

PHYSICAL WORKLOAD OF PLANTING

Mark Sullman
Janelle Byers



Figure 1 - Planter working on untreated pasture

SUMMARY

Heart rate and body part discomfort were measured to determine the physical strain of planting under three different site conditions (untreated pasture, untreated cutover, and spot-mounded cutover). Hazards, productivity and quality were also measured.

CONCLUSIONS

- An assessment of the planters indicated that they were working at unsustainably high levels of physical workload on all three sites.
- Productivity on the untreated pasture was significantly lower than on the other two sites; to some extent, this was a result of the steeper slopes, heavier boxes and stronger soil.

- Body part discomfort was only experienced when planting on pasture, where slight to severe discomfort was reported 48% of the time.
- Slips accounted for 76% of all hazards identified.

RECOMMENDATIONS

- As planting has a very heavy workload, two rest breaks (rather than one) are needed to allow planters time to rest, eat and replace lost fluids.
- Planters should wear footwear which reduces the chance of slipping, and protects the foot from the impact of the spade (for example, spiked forestry boots).

INTRODUCTION

The work of tree planters is extremely important, as the quality of their work will affect the growth of the tree over the next 20 to 30 years. Accordingly, we would expect that planters would be an intensively studied group; this is not the case. Only one study has measured the physiological workload of planting under New Zealand conditions. This study (Trewin and Kirk, 1992) measured one individual, planting in three different conditions (ripped and mounded on the flat, uphill planting, and contour planting).

Trewin and Kirk found that planting flat, ripped and mounded cutover imposed the highest workload, resulting in a mean working heart rate (HR_w) of 153.1 beats per minute ($bt. min^{-1}$). Contour planting induced a mean HR_w of 129.6 $bt. min^{-1}$ and uphill planting 144.1 $bt. min^{-1}$. According to the classification of workload (Åstrand and Rodahl, 1986), the findings of Trewin and Kirk placed contour and uphill planting in the "Very heavy work" category, while planting on flat, ripped and mounded cutover was classified as "Extremely heavy".

However, Trewin and Kirk also found productivity differed significantly between the three conditions. Planting productivity on the flat, ripped and mounded site was much higher than on the other two sites. Thus, it would appear that the increase in workload was mainly due to an increase in productivity. This was supported by Apud and Valdes (1994), who stated that when planters were able to plant at a faster rate on the flat, they produced more and hence had a higher physical workload.

A Canadian study (Trites, Robinson and Banister, 1993) investigated cardiovascular and muscular strain among tree planters and found a group mean heart rate of 116.5 $bt. min^{-1}$. This placed planting in the "Heavy work" category. The large difference between the findings of Trewin and Kirk and the findings of Trites *et al.* (1993) may be due to a number of factors, including; length of time studied (only Trites *et al.* measured eight hour days), type of terrain planted (Trites *et al.* did not separate terrain types), and the fact that only one planter was studied by Trewin and Kirk (1992).

Consequently, this study was established to determine the level of physical strain involved in planting under three different site conditions: untreated pasture (pasture), untreated cutover (cutover) and spot-mounded cutover (mounded).

METHOD

Subjects

Table 1 shows the number of planters measured and the sites where they were measured. Planters were observed for one complete working day on each site at which they worked.

Productivity

Productivity information collected included time spent on each task, the number of trees planted, the weight of planting boxes, and planting quality. Quality measures were undertaken on a 5% sample of the seedlings planted. This involved a combination of six quality measures (tree straightness, firmness, tips

Table 1 - Planters and conditions

Site Condition	Planter 1	Planter 2	Planter 3	Planter 4	Planter 5
Pasture	yes	yes	yes	yes	no
Spot-mounded	no	yes	yes	yes	yes
Untreated Cutover	no	no	no	yes	yes

pulled off, planting depth, root orientation, and cultivation depth) to produce a subjective rating of good, acceptable, or unacceptable.

Environmental Conditions

An inclinometer was used to measure the ground slope along the direction of planting. Measurements of wet and dry bulb temperatures were made throughout the day, as close as possible to the area of planting. Soil shear strength was measured, in megapascals (MPa), using a shear vane.

Physiological Workload

Pe3000 heart rate monitors were used to measure working heart rate for each of the planters in order to determine their physiological workload. The mean heart rates were converted into a relative measure of strain, the percentage of cardiovascular load (%CVL).

