AN ECONOMIC STUDY OF EARLY CLEARFELLING OF IMPERFECTLY MANAGED STANDS IN OTAGO COAST AND BERWICK STATE FORESTS

L. A. J. HUNTER* AND B. EVERTS†

ABSTRACT

Certain stands in Otago Coast and Berwick State Forests which had received little or no silviculture owing to heavy gorse infestation were the object of an early clearfelling proposal for the supply of industrial wood. An economic analysis was undertaken to determine the price at which the forest grower would be indifferent between early clearfelling and allowing the stands to reach maturity (the laissez-faire *choice). The method retains in essence the usual DCF format, but substitutes the concept of Current Net Worth (CNW) for the customary present value at the start of the rotation. Sensitivity analyses were conducted on the discount rate, the rotation length and the felling revenues.*

Results showed that the "indifference" stumpage for early clearfelled material was minimised at between $\$8/m^3$ and $\$12/m^3$ when the decision to early clearfell was made between the 13th and 18th year of age. At the time of the study these stumpages were high, but more recently actual examples have been recorded in other regions. The method may be useful for local situations, but care should be exercised in extending results to larger areas.

OBJECTIVE

The objective of the study was to determine a price for timber clearfelled prematurely to supply industrial wood such that the forest grower would be indifferent between accepting the early clearfelling at the calculated price, and continuing with his planned rotation and expected returns.

INTRODUCTION TO METHOD

The problem is that a choice must be made between an immature enterprise which has fallen patently short of its pre-planned objectives, and alternative enterprises whose expectations of success are much greater. Throughout the analysis, the best course

*School of Forestry, University of Canterbury, Private Bag, Christchurch.
†J. G. Groome & Associates, P.O. Box 13-382, Christchurch.

of action with respect to the situation *at the present moment* is studied, and in accordance with economic principles, no attempt is made to resurrect sunk costs and to consider how these might be recouped — *i.e.*, money spent on bringing the plantations to their present state is irrelevant to the analysis.

THE MODEL

The model is built upon the choices open to the forest grower at the moment of decision, *m*, and depends upon discovering the price for prematurely felled timber at which the grower would be *indifferent* between this course of action and his planned schedule. The choices considered are:

(1) A *laissez faire* choice.
The *laissez faire* choice involves leaving the gorse-infested stands to reach maturity (45 cm dbhob or age 30, whichever is the earlier), and to sell the heterogeneous crop as a mixture of sawlogs and pulpwood.

(2) Early clearfelling followed by a framing regime.
After clearfelling, an intensive gorse-control operation is undertaken, which occupies two years in the economic model as it is composed of a lengthy sequence of crushing, burning and spraying with 2,4,5-T. A framing regime is established on the cleared ground. This preference, rather than a maximum clearwood regime, is based on a Forest Service verbal communication. According to the Southland Growth Model, 45 cm dbhob is achieved at age 22. This seems remarkably early, but the figure is retained in the calculations as it does not affect the methodology.

Each of the choices is considered as a whole project in itself, and is composed of the remainder of the current regime and the framing regime which occupies the next rotation in both cases (see Fig. 1). There are two points which require clarification: first, as can be seen in Fig. 1, the alternatives are of different duration, and secondly, the start-times are the bare-ground situations typical of most discounted cash flow analyses of forest regimes. In practice, at ruling rates of discount, extension of the two lines into the next rotation and equalising their duration at some time makes a negligible difference to the sum of the discounted values, and is consequently ignored. As for the second matter, the use of a mid-rotation year is analytically equivalent to the conventional use of the start of the rotation, and the use of current net worth (CNW) in this paper is in no way different

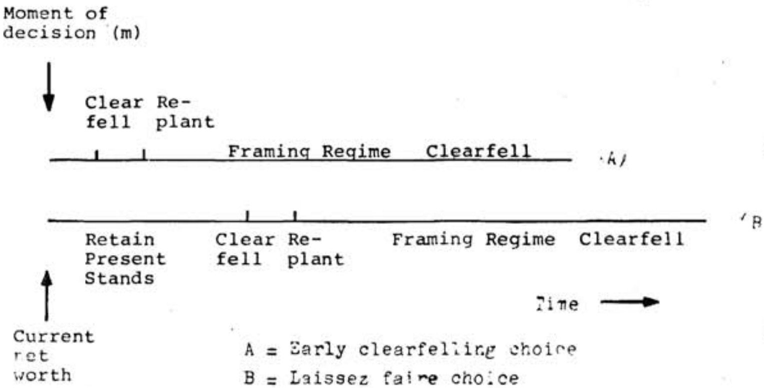

FIG. 1: *Early clear-felling choice (A) and* laissez-faire *choice (B).*

from the more usual present value, merely serving to remind the reader that a mid-rotation point is being used.

