data collection, every effort was made to sample as many different planters as possible. Usually, a different planter was selected after a rest break or after an individual exhausted his/her supply of seedlings. Table 3 summarizes number of observations obtained from each different planter.

## Data Collection

The following procedure was used for plot establishment and data collection:

(1) The observer arbitrarily decided which tree would be the first to be included in the sample line. When the planter stepped forward to plant that tree, timing commenced. After the planter had advanced several steps into the sample line, the point where timing started was appropriately marked.

(2) During planting of the sample line, frequency of planter activities was recorded. These activities included:
   (a) planting tool hitting stones or roots at the planting hole
   (b) clearing brush or slash at the planting spot
   (c) searching for planting spot
   (d) checking tree spacing or planting quality
   (e) refilling planting bag or opening new seedling bundle
   (f) cleaning or adjusting planting tool
   (g) personal or other activity

(3) As the five minute mark approached, the observer decided which tree would be the last to be included in the line. When that

TABLE 2. Sample line summary by study area.

| Study area | Number of sample lines | Length of sample lines (m) | | |
|---|---|---|---|---|
| | | Average | Minimum | Maximum |
| 1 | 61 | 27.5 | 13.4 | 40.6 |
| 2 - Site 1 | 31 | 37.0 | 20.1 | 58.8 |
| - Site 2 | 39 | 31.0 | 18.1 | 65.6 |
| - Site 3 | 19 | 36.4 | 22.7 | 45.3 |
| 3 - Site 1 | 13 | 27.3 | 19.2 | 39.4 |
| - Site 2 | 26 | 26.7 | 14.1 | 38.8 |
| 4 | 34 | 29.8 | 11.6 | 47.1 |
| 5 | 40 | 57.4 | 25.9 | 109.5 |
| 6 - Site 1 | 6 | 24.5 | 17.8 | 30.7 |
| - Site 2 | 17 | 25.8 | 11.1 | 52.6 |

TABLE 3. Number of observations per planter by study area.

| Planter identification code | Study area | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 8 | - | - | - | - | - |
| 2 | 10 | - | - | - | - | - |
| 3 | 14 | - | - | - | - | - |
| 4 | 6 | - | - | - | - | - |
| 5 | 7 | - | - | - | - | - |
| 6 | 8 | - | - | - | - | - |
| 7 | 8 | - | - | - | - | - |
| 8 | - | 15 | 3 | - | - | - |
| 9 | - | 10 | 5 | - | - | - |
| 10 | - | 9 | 5 | - | - | - |
| 11 | - | 6 | - | - | - | - |
| 12 | - | 9 | 3 | - | - | - |
| 13 | - | 11 | 12 | - | - | - |
| 14 | - | 10 | 7 | - | - | - |
| 15 | - | 11 | 3 | - | - | - |
| 16 | - | 8 | - | - | - | - |
| 17 | - | - | 1 | - | - | - |
| 18* | - | - | - | 4 | - | - |
| 19* | - | - | - | 4 | - | - |
| 20* | - | - | - | 7 | - | - |
| 21* | - | - | - | 3 | - | - |
| 22 | - | - | - | 3 | - | - |
| 23 | - | - | - | 4 | - | - |
| 24 | - | - | - | 4 | - | - |
| 26 | - | - | - | 3 | - | - |
| 27* | - | - | - | 2 | - | - |
| 28 | - | - | - | - | 12 | - |
| 29 | - | - | - | - | 11 | - |
| 30 | - | - | - | - | 11 | - |
| 31 | - | - | - | - | 6 | - |
| 32 | - | - | - | - | - | 8 |
| 33 | - | - | - | - | - | 4 |
| 34* | - | - | - | - | - | 9 |
| 35* | - | - | - | - | - | 2 |
| Totals | 61 | 89 | 39 | 34 | 40 | 23 |

* Planters in group of two persons.

tree was planted and the planter moved to plant the next tree, timing ceased. After the planter had advanced several steps further, the point where timing ceased was marked.

