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Ergonomics of Tree Planting

by
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SUMMARY

Responses of tree planters to an extensive health questionnaire administered several times throughout a planting season have been correlated with objective measures of health status and fitness. These measures included continuous heart rate records measured during work; and pre-and post-work measures of serum enzyme activity, plasma norephinephrine (NE) and epinephrine (E) concentration, and blood cholinesterase activity (also measured serially). Video monitoring of work patterns of experienced and inexperienced workers complemented the physiological and biochemical measures.

That tree planting is strenuous work was confirmed from 10- to 15-hour records of the heart rate of experienced and inexperienced tree planters. Inexperienced planters seem to be particularly stressed, maintaining heart rates equal to 60-70% of maximum for long periods (>6 hours) each day.

Further evidence of this stress was obtained from the serial measurement of pre- and post-work mean elevation of serum enzyme activity (ESEA) and plasma NE and E concentration in the planters. Although some adaptation to the strenuous activity was shown by a decline from extreme initial ESEA early in the season to lower levels after 2-3 weeks of working, a return to baseline levels was not recorded until after a rest period when the contract had finished. Pre- to post-work elevation of NE and E concentrations was not significantly different, but both plasma NE and E increased progressively throughout the period, and NE elevation above the initial day's measurement reached a significant level by the end of the period. Post-season measurement of their concentration was not made.

Continued elevation of circulating levels of NE and E, both indicators of cardiorespiratory, thermoregulatory, and metabolic stress, is conducive to the development of "adrenal exhaustion syndrome." The symptoms of this are similar to those described by tree planters for "burn out" syndrome, and include lethargy, weakness, and light-headedness, all of which induce a disinclination to work at the job for a long period. Given the significant manpower requirement in backlog reforestation, this loss of workers is a serious problem for the industry.

Preliminary evidence has also been gathered on the susceptibility of tree planters to the effects of pesticides with which they may come into contact through handling seedlings. Symptoms of muscle weakness, muscle cramps, and gastrointestinal disorders were reported on health questionnaires received from some workers, and these are typical symptoms of illness attributable to anticholinesterase agents. Although a significant group mean blood cholinesterase depression was not shown in the planters studied, some individuals with symptoms had accompanying low blood cholinesterase activity.

ACKNOWLEDGEMENTS

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1 INTRODUCTION

It has been estimated that forest-based industry provides, directly or indirectly, one job in every 10 in Canada and contributes $12-15 billion annually to the GNP (Burch 1981; Canadian Pulp and Paper Association 1981). Central to the continued success of this industry will be the capacity to replant harvested trees. Tree planters in British Columbia now number approximately 10 000 full-time employees (Silviculture Joint Adjustment Committee Report 1988).

Until recently, we had little understanding of the physical effort of tree planting. Smith and his co-workers initially drew attention to the strenuous nature of the job in a comprehensive paper on tree planting work (Smith 1987). These investigators studied the ergonomics (i.e., the worker friendliness of the job, the ease of use of tools designed for the job, and the working environment generally) and the health and safety aspects of the work. They also reported results from a health questionnaire survey of workers on the frequency, type, and severity of their health concerns; and described the energy demands of the job and the productivity achieved by the typical worker. The conclusions of the study were sufficiently disturbing (it was found, for example, that 8 hours per day were spent doing very exhaustive work at 60% of maximum capacity) to warrant further research.

2 AIMS OF THE RESEARCH PROGRAM

The goals of the present research were to verify previous studies and to extend the analysis of how tree planting work affects worker health. To do this, objective serial sampling was carried out of several physiological and biochemical parameters indicative of stress and breakdown in the worker.

The investigation has focussed on:

1. comparing the relative energy expenditure, reflected in the heart rate elevation during work, of different tree planters;
2. attempting to identify the skills and physical attributes of an efficient planter by video-filming experienced and inexperienced planters while simultaneously monitoring heart rate (HR);
3. showing the strenuous nature of tree planting by documenting work-induced changes in serum-enzyme activity both pre- and post-work, measured serially, from the start to completion of a planting contract;
4. attempting to understand the physiological cause of the phenomenon described as "burn out" by planters, and the course of its development. This was done by monitoring changes in the circulating catecholamines, norepinephrine (NE) and epinephrine (E), which are elevated in association with strenuous activity and anxiety states, respectively; and
5. determining health hazards in tree planting attributable to the handling of chemically treated seedlings, by serial measurement of depletion of plasma cholinesterase activity in tree planters throughout several weeks of work.

3 METHODS

3.1 General

Sub-sample groups from a main cohort of Western Cooperative tree planters, usually numbering from 5 to 10 individuals, were studied in the field at various locals on Vancouver Island, and in Squamish, Kamloops, and Golden, B. C., during a 3- to 4-month period between February and June in 1988.

Data collection and observation with a group usually lasted 4-7 days. During each period, observations on several aspects of work were made and data were collected on the following:

1. The health status of an individual was initially evaluated from a questionnaire response (Appendix 1). Serial comments on current health status were assessed at the time of each blood sampling from an abbreviated questionnaire (Appendix 2).
2. A blood sample was collected from each planter for the assay of:
   i. cholinesterase activity in the serum
   ii. Norepinephrine and epinephrine in plasma
   iii. Creatine kinase activity in serum.

   Blood was taken in vacutainers and immediately centrifuged (plasma) or allowed to stand for 10 minutes before centrifugation (serum). All samples were kept on dry ice while being shipped back to Simon Fraser University for analysis.