There are two ways in which the "indifference" concept could be applied. In each case the price of the early clearfelling material is the unknown in the equation. Either:

(a) The internal rate of return (IRR) of the *laissez-faire* choice can be calculated and then the price of the early clearfelling material can be found which produces the same IRR for the early clearfelling choice — *i.e.,* the forest grower is indifferent between two equal internal rates of return.

(b) The current net worth (CNW) of the *laissez-faire* choice can be calculated at a given discount rate and then the price of the early clearfelling material which, at the *same* discount rate, produces an identical CNW, can be found. This makes the forest grower indifferent between two equal CNWs.

Both methods have a series of solutions depending on the value of *m,* the moment of decision, and both methods were tested by the authors. However, the IRR method proved to contain conceptual difficulties in the shape of very high rates as *m* approaches the planned rotation length. Whilst theoretically correct, these values are not easy to reconcile with the range of values normally encountered by foresters, and consequently the remainder of this paper will explain the method only in terms of the CNW approach.

The moment of decision, *m,* is specified in terms of the age of the gorse-infested stand, and its value is constrained in the following ways:

(1) The decision-making process, practical administration, and construction or upgrading of access roads to logging standards are assumed to occupy one year. Thus, logging cannot commence before $m + 1$.

(2) Very young material will have undesirable properties for the user of industrial wood in respect of fibre length and high costs of logging and transport associated with small piece sizes. (There may be some gains from decreased bleaching costs). But the forest grower may also be disinclined to sell such material, for, even if the gorse problem has induced neglect of thinning to waste and a first pruning lift, he still retains the possibility of a late production thinning for posts. Therefore m is $\geqslant 6$, giving freedom to decide upon a late thinning, but excluding the early sale of very small material.

(3) At the other end of the rotation, $m \leqslant n - 2$, where n is the length of the rotation. If this condition were transgressed, the felling would not be premature at all.

Thus $6 \leqslant m \leqslant (n - 2)$. Also, the time axis commences at 0, a point *in the past* when land preparation took place for the plantations now existing — *i.e.*, these were planted in year 1, and planned harvest age is year $n + 1$.

Equation 1 below sets out the equation used to determine the CNW of the laissez-faire choice. It is based on a predetermined discount rate,

Equation 1

$$\frac{{}^{G}R_{n+1}}{(1+d)^{n-m+1}} + \frac{{}^{F}R_{2n+3}}{(1+d)^{2n+3-m}} - \frac{{}^{Road}C_{n}}{(1+d)^{n-m}} -$$

$$\sum_{x=n+2}^{2n+2} \frac{{}_{Silv}^{F}C_{x}}{(1+d)^{x-m}} - A - A \left\{ \frac{1 - \frac{1}{(1+d)^{2n-3-m}}}{d} \right\} = CNW_{lf}$$

Notice the neglected "third" rotation term is:

$$\sum_{x=2n+4}^{3n+4} \frac{{}_{Silv}^{F}C_{x}}{(1+d)^{x-m}} -$$

(Its contribution to CNW is negligible, when d is large).

Explanation of Symbols and Terms

Costs and revenues are presented in more detail in Appendix 1.

${}^{G}R_{n+1}$ Revenue from gorse-infested stands felled in year $n + 1$ as originally planned ($6 640 per ha).

${}^{F}R_{2n+3}$ Revenue from framing regime felled in year $2n + 3$ ($8 090 per ha).

${}_{Silv}^{F}C_{x}$ Silvicultural costs incurred in the framing regime during year x.

A Administration costs ($40 per ha per annum), occurring at the end of every year.

${}^{Road}C_{n}$ Cost of upgrading logging roads in year n, the year before felling ($650 per ha).

n Rotation age (age at which mean stand diameter is 45 cm dbhob, or age 30, whichever is earlier).

d Discount rate expressed as a decimal. Here taken as 0.10.