(4) The length of the travel line (to the nearest 1/10 m) and the time required to plant the line (determined with a stop watch to the nearest second) were recorded.

(5) The number of trees planted along the sample line was recorded and each tree assessed for planting spot and planting quality. A planting spot was classed acceptable if the seedling was placed in a location consistent with the planting supervisor's instructions. For example at the Pine Falls sites, seedlings were to be planted on the mounded edge of the prepared trench while at the Lac du Bonnet site, seedlings were to be planted within the trench. Planting spot was considered unacceptable if the seedling was planted within one metre of an established conifer seedling or residual. Planting quality was based on how well the seedling was planted in terms of firmness, depth, and if the tree was planted in a vertical position.

(6) All slash pieces crossing the centre line of the planter's travel path were measured for diameter and height above ground level (at the point of intersection of slash piece and centre line).

(7) Standing trees and/or shrubs greater than 1 m in height located within the planter's travel path (considered to be 1 m wide) were counted and their average height was estimated.

Items (6) and (7) above are measures of obstacles to planting. Table 4 presents slash and standing tree statistics adjusted to a standard 100 m long planting line. Activity counts in item (2) included the number of times the planter enountered stones or roots at the planting spot. This count also provides a measure of planting difficulty. Table 5 summarizes frequencies of planter activities adjusted to a standard 100 m long planting line.

Throughout the sample line establishment procedure and subsequent measurements, the planter continued uninterrupted in his/her normal work pattern, i.e. the planter entered and exited the sample line continuing to plant at his/her usual rate. There was no interaction required between the planters and the research team.

TABLE 4. Residual stems and slash conditions by study area.

| Study area | Number of standing stems * (per 100m row) | | Number of slash pieces all sizes ** (per 100m row) | Slash piece diameter (cm) | | Slash height from ground (cm) | |
|---|---|---|---|---|---|---|---|
| | Average | Maximum | | Average | Maximum | Average | Maximum |
| 1 | 66 | 201 | 150 | 4 | 32 | 18 | 105 |
| 2 - Site 1 | 5 | 36 | 49 | 7 | 60 | 10 | 50 |
| - Site 2 | 1 | 4 | 32 | 8 | 53 | 12 | 75 |
| - Site 3 | 1 | 14 | 21 | 8 | 50 | 13 | 70 |
| 3 - Site 1 | 1 | 8 | 77 | 12 | 100 | 18 | 91 |
| - Site 2 | 0 | 9 | 64 | 11 | 100 | 22 | 200 |
| 4 | 0 | 0 | 36 | 11 | 100 | 13 | 100 |
| 5 | 13 | 47 | 52 | 22 | 200 | 18 | 200 |
| 6 - Site 1 | 10 | 20 | 376 | 4 | 36 | 13 | 60 |
| - Site 2 | 8 | 29 | 344 | 5 | 50 | 16 | 150 |

* Stems taller than 1m within 1 m wide planter's walking path.
** Pieces crossing centre line of planter's walking path.
Note: Included in slash measurements are uprooted stumps/windfalls which account for the large diameters and heights.

TABLE 5. Seedlings planted and frequency of planter activities over a standardized 100 m planting row.

| Study area | Average number of seedlings planted (per 100m row) | Activity codes * | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | a | b | c | d | e | f | g |
| | | (average counts per 100m row) | | | | | | |
| 1 | 56 | 17 | 6 | 0 | 0 | 0 | 0 | 0 |
| 2 - Site 1 | 55 | 0 | 9 | 0 | 0 | 2 | 0 | 0 |
| - Site 2 | 63 | 0 | 3 | 1 | 0 | 2 | 0 | 1 |
| - Site 3 | 58 | 0 | 4 | 0 | 0 | 2 | 0 | 0 |
| 3 - Site 1 | 52 | 1 | 13 | 0 | 0 | 2 | 0 | 1 |
| - Site 2 | 53 | 3 | 7 | 0 | 0 | 2 | 0 | 0 |
| 4 | 52 | 1 | 13 | 0 | 0 | 0 | 1 | 2 |
| 5 | 49 | 0 | 7 | 0 | 1 | 0 | 1 | 0 |
| 6 - Site 1 | 61 | 0 | 14 | 1 | 0 | 1 | 0 | 2 |
| - Site 2 | 69 | 0 | 16 | 0 | 2 | 1 | 0 | 2 |

