TAXES ON YIELD, PROPERTY, INCOME, AND SITE: EFFECTS ON FOREST REVENUES AND MANAGEMENT

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Appendices A, B, and C to be added.

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B.C. Institute for Economic Policy Analysis
3771 Haro Road
VICTORIA, B.C. V8P 5C3

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There have been and continue to be strong proposals to remove the general property tax from standing timber in order to encourage restocking cutovers and discourage early cutting of mature timber. Many jurisdictions have done so in whole or part, and others are actively considering it. It is proposed to replace it with a yield tax, or a site tax, or some combination.

Richard Trestrail has effectively stated the rationale for the property tax.[1] His argument is implicitly in the modern general equilibrium tradition associated with Rolph, Stockfisch, Harberger and more recently Mieszkowski which treats the property tax as a universal tax which is not shifted and so reduces the rate of return after taxes - otherwise put, the tax lodges in the rate of interest. David Klemperer in another able article has replied that a local taxing jurisdiction is an open economy where partial equilibrium assumptions hold, and the tax is shifted to landowners - it lodges in lower site values.[2] On these

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1 Richard Trestrail, "Forests and the Property Tax - Unsound Accepted Theory", NTJ 22(3): 347-56 (1969).

2 David Klemperer, "Forests and the Property Tax - A Re-examination" NTJ 27(4): 645-51 (Dec. 1974).

grounds he finds the tax less than ideal, but stops short of dismissing it. Indeed, he rather leaves the issue hanging, although he does provide the skeleton of an evaluative model.

The present study accepts Klemperer's assumption that local taxes, locally considered, must lodge in site values. It goes on to lend some comfort to Trestrail's defense of the property tax, finding it generally superior to an equivalent yield tax on several counts. It concludes by suggesting third alternatives which are better than either. These are taxes that zero in on site rent by various means: deducting restocking costs; deducting interest; and assessing land directly. The last is judged best overall. The paper shows how to calculate equivalent tax rates for the various alternatives.

I. Harvest or Yield Tax

S = Site value derived from discounted future yields less costs, in absence of taxes.

R = Revenue from sale of stumpage, net of harvest cost, in year *m*.

m = years from regeneration to maturity and harvest.

i = interest rate.

t = tax rate applied to *R*.

C = Cost of regeneration, year *O*.

Intermediate costs and revenues are incorporated by compounding them forward to m or discounting them back to O. Taxes are assumed born by site owners in lower valuations, logs being sold at a market price independent of tax.

$$(C + S)e^{mi} = R + S \tag{1}$$

(1) says you invest site plus regeneration cost at time O, and recover site plus stumpage revenue at m. Solving for S, we get:

$$S = \frac{R - Ce^{mi}}{e^{mi} - 1} \tag{2}$$

(2) is Faustmann's formula for "Soil Expectation Value", widely discussed in the literature.

Maturity is assumed to arrive when growth just covers interest on its own value plus site value:

$$\Delta R = i(R + S) \tag{3}$$

This can be shown to maximize S.

To show the effect of a harvest tax, let:

σ (Sigma) = Site value after deducting harvest tax.

$$\sigma = \frac{R(1 - t) - Ce^{mi}}{e^{mi} - 1} \tag{4}$$

By inspection, since C is not deductible, there is a leverage effect in the tax, and it falls harder on marginal investments. Marginal land is made submarginal, and there is an "excess burden" on all land, with sterilization of marginal increments to investment. If this occurred to an existing mature stand at harvest time we would call it "high-grading", a familiar problem. The harvest tax is net of harvest costs (except for substantial administrative problems), so high-grading at harvest is not its major problem. The major problem is "invisible high-grading", i.e. the abortion in advance of marginal effort and investment in T.S.I. and regeneration.

An aspect of this problem is an associated bias against shorter growth periods. This is both more and less than a bias against intensive use of land: more a bias against labour, and less a bias against capital. It is specifically a bias against applying labour for regeneration and harvest frequently and heavily. It is a bias to substitute capital (growing stock) for labour by hiring less labour for stocking, and letting trees stand longer. It is also a bias to substitute land-time for labour by letting land restock itself over 10-20 years instead of immediately by hiring labour. This also results in understocking land, again substituting land for labour.[3]

Putting it all together the strongest bias of the tax is to induce substituting land for labour. Almost as strong is the bias to substitute capital for labour. A weaker bias is to substitute land for capital, during the initial un-restocked decades after a cut.

To show the bias, we find $\sphericalangle$ as a percentage of S. Substituting (1) in (4):

$$\sphericalangle = \frac{S(1 - t)\ (e^{im} - 1) - tCe^{im}}{e^{im} - 1} = S(1 - t) - \frac{tC}{1 - e^{-im}}$$

$$\sphericalangle/S = 1 - t(1 + \frac{C/S}{1 - e^{-im}}) \qquad (5)$$

The presence of tax-induced bias is suggested whenever a ratio, like (5), of after-tax value to before-tax value, is other than simply (1 - t). (5) is smaller than (1 - t) except when C = O, and is very sensitive to the parameters C/S, i and m. (5) is a decreasing function of C, and an increasing function of S, m, and i.