CNW_{lf} Current net worth of *laissez-faire* choice.

The equation is functionally identical in every way with that used in orthodox discounted cash flow analyses. The apparent complexity of formulation is merely due to taking a mid-rotation point as the base year, and to including the next rotation as well. The administration costs term, for example, is merely the usual formula for determining the present value of a stream of equal future cash sums, spent at the end of each year.

A CNW if determined from equation 1 may then be entered into equation 2 below.

Equation 2

$$P_{m+1} = \left(CNW_{lf} \cdot (1+d) + \frac{{}^{Road}C_{m}}{(1+d)^{-1}} + \sum_{x=m+2}^{m+2+n} \frac{{}_{Silv}^{F}C_{x}}{(1+d)^{x-m}} \quad (1+d) + \left\{ 1 + \frac{1 - \frac{1}{(1+d)^{n+3}}}{d} \right\} \cdot A\,(1+d) - \frac{{}^{F}R_{m+3+n}}{(1+d)^{n+2}} \right) \div V_{m+1}$$

Equation 2 contains terms describing the early clearfelling choice, and may be solved to give P_{m+1} the indifference price for the early clearfelling material. All other symbols are as in equation 1, except for the volume of early clearfelling material V_{m+1} obtained from a pre-harvest inventory.

It will be recalled (refer Fig. 1) that two projects of unequal duration are being compared, and, the lower the value of *m,* the more this will be true. However, because of the high discount rates prevailing, and also the characteristic brevity of rotations of *Pinus radiata,* the difference between CNWs of the two choices is not much affected by equalising their duration at some future point. For example, even when $m = 6$, the first cost "over the horizon", namely, land preparation for the third rotation, contributes only $16 to the CNW at a 10% discount rate. Another

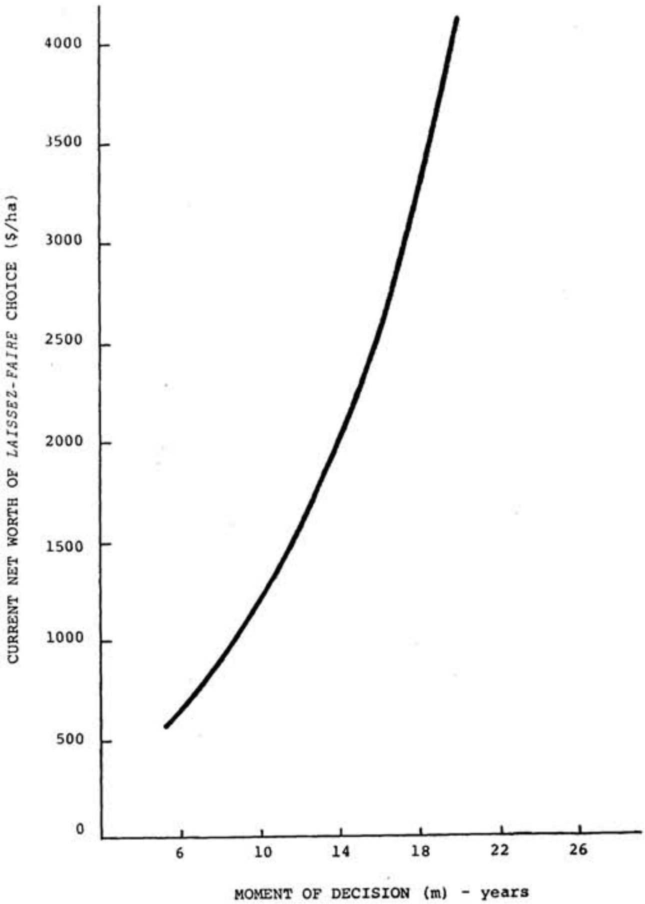

FIG. 2: *Moment of decision versus current net worth (CNW) of* laissez-faire *choice.*

illustration is afforded by one of the most important terms, the administrative overheads, whose CNW quickly converges upon its perpetuity value of A/d with increasing n.

Consequently, limiting the equations to the length shown above is satisfactory in practice. Furthermore, both equations could be combined for ease of use into a single algorithm, which allowed even a hand-held programmable calculator to generate rapid answers.

RESULTS

Figure 2 shows the CNW for the *laissez faire* choice for increasing values of m using a predetermined discount rate of 10% as calculated using equation 1. Based on "indifference" prices calculated from equation 2 and the growth function showed in Fig. 3, Table 1 shows the indifference price calculated for a range of values of m, the moment of decision.