   Blood samples for cholinesterase, norepinephrine, and epinephrine assays were frozen and kept at -80°C for periodic batch analysis. Creatine kinase activity was measured immediately within 1 day of receipt at Simon Fraser University. Cholinesterase was measured by the method of Ellman *et al.* (1961). Norepinephrine and epinephrine were analysed by HPLC with electrochemical detection, using a Bioanalytical Systems liquid chromatograph according to the method of Mefford *et al.* (1981). Creatine kinase activity was measured on a Roche Cobas Bio analyser at 30°C using BMC reagent (Boehringer-Mannheim CmBH West Germany) according to the method of Szaz *et al.* (1976).
3. The degree of energy expenditure by each worker studied was estimated from the duration of the activity and the heart rate elevation. Heart rate was monitored by an FM transmitter, secured to an individual's chest, which transmitted a record of each beat to a wristwatch for storage of minute heart rate throughout a period of 4-15 hours. These data were transferred from the watch after each observation and stored permanently for later analysis (Appendix 3).
4. For each individual, general ergonomic data on the type of working terrain, type of equipment used, number of trees planted, and travel time from camp to work site were recorded (Appendix 4).
5. Individual skill level and technique of planting were recorded on video film at the work site.

3.2 Statistics

The group mean, standard deviation, and standard error of measurement were calculated for each data set measured on serial, separate occasions when a group of tree planters was studied. A one-factor, repeated measures ANOVA was made of the parameters described under Section 3.1 to determine an F statistic of significance. Post-hoc paired t-tests or a Scheffe F test then compared pre- and post-planting data on different days for within-day differences or between-day differences (e.g., the beginning and end of the contract period) to determine any significant differences in the comparisons made.

4 RESULTS

4.1 Heart Rate

Figure 1 shows representative heart rates for an experienced planter and an inexperienced worker. No group mean data were calculated for heart rate variations throughout a planting period since data collection varied depending on the environmental conditions, terrain, and ground conditions. Nevertheless, the differing pattern of heart rate shown by the experienced and inexperienced planter, respectively, was clearly distinguishable and repeatable. A much lower elevation of HR with regular rest pauses (defined by periods of resting level HR) usually differentiated the experienced planter from the inexperienced.

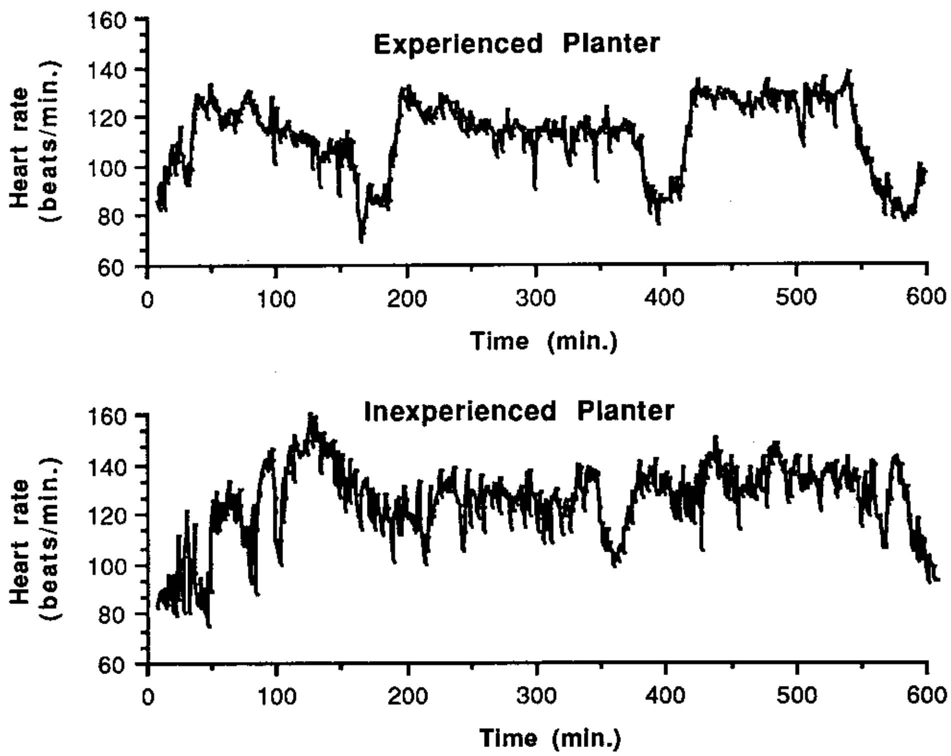


FIGURE 1. Representative heart rates in an experienced planter (top) and inexperienced planter (bottom). Well defined rest pauses characterize the experienced planters work period. These are absent in the inexperienced planters profile.

4.2 Video-Filming

Representative, taped film sequences were video-recorded on different planters throughout different days during the 5- to 7-day period spent with a group in the field on each serial occasion. These loops were used to analyse major differences in style and habit (in both skill and safety) between planters.

4.3 Elevated Serum Enzyme Activity

Table 1 and Figure 2 show the group mean elevation of serum enzyme activity (ESEA) induced by tree planting during one contract period.

TABLE 1. Serum Enzyme Activity (U/L) serially measured pre- and post-daily workshifts in male tree planters (n = 7) throughout a period of planting, in addition to single occasions immediately before planting (pre-season) and 3 weeks after planting (recovery)

Date	Pre-work	Post-work	Significance
Pre-season	45 ± 2		
Week 3	86 ± 11	133 ± 17	$p \leq .01$[a]
Week 5	72 ± 10	115 ± 14	$p \leq .02$
Week 7	76 ± 9	112 ± 10	$p \leq .001$
Recovery	50 ± 9		

[a] Pre- and post-shift values of serum enzyme activity significantly greater than pre-season and recovery enzyme activity ($p \leq .05$).