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3 A third aspect is that understocking alters the growth of stand value over time. The "trend to normality" of understocked stands probably defers growth and lengthens cycles, although the point is mooted among foresters even yet.

That means that yield taxes discourage restocking (C), encourage long cycles between input and output (m), and are harder on poor sites (low S) than good ones. They reduce the pressure to put land promptly back into growing stock after cutting, by making all land more marginal to the private owner. If site value is made equal to zero, there is no hurry at all for the owner to restock it. Downtime of land of no private value is free to the owner. There is a loss to society, because the land can yield a surplus, but the private owner does not feel the cost.

Yet a yield tax makes no land submarginal if it will grow timber with little or no outlay (C) by the owner. When $C = 0$, α cannot fall below $S(1-t)$. There is no gain in restocking, but no loss in waiting for natural restocking. This combination of incentives militates against thrifty and intensive forest management.

Along with a bias against C, the yield tax has another bias against low values of m, i.e. against short growing cycles. Table 1 is a numerical example showing how the fraction on the right side of (5) varies with m. The bias of the yield tax is minor as between cycles of 60 and 70 years, which helps explain why it has been so easily overlooked in the past. But the bias accelerates and grows quite fierce as we move towards shorter cycles. Christmas trees would be wiped out. Species of faster growth would be penalized relative to traditional slow-growing Douglas-fir. Pulpwood rotations would suffer relative to saw timber. Genetic improvement to speed growth would suffer. Cost outlays like planting nursery stock designed to advance maturity would be discouraged. The premium would be on slow natural restocking.

Many forest outlays come well after the planting date: thinning, fire and pest control, T.S.I., etc. Each such outlay is a separate investment cycle of shorter life than the whole cycle, and would be affected by a yield tax in terms of its own short life, not the whole cycle. It is the investment cycle, not the growth cycle, that rules. A harvest tax of any weight would prevent most investments in T.S.I. for about 20-30 years before harvest. It is also likely that it would be difficult to deduct every cost associated with harvest itself, but that is treated separately.

The use of the ratio C/S in (5) and Table 1 warrants close attention. On marginal land C/S is high because $\underline{S}$ is low. But high C/S also refers to high outlays on good land. The latter suffer more than the former from a yield tax because of the shorter cycles involved. Thus, the bias against marginal land is softened by the slowness of growth there;

Table 1: The Excess Site Burden Factor in a Yield tax (See Eqn. (5))

Values of $\frac{C/S}{1 - e^{-im}}$ (i = .07)

		$C/S \div (1 - e^{-im})$									
m	$1-e^{-im}$	C/S=0	.5	1	1.5	2	3	5	10		
1	.07	0	7.14	14.3	21.4	28.6	43.-	71.-	144,		
5	.29		1.72	3.45	5.17	6.90	10.3	17.2	34.5		
10	.49		1.02	2.04	3.06	4.08	6.12	10.2	20.4		
15	.64		.78	1.56	2.34	3.13	4.69	7.81	15.6		
20	.74		.68	1.35	2.03	2.70	4.05	6.76	13.5		
30	.87		.57	1.15	1.72	2.30	3.45	5.75	11.5		
40	.93		.54	1.08	1.61	2.15	3.23	5.38	10.7		
50	.97		.52	1.03	1.55	3.06	3.09	5.15	10.3		
60	.98		.51	1.02	1.53	2.04	3.06	5.10	10.2		
70	.99		.51	1.01	1.52	2.02	3.03	5.05	10.1		
80	1.00		.50	1.00	1.50	2.00	3.00	5.00	10.0		
90	1.00		.50	1.00	1.50	2.00	3.00	5.00	10.0		
100	1.00	0	.50	1.00	1.50	2.00	3.00	5.00	10.0		

but the bias against intensive management on good sites is worsened by the fast growth there. That is *a fortiori* true of outlays designed to speed growth; and outlays near harvest time.

The yield tax leaves owners of good sites the option of protecting most of their income by lowering *C* towards zero. This eliminates the bias against short cycles. The harvest tax does not penalize forestry on good sites until it becomes intensive. It protects values while damaging incentives to restock. It is not an effective way of tapping rents, therefore.

As to marginal land, we must evaluate the bias against it in conjunction with the heavy public costs and cross-subsidies associated with using it. Much land that is marginal to private persons is submarginal to society. The damage of greatest social concern is the bias against full use of good land.