Hazards

Hazards were observed and recorded. Hazards included slips/trips, striking solid objects with spade, material flicking into eye, and hitting boot with spade.

Body Part Discomfort

Body part discomfort was measured hourly using the modified method used by Ford (1995). The planters were shown the body part diagram and asked to indicate where (if at all) they felt discomfort as a result of work. They were then asked to rate how severe the discomfort was on a five point scale, with 1 being "none" and 5 being "unbearable".

RESULTS AND DISCUSSION

The pasture site differed significantly from both the mounded and cutover sites, in that the pasture site had a significantly steeper average slope and greater soil strength (Table 2). Slope was the only difference

between mounded and cutover, with the cutover being steeper.

Table 2 - Environmental conditions (Mean ± Standard Deviation)

	Pasture	Mounded	Cutover
Slope travelled (°)	22.8 (± 13.0)	1.6 (± 1.4)	7.9 (± 4.8)
Soil strength (MPa)	1.5 (± 0.5)	0.3 (± 0.1)	0.7 (± 0.2)
Temperature (°C)	8.1 (± 1.2)	9.6 (± 2.3)	10.8 (± 0.5)

The boxes of seedlings carried by the planters were significantly heavier on the pasture than the cutover (Table 3). The number of trees planted per hour was significantly lower for pasture than for mounded and cutover, which were the same. The planting methods differed between sites, with the pasture and cutover sites requiring three spade cuts and the mounded only one. Planting quality remained high across all three sites.

Table 3 - Productivity (Mean ± Standard Deviation)

	Pasture	Mounded	Cutover
Box weight (Kg)	6.9 (+ 1.9)	6.4 (± 0.9)	5.4 (± 0.4)
Productivity (Trees/hr)	154.0 (+ 42.4)	193.7 (+ 118.2)	202.1 (+ 78.8)
Planting Method	3 cuts	1 cut	3 cuts

Unlike the findings of Apud and Valdes (1994), mean heart rates were remarkably similar across the three sites (Table 4). Vik (1984) found that forest workers adapt to increasing demands (steeper slopes and difficult terrain) by decreasing productivity. This was also the case in the present study, where the planters compensated for the increased demands of planting on the pasture (steeper slopes, stronger soil and heavier boxes), by planting significantly fewer trees per hour.

Table 4 - Heart rate measures (Mean \pm Standard Deviation)

	Pasture	Mounded	Cutover
Heart Rate	134.8	132.7	134.9
Work HR _w	(+ 14.7)	(+ 16.2)	(+ 13.8)
%CVL	53.0	51.9	56.0
	(+ 4.2)	(+ 8.8)	(+ 7.2)

The mean heart rates calculated here place planting in the "Very heavy work" category (Table 5). This is higher than all other tasks measured by LIRO, including:

- Breaking-out - Moderate work (Kirk and Sullman, 1995)
- Log making - Moderate work (Parker, Cossens and Strang, 1993)
- Clearfell felling - Moderate to Heavy work (Kirk, Sullman and Parker, In Press)
- First lift pruning of Douglas fir - Heavy work (Kirk and Parker, 1996)
- Second lift pruning of Douglas fir - Heavy work (Hartsough and Parker, 1993)
- Third lift chainsaw and manual pruning of Pinus radiata - Heavy work (Ford, 1995).

Table 5 - Classification of workload (Åstrand and Rodahl, 1986)

Light work	up to 90 bt. min ⁻¹
Moderate work	90-110 bt. min ⁻¹
Heavy work	110-130 bt. min ⁻¹
Very heavy work	130-150 bt. min ⁻¹
Extremely heavy work	150-170 bt. min ⁻¹

To avoid excessive fatigue, it is generally recognised that self-paced workers will not exceed 35% to 45% of their maximum CVL when working an eight-hour day (Johansson and Ljunggren, 1989; Evans, Winsmann, Pandolf and Goldman, 1980).

The findings from the present study indicate that, on average, the planters were working from 51.9% (\pm 8.8) (spot-mounded) to 56.0% (\pm 7.2) (untreated cutover) of their maximum cardiovascular

load (Table 4), which is above the 35% to 45% level. This indicates that the planters were working at an unsustainable level and would be expected to be experiencing high levels of fatigue, accumulating over the working week.

As the %CVL is calculated for an eight-hour day, measuring a shorter day will result in an over-estimate. The planters, for the most part, worked a seven to eight-hour day (plus one half-hour break), therefore the %CVLs calculated here are not over-estimates.