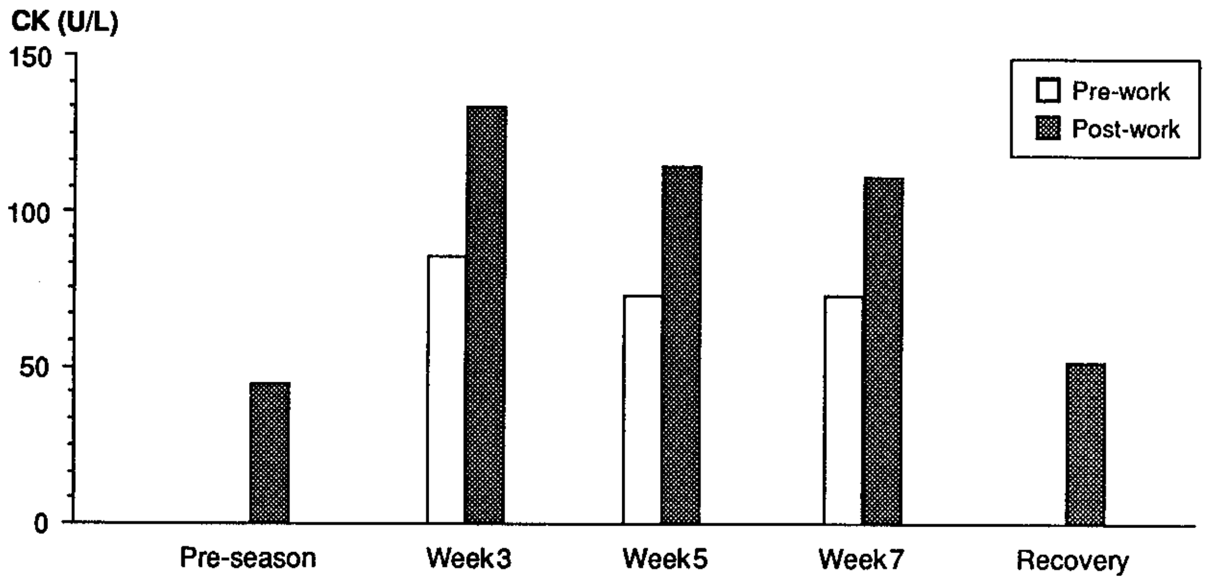


FIGURE 2. Group mean elevation (n = 7) of serum creatine kinase (CK) activity before and after a working day. The first pre-work value and the recovery value represent a control condition. Elevation of CK activity in serum rises quickly to a peak and subsides to a lower level higher than the control condition.

A significant ESEA above the group mean pre-season value took place in both pre- and post-work blood samples immediately after field work began at season's start. Post-work ESEA peaked 3 weeks into the contract period and subsided slightly thereafter, although it remained significantly elevated above pre-season serum enzyme activity. An ESEA did not return to baseline until after a recovery period following contract completion.

4.4 Plasma Catecholamine Elevation

Tables 2 and 3 show the group mean response of the plasma NE and E respectively, induced by tree planting work. No significant increase occurred between pre- and post-work samples in either norepinephrine NE or epinephrine E, respectively, on any day of planting which was monitored.

TABLE 2. Plasma norepinephrine concentration (nM) in male tree planters (n = 5) measured serially pre- and post-workshifts throughout a period of planting

Date	Pre-work	Post-work	Significance[a]
3 April/88[b]	3.335 ± 0.401	3.105 ± 0.340	NS ($p > 0.1$)
10 April/88	2.554 ± 0.345	2.652 ± 0.413	NS ($p > 0.1$)
23 April/88	3.504 ± .620	3.882 ± 0.556	NS ($p > 0.1$)
30 April/88[b]	5.105 ± 0.617	6.705 ± 0.365	NS ($p > 0.1$)

[a] NS: Not significant.
[b] A significant elevation of norepinephrine was observed by the 30 April 1988 in both pre- and post-group mean values compared with corresponding initial values on the 3 April 1988.

TABLE 3. Plasma epinephrine concentration (nM) in male tree planters (n = 4) measured serially pre- and post-workshifts throughout a period of planting

Date	Pre-work	Post-work	Significance[a]
3 April/88	0.883 ± 0.514	.282 ± 0.047	NS (p > 0.1)
10 April/88	0.812 ± 0.297	0.426 ± 0.196	NS (p > 0.1)
23 April/88	1.053 ± 0.186	0.790 ± 0.197	NS (p > 0.1)
30 April/88	1.815 ± 0.475	1.953 ± 1.181	NS (p > 0.1)

[a] NS: Not significant.

A significant increase above the pre-season NE concentration occurred, however, by the end of the planting contract (week 7) in both pre- and post-work samples. No significant increase occurred in plasma epinephrine at any point in the planting cycle. General chronic trends in work-induced NE and E plasma concentration for tree planters are shown in Figure 3.

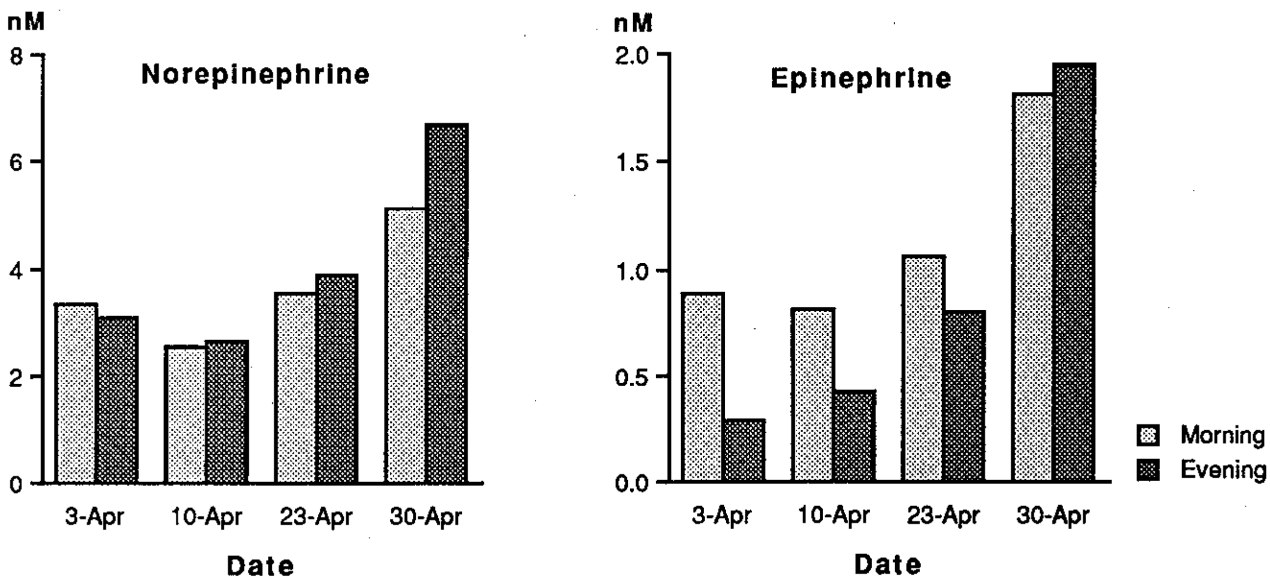


FIGURE 3. Serial measures of group mean plasma norepinephrine (NE) and epinephrine (E) concentration throughout a planting period in tree planters. Pre- and post-work concentrations of NE (left) both rise by the end of the period to become significantly elevated ($p < 0.1$). The E concentration (right) did not rise significantly in the same period, although the trend to increase was similar.