TABLE 1: INDIFFERENCE PRICES — CNW APPROACH.

	m				
	Year 6	*Year 10*	*Year 14*	*Year 18*	*Year 20*
CNW ($/ha)	658.21	1198.34	2004.12	3206.20	4013.48
Merchantable volume (m^3/ha)	41	95	294	407	496
Indifference price ($/$m^3$)	44.85	25.60	11.29	11.40	12.40
Indifference revenue ($/ha)	1838.74	2432.88	3319.24	4641.53	5529.54

The CNW approach accords with the commonsense view that the grower would require greater compensation for early clearfelling, the closer to the end of the rotation a stand actually is, and the indifference revenues are also calculated in Table 1 to demonstrate this.

The indifference price is minimised at about $m = 16$, when it falls to $10.37 per cubic meter. This minimum value of the forest grower's indifference price is henceforth referred to as the "datum" price.

A word of warning must be sounded here. The indifference prices only give the *minimum* prices which the forest grower should be prepared to accept, given the foregone opportunity of the *laissez faire* choice. In any particular set of competitive circumstances, it may be the most favourable price for the industrial buyer, but not necessarily for the forest grower.

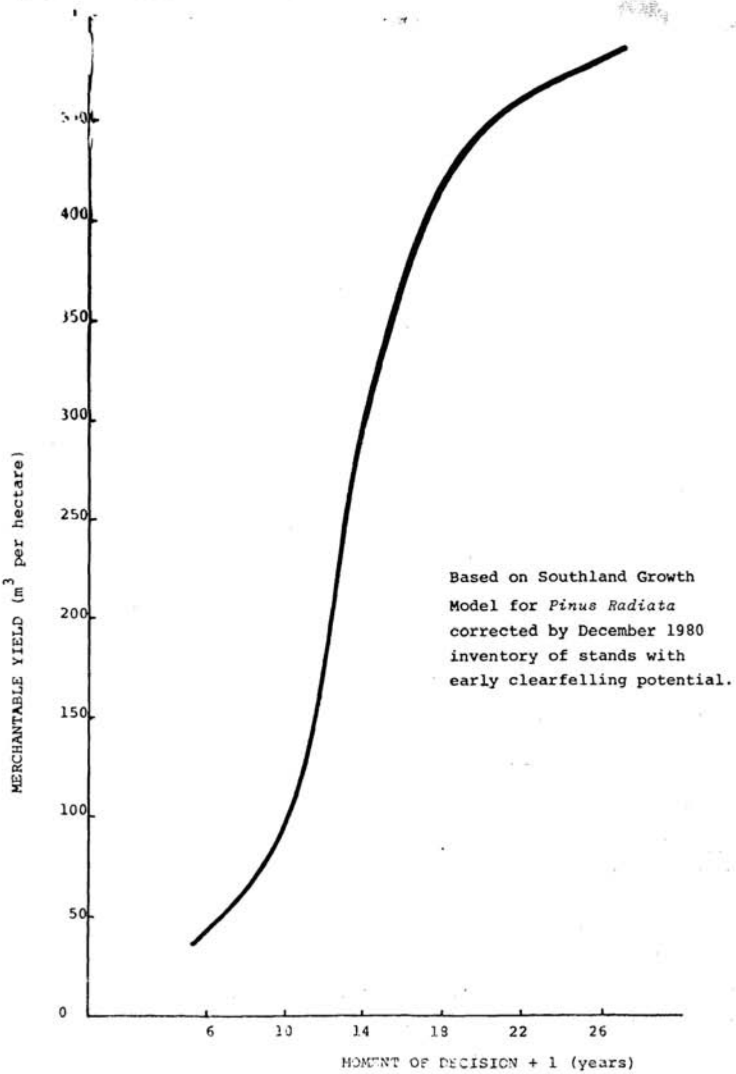

FIG. 3: *Harvestable volume/moment of decision.*

The prices which compensate the grower for his early clearfelling certainly appear comparatively high, but it must be recalled that, under *laissez faire* choice, the full rotation was estimated to yield 460 m³ valued at $6 640, an average value of $14.43/m³ stumpage. Even if the forest grower does not model his full choices, but simply discounts back his expected revenues in naive fashion, the compensatory price at, for example $m = 18$, is still $10.08.