The point is often made that an *ad valorem* harvest tax has little effect on the timing of harvest, because the tax has little effect on the percentage growth rate of after-tax value.[4] That is true enough, and argues for a one-time

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4 It has some effect because the base of the percentage growth rate includes site value which the tax reduces disproportionately much. Even this small effect disappears if we levy the tax on old growth only, for site value depends on the taxes to be levied on new crops, not old.

Table 2:

Values of $\tilde{V}/S$ (from Eqn. 5), for $i = .07$, $t = .38$. $\tilde{V}/S$ is site value after a harvest tax, expressed as a percentage of the value with no tax.[5]

$$\tilde{V}/S = 1 - t\left(1 + \frac{C/S}{1 - e^{-im}}\right)$$

m		$\tilde{V}/S$						
	C/S=0	.5	1.	1.5	2	3	5	10
1	.62	-2.09	-4.8	-7.52	-10.2	-17.7	-26	-54
5	.62	- .03	- .69	-1.34	-2.0	- 3.3	- 5.9	-12.5
10	.62	.23	- .16	- .54	- .93	- 1.7	- 3.3	- 7.1
15	.62	.32	.03	- .27	- .57	- 1.2	- 2.4	- 5.3
20	.62	.36	.11	- .15	- .41	- .94	- 1.95	- 4.51
30	.62	.40	.18	- .03	- .25	- .71	- 1.57	- 3.75
40	.62	.41	.21	.01	- .20	- .61	- 1.42	- 3.45
50	.62	.42	.23	.03	- .16	- .55	- 1.34	- 3.29
60	.62	.42	.23	.04	- .16	- .54	- 1.32	- 3.26
70	.62	.43	.24	.04	- .15	- .52	- 1.30	- 3.22
80	.62	.43	.24	.05	- .14	- .52	- 1.28	- 3.18
90	.62	.43	.24	.05	- .14	- .52	- 1.28	- 3.18
100	.62	.43	.24	.05	- .14	- .52	- 1.28	- 3.18

[5] A harvest tax of 38% is comparable to a property tax of 1%. See under "II, Property Tax."

use of the tax on old-growth. As to new forests, however, we must consider the effect on incentives to restock cutover lands. The urgency to minimize the downtime of land between crops of trees is a function of its value: no value, no hurry. A tax that lowers site rent and value therefore delays restocking.

Some of the effects of a harvest tax may be inferred from Table 2, showing values of δ/S (see Eqn. 5) at a tax rate of 38% (equivalent to a 1% property tax, as explained later). The stepladder line running through the table divides positive from negative values. All values northeast of it are negative. The forest owner is induced to move southeasterly, toward lesser stocking and longer cycles, but especially easterly toward lesser stocking. The table does not show that lesser stocking also defers the beginning of the growth cycle.

II. Property Tax Applied Annually to Inventory Value of Timber

Let:

θ (theta) = site value after deducting property tax, on timber only (but not on site, treated separately later).

The base (B_n) in any year n is greater than the value for immediate harvest in that year. B_n is the investment value or inventory value of timber, found by discounting future liquidation value to the present at market rates of interest. B_n grows along a (modified)[6] curve of exponential growth (a compound interest curve) rather than the S-shaped biological growth curve of the liquidation value. They are equal at maturity, where they are tangent.

Finding θ is complicated by "capitalization" of the tax - that is, it reduces the value of its own base, just as a land tax does, quite apart from reducing any physical volume of its base. Future liquidation value is now discounted at the sum of interest rate plus tax rate.

This would result in a present net worth in time zero less than C (regeneration cost). So <u>any</u> outlay would be rendered uneconomic unless the tax lodges in lower site value, as we assumed for the harvest tax. That we do here, too. Site value is the cushion that permits a tax to be paid without driving away all labour and capital.

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[6] The growth curve is "modified" by the subtraction of a constant, the site value. The tree must earn interest and taxes on both the cost of regeneration, C, and site value. See Eqn. (7).

Let:

p = property tax rate on timber inventory.

$\underline{\theta}$ is now the value that satisfies (1) when we add $\underline{p}$ to $\underline{i}$:

$$(C + \theta)e^{(i + p)m} = R + \theta \qquad (6)$$

$$\theta = \frac{R - Ce^{(i + p)m}}{e^{(i + p)m} - 1} \qquad (7)$$

(7) is the same as (2), but with $\underline{p}$ added to $\underline{i}$.

Like the harvest tax, the property tax has an excess burden, exemplified by its sterilizing marginal land. The present net worth of future harvest just covers regeneration costs when there is no tax, by definition of marginal land. Discounting at the higher rate including tax (i + p) lowers present net worth below starting costs, and there is no cushion of land value to absorb the blow.

But unlike the harvest tax, the property tax is biased against long cycles rather than short. Since long cycles use more land-time per unit of labour, the property tax operates to substitute labour for land, and the harvest tax vice versa.