4.5 Plasma Cholinesterase Activity

Table 4 shows changes in plasma cholinesterase activity measured throughout the planting period. No significant changes were observed in the serial mean values of these groups either acutely during each day of planting or chronically between the values at the beginning and end of the contract. Figure 4 shows two individual plasma cholinesterase profiles: one in a planter with continuous health problems and the other in one suffering few effects. These patterns are dissimilar and indicate a widely varying individual susceptibility to any anticholinesterase agent encountered or to other non-specific causes not monitored.

TABLE 4. Plasma cholinesterase activity (μmol/min per mL) pre- and post-work throughout a planting period in groups of male tree planters

Date	Pre-work	Post-work	Weeks of Planting	Significance[a]
3 April/88	3.386 ± 0.403	3.182 ± 0.125	3	NS ($p > 0.1$)
10 April/88	4.426 ± 0.380	5.348 ± 1.083	7	NS ($p > 0.1$)
23 April/88	3.469 ± 0.404	3.481 ± 0.264	10	NS ($p > 0.1$)
30 April/88	3.332 ± 0.304	3.583 ± 0.404	9	NS ($p > 0.1$)
26 May/88	3.997 ± 0.331	4.354 ± 0.348	14	NS ($p > 0.1$)

[a] NS: Not significant.

4.6 General Camp Logistics

From data accumulated from 110 worker-response questionnaires, and from daily observations and notes made by field workers, the disposition of a worker's time was evaluated. Figure 5 shows the general distribution of time spent by the planting crew in work, leisure, sleep, and camp chores and the distribution of work time between planting, travel, breaks, and lost time, during the period under study.

5 DISCUSSION

That tree planting is energetically taxing to both experienced and inexperienced workers alike is evident from Figure 1. The experienced planter's HR elevation throughout a work day, while much lower than the inexperienced worker, is, nevertheless, very high compared with the average of most other job heart rates. The working heart rate of the experienced planter rose gradually during the day until, in the late period of work, it reached 114-126 b.min-1, (57-63% maximum work capacity). This heavy rate of work is offset somewhat by the worker's judicious use of rest pauses throughout. The novice planter's energy expenditure, revealed by the degree of his/her HR elevation, was much higher throughout the workshift and was close to 140 b.min-1 (70% of maximum work capacity) for almost the whole day. The periodic, recuperative rest pauses used by the experienced planter are conspicuously absent from the inexperienced worker's duty cycle.

Video analysis confirms the unskilled activity, relatively poor distribution of work to rest time, and indecisive action in choosing planting sites on the part of the inexperienced worker. The experienced worker's activity, on the other hand, is characterized by incisive choice of planting site, skilled planting action, all-round general alertness, and judicious choice of rest breaks within the working day.

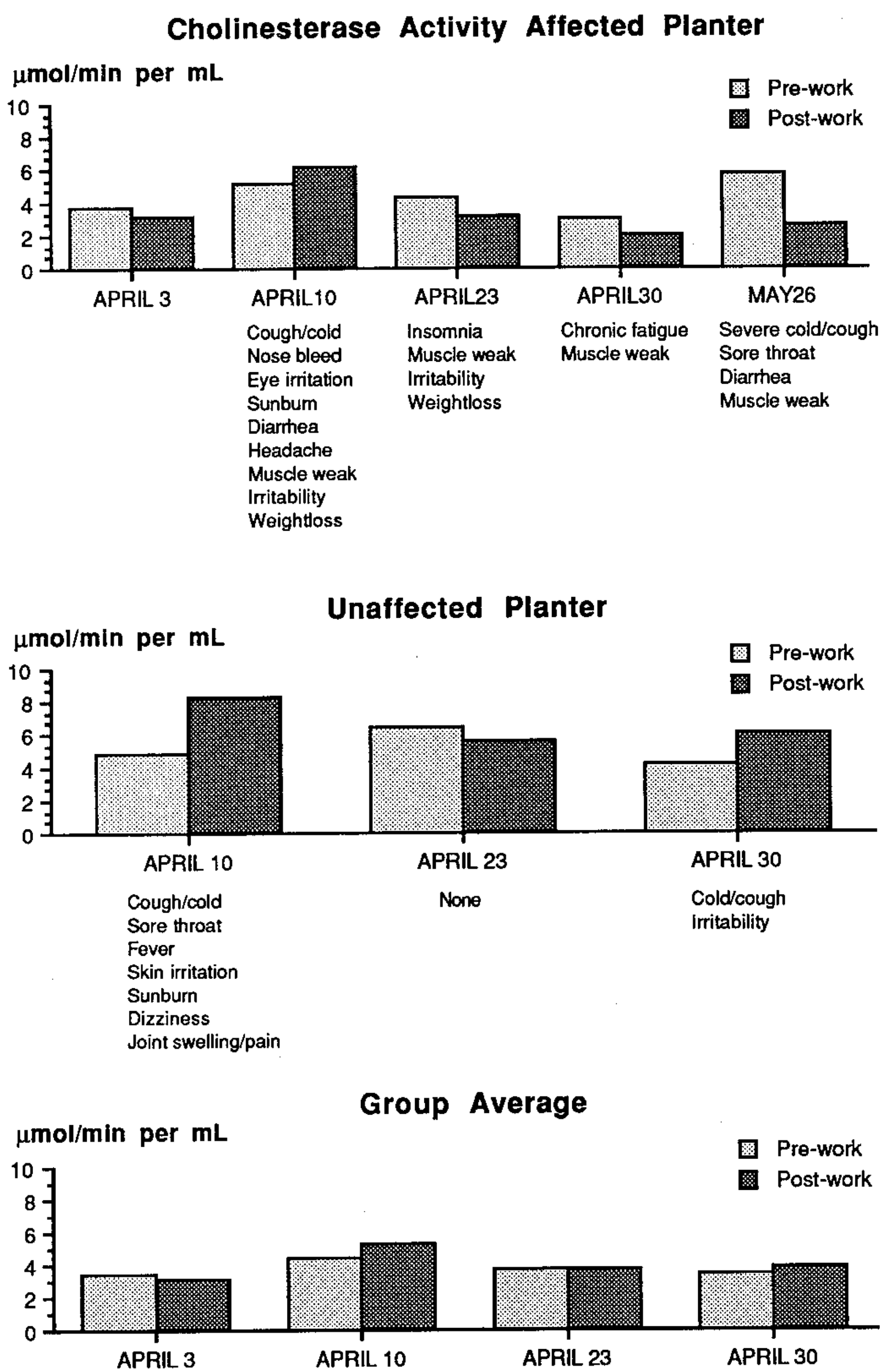
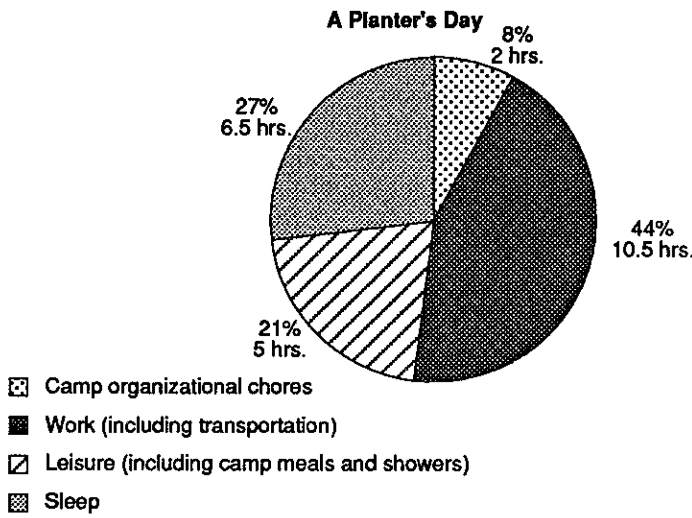