The sensitivity of the CNW approach to changes in the discount rate, rotation length and values of ${}^{G}R$ was examined.

(a) *Discount Rate*

If the discount rate is increased, for example, to 15%, the increased time preference (decreased concern about the future) leads to reduced indifference prices, as shown in the following table:

	m				
	Year 6	*Year 10*	*Year 14*	*Year 18*	*Year 20*
CNW ($/ha)	124.90	478.22	1123.49	2299.25	3210.96
Indifference price ($/m³)	39.59	21.36	9.43	10.13	11.60

The datum price is now reduced to $9.01 at $m = 15$, so that a higher discount rate induces lower prices and favours an earlier moment of decision.

(b) *Rotation Length*

The age at which 45 cm dbhob is achieved in the Southland Growth Model, namely 22 years, appears early and an alternative assumption of $n = 26$ may be adopted. (The corresponding yield suggested by the growth function, 475 m^3/ha, also appears to be only a small increase, but the principle of the sensitivity analysis is unaltered by these figures).

	m				
	Year 6	*Year 10*	*Year 14*	*Year 18*	*Year 20*
CNW ($/ha)	265.34	612.25	1129.77	1901.83	2420.31
Indifference price ($/m³)	40.44	21.47	8.87	8.49	9.03

In this case the datum price is $8.06 at $m = 16$, so that, although the price level falls, the most favourable moment of decision tends to advance through the rotation.

(c) *Value of* ${}^{G}R$

If the expected revenue from the imperfectly managed stand at rotation age was over-estimated by, for example, $1 500 per hectare (29%), then for ${}^{G}R = \$5\,140$ per hectare reduced indifference prices result, as shown in the following table:

	m				
	Year 6	*Year 10*	*Year 14*	*Year 18*	*Year 20*
CNW ($/ha)	384.19	789.55	1394.27	2296.40	2902.25
Indifference price ($/m³)	37.50	20.88	9.01	8.95	9.66

The datum price is now reduced to $8.39 at $m = 16$.

Basic pricing discoveries and sensitivity analyses are presented in Fig. 4.

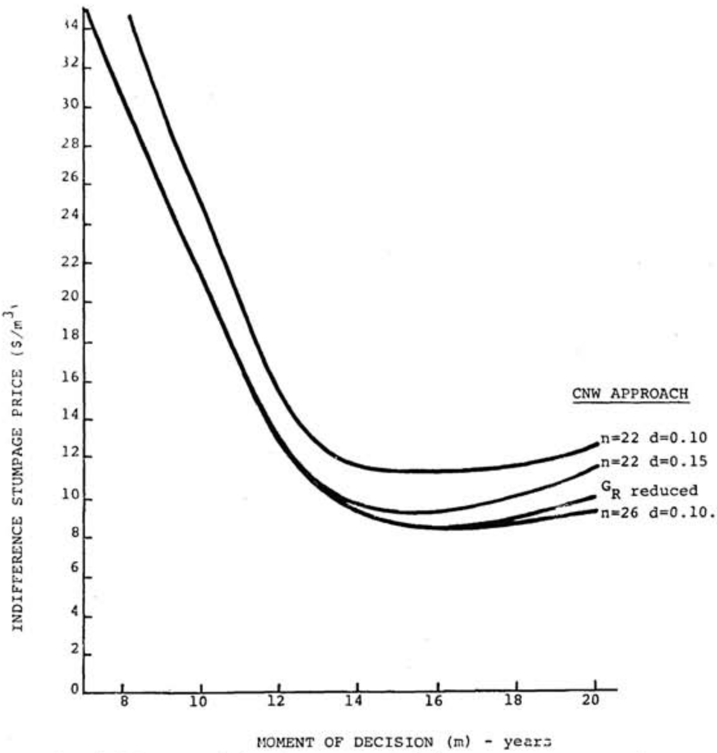

FIG. 4: *Moment of decision versus indifference stumpage price.*

It should be noted that the study was conducted in late 1980 and costs and prices may seem low by present standards. The methodology is unaffected.

SUMMARY

This study has examined a CNW approach to determine the price at which a forest grower would be indifferent between early clearfelling of an imperfectly managed stand for industrial wood,

and waiting for the stand to mature to produce a product mix of much lesser value than originally planned.