To show the bias and the contrast we find θ as a percentage of the no-tax site value, $\underline{S}$.

From (1):

$$R = (C + S)e^{im} - S \qquad (8)$$

Substituting (8) in (7), and dividing by S.

$$\frac{\theta}{S} = \frac{e^{im} - 1}{e^{(i + p)m} - 1} - C/S \; \frac{e^{pm} - 1}{e^{pm} - e^{-im}} \qquad (9)$$

(9) may look formidable at first glance, but may be tamed by tabulating its two coefficients.

Let:

$$\Omega \text{ (omega)} = \frac{e^{im} - 1}{e^{(i + p)} - 1} \qquad (10)$$

and

$$\Psi \text{ (psi)} = \frac{e^{pm} - 1}{e^{pm} - e^{-im}} \qquad (11)$$

Appendix A gives values of Ω and Ψ for various values of i and p, from which one may construct many tables like Table 3. Table 3 displays values of θ/S when $i = .07$ and $p = .01$. In format and parameter values it is directly comparable with Table 2, to facilitate comparing the effects of the property and harvest taxes.

Table 3 Values of Θ/S (from Eqn. 9) for i = .07, p = .01

Θ is site value after a property tax; and Θ/S is Θ expressed as a percentage of the value with no tax

$$\Theta/S = \Omega - \frac{C}{S}\psi$$

m	Ω	ψ	Θ/S							
			C/S=0	.5	1	1.5	2	3	5	10
1	.88	.13	.88	.82	.75	.68	.62	.49	.23	- .42
5	.85	.15	.85	.78	.70	.63	.55	.40	.10	- .65
10	.84	.17	.84	.76	.67	.59	.50	.33	- .01	- .86
15	.81	.20	.81	.71	.61	.51	.41	.21	- .19	-1.19
20	.78	.23	.78	.67	.55	.44	.32	.09	- .37	-1.52
30	.73	.29	.73	.59	.44	.30	.15	-.14	- .72	-2.17
40	.67	.35	.67	.50	.32	.24	-.03	-.38	-1.08	-2.83
50	.62	.40	.62	.42	.22	.02	-.18	-.58	-1.38	-3.38
60	.57	.46	.57	.34	.11	- .12	-.35	-.81	-1.73	-4.03
70	.52	.51	.52	.27	.01	- .25	-.50	-1.01	-2.03	-4.58
80	.47	.55	.47	.19	-.08	- .36	-.63	-1.18	-2.28	-5.03
90	.43	.59	.43	.14	-.16	- .46	-.75	-1.34	-2.52	-5.47
100	.39	.63	.39	.08	-.24	- .56	-.87	-1.50	-2.76	-5.91

As in Table 2, the stepladder line running through the table divides positive from negative values. All values southeast of it are negative. The forest owner is induced to move northwesterly, toward lesser stocking and shorter cycles.

Inspection of the numbers suggests that the property tax gives the owner somewhat more scope to avoid moving "west", i.e. to avoid reducing C̲. In Table 3, where C/S = 1 and m = 70, θ/S = .01. From that low value the owner can move west to .52 by letting C̲ fall to zero. He could also move north to .55 by letting C̲ fall to 20. Now compare Table 2, where C/S = 1, m = 15, and ϑ/S = .03. The owner can move west to .62 by letting C̲ fall to zero, but by moving south he can reach no higher than .24, however long the cycle. The thrust of the two tables then is that owners will react to property taxes by shortening cycles as well as reducing stocking inputs per acre; and they will react to harvest taxes mainly by reducing stocking inputs, and incidentally by lengthening cycles a small amount. The last clause is not true for cycles under 20-30 years, where the stretching or Procrustean effect is strong. But note that in this reach of Table 2 the gradient of increase in ϑ/S is even steeper moving west into lower values of C/S. So at every value of m, the harvest tax cuts down on restocking. The property tax, by contrast, exhibits flatter gradients moving west in Table 3. For $m > 50$ the property tax gradient is steeper, it is true. But it is not nearly as much steeper as the yield tax gradient is steeper when $m < 50$. On balance overall, the yield tax has the stronger bias against restocking.

There is a greater symmetry about the property tax. It cuts down both on labour per acre (C) and the time that capital and land are tied up with each "dose" of labour. The yield tax cuts down on labour per acre, but then adds to the time that capital and land are tied up with each dose of labour. Thus the yield tax clearly induces substituting capital and land for labour, while the property tax is much more compensatory and balanced in overall effect.

Subject to the above, a way of viewing these effects is that the property tax, being a tax on capital, acts mainly to inhibit its use on given lands. It acts incidentally to reduce labour per acre, but this is compensated by the substitution of labour for capital and land (shorter cycles). The harvest tax acts mainly to inhibit use of labour per acre. It acts incidentally to reduce capital per acre. This is compensated by the substitution of capital for labour (longer cycles).