FIGURE 4. Plasma cholinesterase activity in silviculture workers; one who reports a variety of non-specific and specific symptoms of cholinesterase depression (top), one who shows little susceptibility (middle), and the group mean average activity (n = 5) throughout a period of planting (bottom). No level of decrease in plasma cholinesterase either daily, pre- to post-work, or longitudinally from the beginning to the end of the period reached a significant level.

A 24-hour work/rest cycle typical for a tree planter. (Note that sleep time is reduced by 6% (1.5 hours) compared with the usual 8-hour population norm. Sleep may be compromised to maintain a satisfactory amount of leisure each day.)



Daily activity chart for tree planting work.
(Represents averaged data from 110 daily questionnaire responses.)

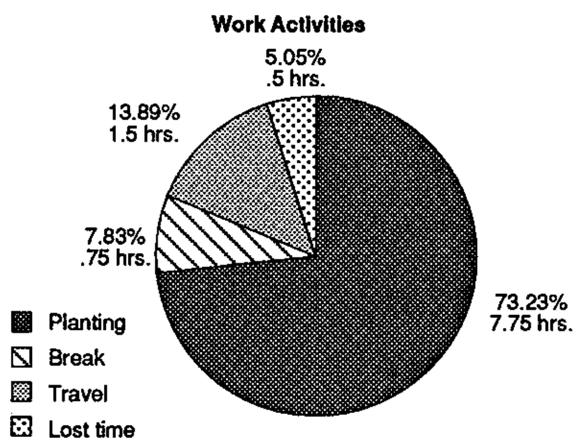


FIGURE 5. Distribution of time spent, on average, in camp routine including planting (top); and distribution of the time allocated to planting with the total proportion of time allocated to work (bottom).

5.1 Burn-Out

It is generally agreed among workers and researchers that silviculture work is strenuous and hazardous, and workers' concern about their health and safety may be a major reason for labour instability (Smith 1987; Silviculture Joint Adjustment Committee Report 1988). A significant contributor has been termed "burn out," a condition tree planters describe of increased fatigue, apathy, non-specific illness, etc., which contributes to an overall disinclination to continue working and an increased accident proneness. This condition, therefore, has the potential to reduce the size of the work force available during a planting season, which now extends over a period of 8 months or more. In 1988, the Pacific Reforestation Workers Association estimated a 50% turnover rate in the industry, with some regions having as high as 80%. More accidents are also being reported.

Physiological support for the ill feelings usually described by workers is evident first in the high heart rates maintained over several hours, as described above.

Secondly, the group mean ESEA shown in Figure 2 is consistent with the chronic strenuous nature of the job. Muscles that are severely used usually "leak" enzymes through the muscle membranes into the blood, producing the ESEA which may be monitored from blood samples. Muscle soreness, tiredness, and even pathology result (Frieden 1984; Janssen *et al.* 1988). The exercise literature extensively documents these conditions. It is noticeable in the present study that the silviculture workers gradually make some adaptation to the work stress, since ESEA abates with continued activity. Full recovery to a baseline level does not occur, however, until after a period of recovery following the end of planting. Serial post-work measurements of ESEA during the planting period show the continuing elevation induced each day by the current work, and the recovery, after overnight rest to the pre-work, measurement. This daily elevation was always significant on any day at the $P \leq .01$ level. Athletes exhibit similar ESEA profiles during strenuous training. Like tree planters experiencing burn out, athletes become overstrained, tired, and unenthusiastic about continuing training and competing.