Hazards

Table 6 shows the percentage of each type of hazard observed at the three sites. Compared to other forestry tasks, the number of hazards was low, ranging from one per hour to one every four hours.

Table 6 - Hazards

	Pasture	Mounded	Cutover
Slips/Trips	81%	50%	100%
Spade hit solid object	19%	40%	0%
Spade hit boot	0%	10%	0%
Hazards/Hour	1.09	0.56	0.25

Slips accounted for the majority of hazards for all three sites, accounting for 76% of all observed hazards.

Body Part Discomfort

Planters did not report any discomfort while planting on spot-mounded or untreated cutover. On the pasture, discomfort was mentioned in 48% of all cases. The right (planting) elbow was the most frequently reported area of discomfort, followed by the mid-back. Possible reasons for discomfort only being found on the pasture include: the soil was significantly stronger (right elbow), the boxes were significantly heavier (mid-back and hips) and the terrain was significantly steeper (feet, ankles, lower leg).

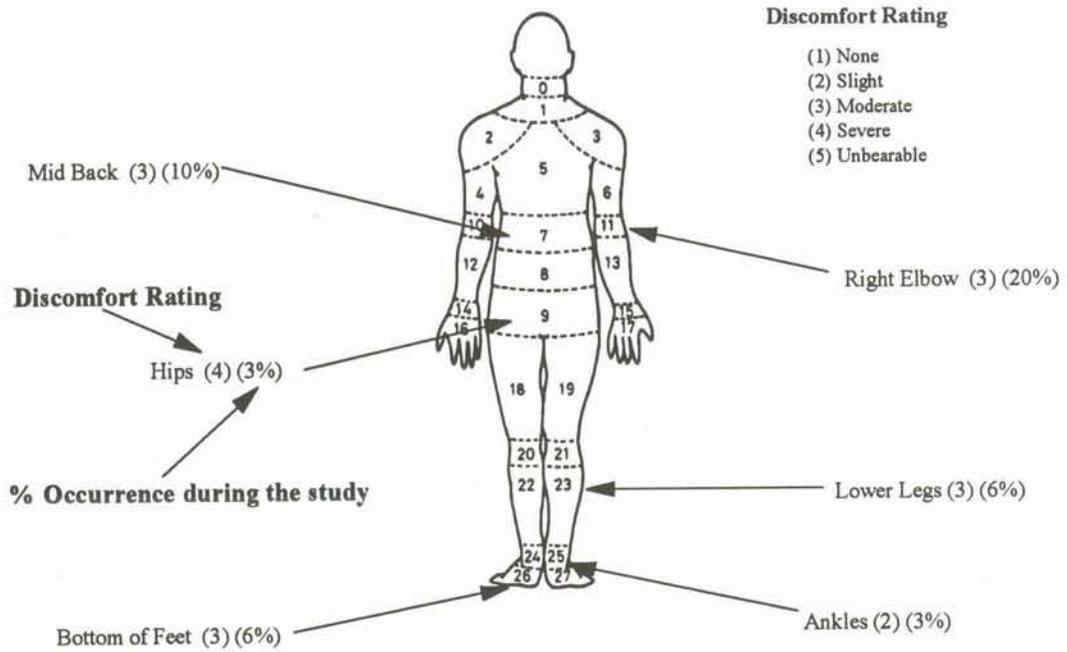


Figure 2 - Body part discomfort on the pasture (all subjects combined)

CONCLUSIONS

- An assessment of the planters indicated that they were working at unsustainably high levels of physical workload on all three sites.
- Planters maintained similar mean working heart rates for all three sites, by decreasing productivity as planting conditions became more difficult.
- Productivity on the untreated pasture was significantly lower than on the other two sites; to some extent, this was a result of the steeper slopes, heavier boxes and stronger soil.
- Body part discomfort was only experienced when planting on pasture, where slight to severe discomfort was reported 48% of the time.
- Hazard occurrence was low for all three site conditions, ranging from one hazard per hour (pasture) to one every four hours (untreated cutover).

- Slips accounted for 76% of all hazards, with hitting a solid object or the boot with the spade accounting for the rest.

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For further information, contact:

LOGGING INDUSTRY RESEARCH ORGANISATION
P.O. Box 147,
ROTORUA, NEW ZEALAND.

Fax: 07 346-2886

Telephone: 07 348-7168