The tables do not tell us that reducing stocking inputs (C) tends to lengthen cycles by adding some barren decades on to the front-end of each cycle. This is the substitution of say 20 years of land-time for labour. Considering this point, the property tax has another compensatory effect: lowering restocking inputs lengthens cycles, and then the other effects of the tax shorten them. The harvest tax on the other hand has a double-barrelled effect in lengthening cycles. Of these two barrels the larger one by far is the inhibition of restocking inputs, and the substitution of empty land-years at the front-end.

In Table 3, the north-south gradient is much steeper in the eastern than the western columns. This represents the effect of tax capitalization, a subtle yet profound and important effect which softens the intertemporal bias of the tax. "Capitalization" refers to the fact that the anticipation of future taxes lowers the value of the tax base today, so that a 1% tax takes less money than otherwise. If that seems obscure, note that it works exactly as compound interest does. A 1% property tax has the same effect on value as raising the interest rate from 7% to 8%. That is still a powerful effect. If m = 70, for example, it cuts values in half, since $e^{.08x70}/e^{.07x70} \doteq 2$. But it is much less than if there were no capitalization.

In this case the tax is capitalized and shifted into lower land rents and values. The compensating effect on tree life works like this: while it now costs more to carry the tree for a year, it costs less to carry the site. The part of the tree value derived from accumulating site rents is also reduced. This point has been developed in an earlier work.[7] The net result is that a property tax (or an increased interest rate) has materially less effect on intertemporal choices than one would think if he overlooked capitalization. Overlooking capitalization is a source of much overstated apprehension about the property tax.

The western column of Table 3 where C/S = 0, shows the softening effect of capitalization in the extreme. Here the site is so good it grows timber without other cost. The north-south gradient is accordingly very gentle. Eqn. (9) shows that $\Theta/S = \Omega$ when C/S = 0, and Ω is never negative, no matter how high the tax rate, p, or how long the cycle, m. Intertemporal bias is a minimum.

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7 M. Gaffney, Concepts of Financial Maturity of Timber and Other Assets, A.E. Info. Series No. 62, N.C. State College, Raleigh, N.C., 1957, pp. 33-35.

As we move east to C/S = .5, the tempering effect of Ω is swamped, and moreso as we move east again. High C/S means that site value is negligible, and the effects approach those we would expect if we overlooked capitalization. The portion of the timber value tax base deriving from $\underline{C}$ is not eroded by capitalization the way the site-derived portion is, so the higher C/S, the less the tempering effect of capitalization.

We noted earlier that the property tax was less biased against high sites because of the shorter cycles there. Now we can add that the tempering capitalization effect is also greater on higher sites, because of lower C/S. This second rule does not however apply to intensive marginal increments of $\underline{C}$ on high sites, for as to these, the marginal C/S ratio is high. (We do not show here how to disaggregate this marginal ratio, but it can be done.)

The tempering capitalization effect is also manifest when $\underline{m}$ is very high, and the property tax is most burdensome. From (9), as $\underline{m} \rightarrow \infty$, $\Omega \rightarrow 0$ and $\Psi \rightarrow 1$, so $\Theta \rightarrow -C$ as its lower limit. The same limits are approached as $\underline{p}$ becomes very high so no matter how high the tax rate and how long the cycle, Θ cannot be less than -C. At first this seems odd, but it is simply capitalization at work. The tax erodes its own base. The present value of future stumpage revenues cannot be less than zero. In that extremity, the negative site value represents a total loss of restocking costs; but no greater loss is possible.

It is sometimes alleged that accumulated property taxes over time may exceed stumpage value, but that is impossible: if future taxes exceeded future revenues there would be no value in the tax base and therefore no taxes.

The yield tax is not softened by capitalization, so it is harder on very short cycles than the property tax is on very long ones. The lower limit of ψ is reached when m = 1, and $\psi = S[1 - t(1 + \frac{C/S}{i})] = S(1 - t) - \frac{Ct}{i}$. The last term is a large multiple of C. If t = .38 and i = .07, it is 5.4 x C. Thus in Table 2 the north-south range of values for ψ is much greater than for Θ, excepting only when C/S = 0. Again, the east-west range is generally greater for ψ.