The third component contributing to the physiological stress of tree planting is a clinical state previously reported as "adrenal exhaustion syndrome" (Sulman *et al.* 1977). The accompanying symptoms (weakness, apathy, hypotension, lassitude, etc.) are similar to those reported by tree planters. The cause of the problem, reported most often in arid, hot climates, is a continuing elevation of the circulating catecholamines, NE and E, as efforts to maintain thermoregulatory control, metabolic rate, and muscular effort become exhausted and physiological regulation begins to fail (Euler and Hellner 1952; Sulman *et al.* 1974). Tables 2 and 3 and Figure 3 show the continuing elevation of NE and E group mean values in tree planters throughout a period of planting. By the end of the period (30 April 1988), NE is significantly elevated over the beginning level (3 April 1988) . No significant difference was observed between pre- and post-work levels in either NE or E, nor did E become significantly elevated by the end of the period over what it was at the start.

Obviously, the burn out syndrome is incompatible with an extended planting season. Consequently, various combinations of work/rest cycles and work intensity must be investigated to find out how the recuperative powers of the worker might be reconciled with longer seasons of work, so that productivity can be optimized. A high productivity resulting from an unrealistic high initial working rate may cause early fatigue and a decline in working capacity. This may overall lead to lowered productivity and an abbreviated planting season.

Lastly, silviculture workers may be subjected to potentially hazardous chemicals during the course of their work. The degree to which workers are affected by chemical pesticide residues on the seedlings or in the field was assessed from the measurement of plasma cholinesterase in serially sampled blood throughout the study period.

Butyrylcholinesterase (ChE) is found in the cytosol and plasma compartments and is sometimes referred to as pseudo-cholinesterase. This distinguishes it from neuronal acetyl cholinesterase (AChE), the enzyme which hydrolyses acetylcholine at all sites of cholinergic transmission, in neural and muscle tissue. The exact function of ChE is not known (Trundle and Marcial 1988). However, measurement of ChE is useful in the diagnosis of pesticide poisoning since it mirrors the action of AChE in being moderately depressed (Trundle and Marcial 1988).

Organophosphate and N-methyl carbamate pesticides inhibit AChE, and this results in accumulation of acetylcholine in the nervous system (Brown *et al.* 1989). This produces clinical symptoms of nausea, vomiting, diarrhea, tightness of the chest, sweating, and salivation. Severe poisoning may result in death.

Any degree of change in enzyme activity is usually referred to a baseline level for evaluation of effect, since there is wide individual variation as well as methodological variation which needs to be considered in assessing cholinesterase activity objectively.

Table 4 shows this variability of ChE activity in small groups of tree planters measured throughout the planting period. No significant depression of the group mean ChE activity took place either during a working day (pre- to post-values) or from the beginning of the planting period to the end (April 3 to May 26 for ChE measurements).

Figure 4 shows group mean pre- and post-work ChE values throughout a planting period and similar measures made on two planters: one "affected," who demonstrated many non-specific symptoms but also some fitting the clinical picture of anticholinesterase action; the other "unaffected," who reported few symptoms. These data show the variability between subjects and of individual worker susceptibility to exposure. The unaffected worker, however, shows little serial variability, consistent with the group mean values. Correspondence between clinical signs of anticholinesterase activity and ChE depression is more apparent in the affected worker.

These data remain equivocal in the absence of greater numbers and frequency of sampling of subjects in the field. However, serial sampling rather than episodic measurement remains the method of choice (Coye *et al.* 1987) if any further insight into a possible problem is to be evaluated.

Currently, California is the only state to impose medical surveillance of agricultural workers exposed to pesticide or herbicide hazards. Surveillance of workers through serial blood ChE measurement is recommended for all who might have exposure of over 30 hours in any 30-day period (Trundle and Marcial 1988).

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APPENDIX 1. Tree planter health and medical questionnaire

NAME OR I.D. NUMBER.	SEX	AGE IN YEARS	HIEGHT	YOUR BODY WIEGHT	PLANTING EXPERIENCE [YEARS]	SMOKING CIGS/DAY	SMOKING OTHER TIMES/WK	ALCOHOL CONSUMPTION drinks/DAY

INDICATE IF YOU HAVE EXPERIENCED ANY OF THE FOLLOWING DURING THIS PLANTING SEASON. (CHECK=YES)
COLDS/COUGHING
SORE THROAT
NOSE IRRITATION
NOSE BLEEDS
EYE IRRITATION
SKIN IRRITATION
SUNBURN
VOMITING
DIARRHEA
DIZZINESS
HEADACHE
INSOMNIA
CHRONIC FATIGUE
MUSCLE WEAKNESS
JOINT SWELLING/PAIN
BACK PAIN
IRRITABILITY
LOSS OF APPETITE
WIEGHT LOSS
DEPRESSION
ALTERED SEX DRIVE
OTHER:

LIST ANY ATHLETIC, SPORTS, OR TRAINING ACTIVITIES YOU DO OUTSIDE THE PLANTING SEASON, ESPECIALLY IF IT IS FOR PRE-SEASON CONDITIONING...

____

____

____

____

____

____

PLEASE DESCRIBE ANY DIET SUPPLEMENTS YOU ARE TAKING	LIST ANY PAIN MEDICATION YOU NOW TAKE	BODY PART INJURED AND NO. OF TIMES		WCB CLAIMS		DAYS LOST TO INJURIES	
		IN 1988	IN 87	1988	87	IN 1988	87

DAYS YOU WORKED		DID YOU RECIEVE ANY TRAINING TO BECOME A PLANTER ? IF SO, WHERE OR WHO FROM?	PRE-SEASON (P) OR ON THE JOB (O)	FOR HOW LONG?	WHEN? (WHAT YEAR?)	DID IT HELP YOU GET A JOB?	WAS IT WORTHWHILE?
IN 1988	87						