* Planter activity codes:
- a - stones/roots at planting spot
- b - clear planting spot
- c - search for planting spot
- d - check spacing or check tree
- e - refill planting bag or open new seedling bundle
- f - clean/adjust planting tool
- g - personal or other

## RESULTS

The intent of this report is to describe field procedures used to determine labor productivity for manual tree planting and to provide preliminary summaries of data collected during the 1986 planting season. No statistical analyses have been conducted to determine relationships between site characteristics and labor productivity. This section therefore merely highlights some findings from the study to date.

Planter productivity in terms of average number of seedlings planted per hour are summarized in Table 6 by study area. These production values are based on time required to plant a sample line and are therefore entirely productive times. No account is made for unproductive time elements such as rest breaks, walking to planting areas, returning to central location to refill planting bags, etc.

Planter productivity ranged from a low of 138 seedlings per hour at Area 4, where somewhat large bare-root seedlings were planted with shovels, to a high of 353 at Area 5 where container stock was planted with pottiputkis. A wide range in productivity was also observed within the same study area where site conditions, operational methods, and planting crew were similar. For example, at Study Area 2, average productivity ranged from 252 seedlings per hour at Site 2 to 312 at Site 3 - a 24% difference. Production variation within planting areas are provided in greater detail in Appendix 1 (Appendix 1 expands Table 6 to include minimum and maximum values).

Planting quality shown in Table 6 was determined from observations on each seedling planted during the time measurements. In general, a seedling was acceptable if it appeared to be planted firmly, in a vertical position, buried at least up to its root collar (a small amount of buried foliage was allowed), and planted in a spot consistent with the supervisor's instructions. Such observations are subjective to some extent. However planting quality in Table 6 is intended only as a relative measure, and may not be comparable to results from quality checks conducted during operational plantation assessments. The objective of planting quality observations were to provide a comparison with site conditions and planter productivity. Although average quality values shown in Table 6 show no relationship with productivity, the highest incidence of poorly planted trees occurred at Area 6 where the site received no treatment prior to planting. Many of the poorly planted seedlings at that area were classified as "loose", perhaps due to the thick duff and heavy slash cover.

TABLE 6. Planter productivity per hour and planting quality by study area.

| Study area | Site preparation | Planting stock | Planting tool | Observed average spacing within rows (m) | Number of seedlings planted * (per person hour) | Planting quality ** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | A | B | C | D |
| | | | | | | (%) | | | |
| 1 | Disk trencher | Bare-root | Shovel | 1.8 | 190 | 83 | 1 | 15 | 1 |
| 2 - Site 1 | Disk trencher | Container | Shovel | 1.8 | 264 | 88 | 0 | 12 | 0 |
| - Site 2 | Disk trencher | Container | Shovel | 1.6 | 252 | 91 | 0 | 9 | 0 |
| - Site 3 | Disk trencher | Container | Shovel | 1.7 | 312 | 91 | 0 | 9 | 0 |
| 3 - Site 1 | Shear blade | Container | Shovel | 1.9 | 262 | 82 | 1 | 15 | 2 |
| - Site 2 | Shear blade | Container | Shovel | 1.9 | 281 | 95 | 1 | 4 | 0 |
| 4 | Shear blade | Bare-root | Shovel | 1.9 | 138 | 89 | 0 | 11 | 0 |
| 5 | Shear blade | Container | Pottiputki | 2.0 | 353 | 91 | 2 | 7 | 0 |
| 6 - Site 1 | None | Container | Pottiputki | 1.7 | 216 | 64 | 3 | 28 | 5 |
| - Site 2 | None | Container | Pottiputki | 1.5 | 177 | 54 | 0 | 44 | 2 |

* Based on time spent to plant sample lines. Does not include unproductive time elements such as rest breaks, travel times, walking to planting areas, etc.