One might write a book on the various points introduced above, but here we press on with comparing the two ways of levying taxes. Now we can explain why t = .38 was chosen an equivalent to p = .01. I chose m = 50 as a middling sort of cycle, neither very short nor very long in forestry terms. To be sure in Georgia it would look long, and in B.C. a bit short, but one can adjust it as desired. Now when m = 50, we ask "What value of <u>t</u> makes $\psi = \Theta$ when p = .01?". This is "equivalent" because the present value of taxes is the same under either system, and the treasury is equally well off. It is a first approximation only, because it does not adjust for taxpayer avoidance reactions. When C = 0, the answer is:

$$S(1 - t) = S\Omega$$

$$t = 1 - \Omega = 1 - .62 = .38 \qquad (12)$$

Reading across the row where m = 50, in Tables 2 & 3, the numbers are nearly identical, indicating that t = .38 is also valid when C/S moves up to 10. This comes about in the following way. The full equation, where $C \geq 0$, is:

$$1 - t\left(1 + \frac{C/S}{1 - e^{-im}}\right) = \Omega - \frac{C}{S}\Psi \quad .$$

$$1 - t = \Omega - \frac{C}{S}\left(\Psi - \frac{t}{1 - e^{-im}}\right) \qquad (13)$$

But the value in parentheses is nearly zero at the parameters we are using because $\Psi = .40$ (from Table 3) and $\frac{t}{1 - e^{-im}} = \frac{.38}{.97} = .39$. So C/S makes no material difference. This makes it possible to name one value for t and be confident of being in the ballpark - assuming we have selected a good representative value for m.[8]

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8 This simplification works quite well for all m, although for $m < 20$, C/S becomes a factor. Then we find a representative value for C/S too, plug it into (13) and solve for t.

The important parameter is m. In Georgia, m + 20 might do, and t = .22. In British Columbia m = 70 is consdered too short by the Forest Service, and for m = 70, t = .48.

Proposals to replace property taxes by yield taxes seldom specify rates so high. What they involve then really is a proposal to reduce the effective tax rate on forests. The same end, if desired, could be accomplished openly by cutting the property tax rate on forests, and everyone could know better what was going on. 48% looks like a very high tax rate until we work out the advantages of deferring the payment, which are enormous.

Actually, the rates coming out of (12) and (13) are too low. They take no account of the heavy tax collections that go with outlays for C: payroll tax, income tax, sales tax, logging tax, etc. The yield tax, compared with the property tax, lowers the amount of C some, and the frequency of C a lot. Most payrolls come at time of harvest, of course, and shorter cycles mean more frequent logging payrolls per acre. In avoiding yield taxes, landowners avoid others as well. If we summed all taxes generated in the forests, even higher yield tax rates would be required to compensate for the loss. Yield taxes tend to turn forests into fiscal deserts.

Yield or harvest or severance taxation of timber has been advanced as a means of escaping intertemporal bias; and fostering restocking of cutovers. It fails on the first count by causing a bias against short cycles. It fails on the second by causing a bias against restocking that is heavier, on the whole, than caused by an equivalent property tax. Let us now summarize our reasons for rejecting yield taxation.

A. There is a strong bias against use of labour, in amount per acre, and frequency. Use of labour provides useful, productive employment; it reduces sterile outlays for the dole; and it generates heavy tax payments. Public policy needs to foster employment, not inhibit it.

B. There is a bias against marginal outlays on all sites but especially high sites with their shorter cycles. This tends to force recourse to marginal sites, where heavy public subsidies are likely required for infrastructure. It is better to intensify the high sites.

C. The yield tax cannot be made consistent with a property tax on non-forest capital. It inherently applies a higher rate to shorter cycles and a lower rate to longer cycles. Thus it fosters locking up scarce capital at lower productivity in long cycles while forcing it out of more productive uses in short cycles.

Under a yield tax, mature forests of long life need only grow at (negligibly more than) $\underline{i}$, the interest rate, to remain unripe for harvest. But meantime other capital, including that in woodmills, must yield $\underline{i} + \underline{p}$, interest plus taxes, to justify tieing up capital. And short term forest investments must yield more yet. In the extreme, where m = 1, the yield would have to exceed i + .38. The example is not irrelevant. Experiments have been under way for some years to grow cellulose on an annual cycle.

The tax also induces misallocation of land, assuming as we have that it lodges in land values. It pushes or pulls land into uses growing longer-lived trees. That is just the intra-mural effect within forestry. It also may pull land into slow-maturing forests that would otherwise be grazed, instead, or reserved for parks or wildlife. As to the grazing, we must note that cattle generally escape property taxes altogether, and farm assets are the most undertaxed class, so here a pro-forest bias would be a net gain. Recreation, too, yields tax-exempt imputed income, giving it a big tax advantage. The defense of proper forest taxation at this margin must therefore rest on the inducement it might create to tax these rival land uses higher.

D. As noted, the yield tax inhibits restocking of cutovers, on the whole more than the equivalent property tax does. Dead land-time is substituted for labour. The loss is not just the simple value of land-time, but the land-derived capital which would have gone into growing stock had the land been restocked from year one.

E. The tax exerts bias against short cycles. The gradient of bias is quite flat from 100 down to 30 years, but grows very steep below 30. It militates against modern trends in forestry which seek to economize on scarce capital and land, and make use of more labour, by shortening cycles. It virtually prohibits cost outlays to preserve or improve mature stands for 20 years before harvest.