APPENDIX 2. Serial health questionnaire

	INDICATE IF YOU HAVE EXPERIENCED ANY OF THE FOLLOWING DURING THIS PLANTING SEASON. (CHECK=YES)
1	COLDS/COUGHING
2	SORE THROAT
3	NOSE IRRITATION
4	NOSE BLEEDS
5	EYE IRRITATION
6	SKIN IRRITATION
7	SUNBURN
8	VOMITING
9	DIARRHEA
10	DIZZINESS
11	HEADACHE
12	INSOMNIA
13	CHRONIC FATIGUE
14	MUSCLE WEAKNESS
15	JOINT SWELLING/PAIN
16	BACK PAIN
17	IRRITABILITY
18	LOSS OF APPETITE
19	WIEGHT LOSS
20	DEPRESSION
21	ALTERED SEX DRIVE
22	OTHER:

APPENDIX 3. Heart Rate data file

	A	B	C	D	E	F	G	H	I
1									
2		SUBJECT		NICK R.		8802			
3									
4		DATE		25 02 88					
5									
6									
7									
8	EVENT	TIME							WORKSHEET
9	OR	OF		HEART		AVERAGES	AVE.		CELLS
10	OBSERVATION	DAY	MIN.	RATE		FOR MINUTES	H.R.		AVERAGED
11		8:14	1	92		1 TO 60	127		D11 TO D70
12			2	95		61 TO 120	138		D71 TO D130
13			3	105		121 TO 180	132		D131TO D190
14			4	116		181 TO 240	119		D191 TO D250
15			5	114		241 TO300	142		D251 TO D310
16			6	111		301 TO 360	130		D311 TO D370
17			7	114		361 TO 420	114		D371 TO D430
18			8	113		421 TO 480	134		D431TO D490
19			9	106		480 TO 540	128		D491 TO D550
20			10	107		540 TO 600	96		D551 TO D610
21			11	101					
22			12	96					
23			13	97		1 TO 600	128		D11 TO D610
24			14	108					
25			15	105					
26			16	118					
27		8:30	17	110					
28			18	108					
29			19	110					
30			20	104					
31			21	118					
32			22	133					
33			23	136					
34			24	130					
35			25	136					

	K	L	M	N	O	P	Q	R	S
1									
2		SUBJECT		BRAD 8803					
3									
4		DATE	26 02 88						
5									
6									
7									
8	EVENT	TIME							WORKSHEET
9	OR	OF		HEART		AVERAGES	AVE.		CELLS
10	OBSERVATION	DAY	MIN.	RATE		FOR MINUTES	H.R.		AVERAGED
11	START	8:31	1			1 TO 60	####		N11 TO N70
12			2			61 TO 120	####		N71 TO N130
13			3			121 TO 180	108		N131TO N190
14			4			181 TO 240	140		N191 TO N250
15			5			241 TO300	####		N251 TO N310
16			6			301 TO 360	####		N311 TO N370
17			7			361 TO 420	####		N371 TO N430
18			8			421 TO 480	####		N431TO N490
19			9			480 TO 540	####		N491 TO N550
20			10			540 TO 600	####		N551 TO N610
21			11						
22			12						
23			13			1 TO 600	136		N11 TO N610
24			14						
25			15						
26			16						
27			17						
28			18						
29			19						
30			20						
31			21						
32			22						
33			23						
34			24						
35			25						

APPENDIX 4. Daily Q data file

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	NAME OR			TOTAL		# OF	BAG WT.	SLOPE		GLOBE			# OF	BRK
2	ID #	DATE	SITE	PROD	TOOL USED	BAGS	[KG]	percent grade	WB °C	°C	DB °C	TOT PLANT TIME	BRKS	TIME
3												MINUTES		
4	8802	25 02 88	CL.CREEK	850	short D-handle shovel	3	13	20 - 75	8	8.5	9.5	450	2	60
5	8804	25 02 88	CL.CREEK	1000	short D-handle shovel	4	.					450	2	60
6		25 02 88	CL.CREEK	700	"SHOVEL"	2						480	2	30
7		25 02 88	CL.CREEK	1000	"SHOVEL"	4						480	2	30
8		25 02 88	CL.CREEK	700	"SHOVEL"	2						470	1	30
9		25 02 88	CL.CREEK	375	"SHOVEL"	1						150	0	0
10		25 02 88	CL.CREEK	600	"SHOVEL"	3						450	2	60
11														
12	8802	26 02 88	CL.CREEK	600	short D-handle shovel	2						335	1	25
13	8804	26 02 88	CL.CREEK	800	short D-handle shovel	3						480	2	60
14		26 02 88	CL.CREEK	700	"SHOVEL"	3						450	2	45
15	[CHECKER]	26 02 88	CL.CREEK	100	short D-handle shovel	0						-	-	-
16		26 02 88	CL.CREEK	600	"SHOVEL"	2						420	1	90
17		26 02 88	CL.CREEK	750	"SHOVEL"	3						480	2	60
18	8803	26 02 88	CL.CREEK	750	short, straight-handle shovel	3	13	25	8.5	8.5	8.5	480	2	45
19														
20	NAME OR			TOTAL		# OF	BAG WT.			GLOBE			# OF	BRK
21	ID #	DATE	SITE	PROD	TOOL USED	BAGS	[KG]	SLOPE	WB °C	°C	DB °C	TOT PLANT TIME	BRKS	TIME
22		27 02 88	CL.CREEK	675	"SHOVEL"	3						456	2	60
23		27 02 88	CL.CREEK	675	"SHOVEL"	3						481	2	35
24	8803	27 02 88	CL.CREEK	800	short, straight-handle shovel	3	13	15 - 45	3 - 12.5	5 - 25	4.5 - 16	430	2	65
25														
26	8801	28 02 88	CL.CREEK	900	D-handle shovel	3						489	2	35
27	8802	28 02 88	CL.CREEK	775	short D-handle shovel	3						450	2	60
28	8804	28 02 88	CL.CREEK	800	short D-handle shovel	3	16	5 - 35	3 - 13.5	7 - 27	7 - 14	420	3	90
29		28 02 88	CL.CREEK	700	"SHOVEL"	3						465	3	45
30		28 02 88	CL.CREEK	600	short D-handle shovel	2						490	2	35
31														
32	8802	29 02 88	CL.CREEK	775	short D-handle shovel	3						465	2	60
33	8804	29 02 88	CL.CREEK	900	short D-handle shovel	3						420	2	90
34		29 02 88	CL.CREEK	600	"SHOVEL"	3						495	2	30
35		29 02 88	CL.CREEK	775	short D-handle shovel	3						505	2	30
36														