** Planting quality codes: A - planting spot acceptable; planted tree acceptable.
B - planting spot not acceptable; planted tree acceptable.
C - planting spot acceptable; planted tree not acceptable.
D - planting spot not acceptable; planted tree not acceptable.

NOTE - Planting quality described in this table is based on observations made on trees planted during time measurements. These trees were not excavated.

## FUTURE WORK

Field data collection for manual tree planting in Manitoba will continue throughout the 1987 planting season. Attempts will be made to sample planting methods and site conditions not included in the existing data base (eg. Bracke prepared sites). Table 7 summarizes number of observations available to date for different combinations of site preparations, planting tool, and planting stock type. More northerly sites will also be sampled as data from those areas are lacking.

The objective of this study is to develop equations suitable for predicting labor requirements and costs of reforesting a wide range of sites. This objective will be addressed as the data base develops to include a variety of planting conditions found in Manitoba.

TABLE 7. Number of observations available to date for different combinations of site treatment, planting tool and planting stock type.

| Site preparation | Planting tool | Planting stock type | |
|---|---|---|---|
| | | Bare-root | Container |
| Disk trencher | Shovel | 61 | 89 |
| | Pottiputki | n.a. | -- |
| Shear blade | Shovel | 34 | 39 |
| | Pottiputki | n.a. | 40 |
| Not treated | Shovel | -- | -- |
| | Pottiputki | n.a. | 23 |

n.a. - not applicable

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APPENDIX 1. Ranges of planter productivity per hour and planting quality.

| Study area | Number of sample lines | Number of seedlings planted * | | | Observed spacing within rows | | | Planting quality ** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Avg. | Min. | Max. | Avg. | Min. | Max. | Avg. | Min. | Max. |
| | | (per person hour) | | | (m) | | | (%) | | |
| 1 | 61 | 190 | 138 | 260 | 1.8 | 1.4 | 2.4 | 83 | 46 | 100 |
| 2 - Site 1 | 31 | 264 | 101 | 352 | 1.8 | 1.1 | 5.9 | 88 | 59 | 100 |
| - Site 2 | 39 | 252 | 156 | 421 | 1.6 | 1.1 | 2.5 | 91 | 73 | 100 |
| - Site 3 | 19 | 312 | 227 | 477 | 1.7 | 1.4 | 2.1 | 91 | 68 | 100 |
| 3 - Site 1 | 13 | 262 | 175 | 349 | 1.9 | 1.4 | 2.2 | 82 | 67 | 100 |
| - Site 2 | 26 | 281 | 165 | 434 | 1.9 | 1.3 | 2.7 | 95 | 72 | 100 |
| 4 | 34 | 138 | 70 | 250 | 1.9 | 1.2 | 2.3 | 89 | 50 | 100 |
| 5 | 40 | 353 | 186 | 694 | 2.0 | 1.6 | 2.5 | 91 | 64 | 100 |
| 6 - Site 1 | 6 | 216 | 176 | 280 | 1.7 | 1.4 | 2.2 | 64 | 42 | 79 |
| - Site 2 | 17 | 177 | 53 | 432 | 1.5 | 1.0 | 2.1 | 54 | 8 | 85 |

* Based on time spent to plant sample lines. Does not include unproductive time elements such as rest breaks, travel times, walking to planting areas, etc.

** Based on planting quality code "A" as described in Table 6.