F. The tax induces high-grading in the woods because harvest costs are deductible in a lump, and not keyed to the marginal log (or top or butt of log) in the woods. Logs are measured at the scale as they leave the woods, so true individual stumpage is not determined.

G. There are additional problems regarding variability and uncertainty of revenues, stability over time, certainty of yield, equity, and transition that go beyond the present model and so are deferred to Appendix C.

H. The property tax is not as black as painted; and there are third alternatives that are even better.

Now we summarize the advantages of the property tax over the yield tax:

A. The bias is not against use of labour, but mainly capital, and the arguments against the yield tax on this score are points for the property tax. Much capital is land-derived and not even "produced by labour". Much more is self-produced by compounding interest---or by the growing of the stock, if one prefers to view it so.

B. The bias is more against marginal land than against intensified management of high sites. It goes easier on higher sites owing to the faster growth there, as well as the greater capitalization effect there. Resource institutions tend to be biased against fully exploiting the "intensive margin", that is marginal effort on better land, and the property tax helps offset this bias.

C. The property tax is compatible with the general taxation of property in other uses. Forest capital is simply required to earn $\underline{i} + \underline{p}$, the same as in non-forest uses. It is sometimes held that the property tax is harder on timber than say buildings, because cash is deferred until sale of timber. There is a point of sorts there, but on the other hand the brunt of property taxes on buildings comes early in life while the brunt of timber taxes do not come until the twenty years before harvest. By that time the nearly ripe merchantable timber is bankable and salable, and there should normally be little liquidity problem. In addition, forest owners are better able than building owners to normalize their operations by staggering cycles. Forest owners have the option, which builders do not, of letting the site generate the capital untouched by human hand, and all forest capital is partly site-derived. Finally, note that few investors in new forests are strapped for cash. There is a pathos about many liquidity-effect pleas that is unrealistic. Some people have problems of excess liquidity, and these are normally the ones to solve it by planting seedlings.

D. There is on the whole less bias against laying out C to restock cutovers, (although there remains a good deal of bias where cycles have to be long).

E. There is less intertemporal bias over the whole range from 1-100 years (although more in the range from 30-100 years). Protection from extreme bias is found in the capitalization effect.

F. There is no problem of high-grading in the woods, or other problem of keying deduction of costs to gross income. Taxes are paid as you go, and add to the value of the trees, which belong entirely to the owner. He has every incentive to harvest as fully as real costs allow, and in all ways to spend to safeguard and improve his investment in ripe timber.

G. If we drop the assumption that the tax lodges in lower site value, and let it lodge in a lower i instead, the property tax becomes perfectly neutral.[9] The sum of the new lower i, plus p, now equals the old i. To some small degree the property tax does lodge in lower i. This is because local capital markets are slightly insulated. The property tax drives capital out of the tall timber and into housing, construction loans, inventories, and other local investments. The increased supply may force down interest rates slightly.

This point is quite parlous where we look at one jurisdiction. It is more telling when we consider property taxation as a whole, in a whole nation. The context will point to the appropriate assumptions.

We have compared the property tax with the yield tax and found the former preferable. We have not found it at

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9 A proof is in M. Gaffney, "Tax-induced Slow Turnover of Capital", WEJ, Sept., 1967.

all perfect, however. It wipes out marginal land. It advances cutting of old growth. It discourages restocking. It has substantial bias against longer cycles. And it drives some marginal capital away from the jurisdiction.

We cannot defend it altogether, either, on the ground that it is consistent with taxing other capital, because other capital is not all taxed at the same rate or at all. There is no non-forest norm against which to measure it.

Therefore we now look at some third alternatives which involve narrowing the tax base to site income, and raising the rate.

III. Taxes on Property Income, Site Income, and Site Value

A. Tax on Property Income

The extreme intertemporal bias of the yield tax, and some of its anti-labour bias, are abated when the grower may deduct C from the tax base. It makes a great difference when he may deduct it. For a tax on property income, let him deduct it at maturity. Let:

π = Site value after tax on property income

r = Corresponding tax rate

$$\pi = \frac{R(1-r) - Ce^{im} + rC}{e^{im} - 1} \qquad (14)$$

Substituting (1)

$$\pi = \frac{S(e^{im} - 1) - r(C + S)\ (e^{im} - 1)}{e^{im} - 1} = S - r(C + S)$$

$$\frac{\pi}{S} = 1 - r(1 + C/S) \qquad (15)$$

(15) does away with explicit intertemporal bias, but retains an anti-labour bias, even though labour cost is deductible. The gradient of bias is only a little less than shown in Table 2 for the yield tax, for $m > 30$. Comparing (5) and (15) makes clear the reason why, using Table 1 for needed numbers. (5) and (15) are the same except for a denominator that approaches one for $m > 30$. But for $m < 30$, deducting C does prevent the high gradients of pro-western bias found in Table 2.