APPENDIX 4. continued

	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
1	TRAVEL TIME	WALK	AMT. OF SLEEP	LOST PROD.		SLOPE	TIME			SCREEF	TIME			SOIL TIME
2	TOT. (MIN.)	TIME	(MIN.)	TIME	REASON FOR LOST PROD. TIME	STEEP %	MOD %	GENTLE %	FLAT %	HEAVY %	MOD %	LIGHT %	NONE %	ROCKY %
3														
4	70	1	330	0	-	25	20	15	40	20	30	30	20	0
5	60	2	480	30	"Delays"	5	25	50	-	10	30	40	20	2
6	70	2	360	0	-	0	90	10	0	0	10	30	60	0
7	70	1	330	0	-	0	10	90	0	0	80	20	0	0
8	60	1	420	30	Gassing trucks, people not ready.	0	70	30	0	30	30	20	20	10
9	60	1	540	390	Back siezed up.	100	0	0	0	-	60	-	-	0
10	90	28 SEC.	360	30	Changing blocks.	40	60	0	0	100	0	0	0	10
11														
12	70	5	330	0	-	20	25	15	40	20	25	25	20	0
13	60	3	480	0	-	0	5	20	75	5	20	70	5	0
14	50	4	270	0	-	0	30	70	0	0	10	80	10	0
15	70	-	-	-	-	20	20	30	30	-	-	-	-	-
16	60	2	420	60	Wet.	-	20	80	-	10	30	30	30	-
17	90	11 SEC.	420	0	-	0	100	0	0	0	100	0	0	0
18	60	1	360	0	-	20	80	0	0	60	-	-	-	0
19														
20	TRAVEL TIME	WALK	AMT. OF SLEEP	LOST PROD.		SLOPE	TIME			SCREEF	TIME			SOIL TIME
21	TOT. (MIN.)	TIME	(MIN.)	TIME	REASON FOR LOST PROD. TIME	STEEP %	MOD %	GENTLE %	FLAT %	HEAVY %	MOD %	LIGHT %	NONE %	ROCKY %
22	80	1	330	0	-	40	10	40	10	5	10	70	15	0
23	60	2	360	0	-	40	10	40	10	5	10	70	15	0
24	70	-	-	0	-	0	50	50	0	0	25	75	0	0
25														
26	70	1	360	0	-	0	33	33	33	0	50	50	0	10
27	70	1	360	0	-	15	10	75	0	30	30	15	15	0
28	60	0	540	30	Delays, switching blocks.	5	20	50	25	5	30	60	5	0
29	80	5	420	45	Changing area.	0	20	70	10	5	10	70	15	0
30	70	3	330	0	-	15	0	75	10	0	70	0	30	-
31														
32	70	1	360	0	-	0	75	25	0	30	30	40	0	0
33	70	0	540	0	-	0	50	50	0	10	50	30	10	0
34	60	3	390	60	Driving / slow start.	10	78	0	2	0	50	50	0	-
35	60	3	480	0	-	-	30	30	30	0	50	50	0	0
36														

APPENDIX 4. concluded

	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM
1	OVERGROWTH	TIME			LOGGING	DEBRIS			BURNT	INJURY OR HEALTH PROBLEM EXPERIENCED	answered
2	HEAVY %	MOD %	LIGHT %	NONE %	HEAVY %	MOD. %	LIGHT %	NONE %	SITE ?	TODAY.	daily Q?
3											
4	0	0	0	100	25	25	20	30	YES	A 2" scratch in rt. forehead,from sharp stick in slash.	Y
5	0	0	10	90	5	10	70	15	YES	"Banged"his knee; pain was aggravated by overuse.	Y
6	0	0	0	100	0	30	30	40	YES	Sore neck from this mornig.	Y
7	-	-	-	-	10	40	30	20	YES	None.	Y
8	0	10	12	75	0	30	40	30	YES	None.	Y
9	-	-	-	0	0	100	0	0	YES	Lower back cramps.	Y
10	100	0	0	0	100	0	0	0	YES	None.	Y
11											
12	0	0	5	95	30	20	20	30	YES	None.	Y
13	0	5	10	85	5	80	10	5	YES	None.	Y
14	0	10	10	80	0	20	60	20	YES	None.	Y
15	-	-	-	-	-	-	-	-	-	None.	Y
16	-	-	-	-	-	20	50	30	YES	None.	Y
17	-	20	-	-	0	100	0	0	50/50	None.	Y
18	-	-	-	-	100	0	0	0	YES	None.	Y
19											
20	OVERGROWTH	TIME			LOGGING	DEBRIS			BURNT	INJURY OR HEALTH PROBLEM EXPERIENCED	
21	HEAVY %	MOD %	LIGHT %	NONE %	HEAVY %	MOD. %	LIGHT %	NONE %	SITE ?	TODAY.	
22	0	20	30	50	5	30	45	0	50/50	None.	Y
23	0	20	30	50	5	30	45	0	50/50	None.	Y
24	0	0	20	80	25	75	0	0	YES	None.	N
25											
26	-	66	-	-	0	100	0	0	YES	None.	Y
27	0	0	25	75	50	25	25	0	YES	Bruised shins.	Y
28	25	25	0	50	20	20	60	0	NO	None.	Y
29	0	30	30	40	15	40	30	15	NO	None.	Y
30	-	-	20	-	0	100	0	0	-	Poked by tree branch in chin.	Y
31											
32	0	0	25	75	50	25	25	0	YES	Bruised shins.	Y
33	20	20	60	0	20	50	30	0	YES	None.	Y
34	50	50	0	0	100	0	0	0	50/50	"Mental stress; psychological injury."	Y
35	50	50	0	0	100	0	0	0	50/50	"Mental stress; psychological injury."	Y
36											