The CNW approach provides results which show the indifference price increasing towards the end of the rotation. All the CNW curves give minima which are relatively high prices for industrial wood based on prices paid at the date of the study. However, more recently prices for chipwood in the \$8 to \$12/m³ band have been recorded in the Nelson and Central North Island districts. There is apparently a considerable "consumer surplus", now revealed, which some consumers are prepared to pay, rather than forgo the wood. Conversely, the price paid must be adequate to persuade the grower to clearfell prematurely and forgo the higher returns possible from higher value products. In the Otago example, there would possibly also be advantages to the grower in the removal of the problem stands.

There is at present no large-scale wood processing plant utilising industrial wood in the area of Otago Coast and Berwick State forests. Factors which the State as the seller may take into account when deciding on an acceptable price are social and national economic benefits of a processing facility, including employment and domestic added value for exports. From the buyer's point of view, the availability of industrial wood from early clearfelling of imperfectly treated stands may enable the buyer to proceed with a processing facility at an earlier date than he would without it, and may pre-empt competitors. Thus the wood may have a strategic value to the purchaser as well as an ordinary financial value.

The method has retained in essence the normal discounted cash flow format, which has shortcomings in respect of the constant interest rate assumption, and the unceasing debate over the "appropriate" level of the discount rate. However, this analysis has sought to determine the *current* indifference price, and to some extent the problem can be overcome by recalculation for different discount rates and stumpage levels, although of course the decision, once executed, is irreversible. More serious divergence between D.C.F. analysis for a single project and the rest of the economy may occur when the project is considered in isolation, and when it is forgotten that very different decision criteria, motivated by, for example, national indebtedness, unemployment, balance of payments deficit, may be used elsewhere. It is therefore very important for the forest grower to consider any early clearfelling decision in a *national* context of supply, demand and price expectations rather than to allow the whole decision to be based on local analyses of this kind.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to Odlins Limited, for their sponsorship of the project, and to the N.Z. Forest Service for permission to inspect the stands and their pre-harvest inventories.

APPENDIX I
Costs and Revenues

COSTS

$_{Silv}^{F}C_{x}$ Silvicultural costs incurred in framing regime.

Year (x)	*Operation*	*Cost ($/ha)*
$n+2$	Gorse control operation	350
$n+3$	Trees and planting @ 2 200 stems per hectare. Blanking assumed negligible	160
$n+5$	Releasing — mostly aerial	140
$n+7$	Low pruning/thinning to waste	240
$2n+2$	Upgrading logging roads	70

$^{Road}C_{n}$ Cost of upgrading and re-aligning roads for logging in year *n*. Estimated at $650 per hectare.

A Administration costs, estimated at $40 per hectare per annum, occuring at the end of each year.

REVENUES

The yield from both the imperfectly tended and the framing regimes is taken as 460 m³ per hectare at age 22 from the Southland Growth Model. The product mix and revenue at age 22 were assessed as follows:

(a) Imperfectly tended regime: yield and revenue per hectare

320 m³	sawlogs @ $20 per m³	$6 400
80 m³	industrial wood @ $3 per m³	240
60 m³	unmerchantable	—
460 m³		$6 640

(b) Framing regime: yield and revenue per hectare

400 m³	sawlogs @ $20 per m³	$8 000
30 m³	industrial wood @ $3 per m³	90
30 m³	unmerchantable	—
460 m³		$8 090

(One difficulty with the analysis is the circular linkage between the indifference price discovered for industrial wood and the value of this category entered into the calculation of revenues above.) *Note:* The results of a pre-harvest inventory of the stands under consideration became available when the analysis was in process. Two strata gave volumes of merchantable timber for 10-year and 18-year-old stands, enabling a better growth function to be drawn (Fig. 3) and a final volume product assortment at the planned rotation ($n = 22$) to be derived as follows:

	Merchantable Volume *(m³)*	*Unit Value* *($/m³)*	*Values* *($)*
Poles	4.60	15	69.00
Small roundwood	23.00	12	276.00
Sawlogs	303.60	20	6 072.00
Short sawlogs	18.40	12	220.80
Pulp	50.60	3	151.80
Waste	(59.80)	(0)	000.00
Total	460.00		$6 789.60

Since this value differed only slightly from the original assessment of $6 640, the original calculations were not altered.