It may seem odd that a tax on the income of land and capital should inhibit use of labour. What is involved is the resolution of two conflicting effects. Deducting C does help labour. Taxing property income tends to inhibit capital relative to labour, which would mean shortening cycles---i.e. tieing up capital for less time with each dose of labour.

But the particular way in which this tax impacts on its base has a countervailing influence. The tax is deferred until harvest, giving an advantage to longer cycles, i.e. capital. The deduction of C is also deferred until harvest, robbing most of its value to labour. The resolution of the forces is what we see in (15), a net bias against C.

The tax is not as good as it looks in Eqn. (15). The absence of intertemporal bias gives added force to the anti-labour bias. The grower has no way to go but west (lower C) to soften the tax impact. As to the shorter cycles, the deduction of C means that the equivalent tax rate is much higher than for a yield tax. The higher rate raises the gradient of east-west bias.

The bias against C results in substituting front-end land-time for labour, and understocking, as with the property and yield taxes, so there is intertemporal bias not shown in equation (15).

Finally there is the same host of administrative problems as with the yield tax, plus another host associated with deducting C. The greatest of these is that growers who do their own work instead of hiring it would not be able to deduct it, and for them this would just be a yield tax. Records of C would have to be retained over long cycles of tree life, and the inflationary factor would be frightful. All told this seems a poor system, even though it resembles the U.S. income tax.

B. Tax on Site Income or Value

The residual biases of the income tax are further abated by excluding the income of capital from the base. This may be approached in five ways: deducting C at the front-end ("expensing" it); sharing the cost (other than land cost) by direct subsidy or tax credit; letting growers deduct interest as well as C; subsidizing C while retaining the property tax; and assessing land directly. The last of these is the best, but we survey them all.

1. Expensing costs (or an equivalent investment tax credit).

Let:

Γ (Gamma) = Site Value after tax on yield when costs are expensed.

u = Corresponding tax rate

$$\Gamma = \frac{R(1 - u) - Ce^{im} + uCe^{im}}{e^{im} - 1}$$

$$= \frac{S(e^{im} - 1)(1 - u)}{e^{im} - 1} = S(1 - u)$$

$$\frac{\Gamma}{S} = 1 - u \qquad (16)$$

Here we have achieved perfect neutrality at last. (16) is independent of C or m.

A fly in the ointment is that u must be quite high to compensate for omitting so much of the base. Let us find the equivalent tax rate as before. When m = 50, what value of u makes $\Gamma = \Theta$ when p = .01? Following the model of (13):

$$1 - u = \Omega - C/S\,\Psi$$

$$u = 1 - \Omega + C/S\,\Psi \qquad (17)$$

From Table 3, when C/S = 0, u is the same as t, that is .38. But for higher C/S higher u are required, and when C/S = 1.5, u = .98. Now that seems quite shocking and confiscatory, but it is no moreso than p = .01. Each takes 98% of the site rent, and nothing more. Site rent is all a locality can really tax anyway, a fact implicit in our assumption that taxes lodge in site values. The supply of labour and capital is elastic, so they will shift any local tax.

There are differences, however. The other taxes provoke growers to reduce the tax base to avoid taxes, and so those taxes collect less than our figures show. That twists incentives and misallocates resources as well. The present tax has no such effects. It collects what it purports to, openly, and taxpayers cannot remove the base. Candor in the fisc promotes the same in the taxpayer.

Another difference is that the present tax collects the rent equally from all sites. The others collect more than 100% from some (which go sterile) and very little from others, as Tables 2 & 3 show.

A problem with expensing is that some growers lack outside income against which to expense: and grower labour itself is likely overlooked.

A worse problem with this approach is psychological, and administrative. With a rate of 98%, the cost of C is essentially borne by the fisc, which is rewarded with 98% of the stumpage. The grower puts up 2% of the capital and gets a fair return on that. But essentially he becomes an administrator of the fisc's capital and land. The moral hazard is enormous, and the system would not work. We could go to lower rates, but they would not be equivalent. There has to be a better way.

2. Subsidies

The same analysis applies as with expensing. A minor problem is overcome - growers need no outside income to offset. But the major problem remains. The rate must be extremely high to recover the subsidy, and moral hazard would wreck the system.

3. Deducting interest

If growers operate on credit, and deduct their interest payments on C, (but not on S), and deduct C at maturity, we might again home in on site rent as the tax base. The administrative capriciousness and moral hazards of this proposal parallel those above, and are so evident that I omit further analysis of an otherwise interesting concept.

4. Property tax with subsidy to C.

Another possible solution is the property tax modified by a subsidy to C. This should abate the anti-labour bias in the property tax, while letting us retain the familiar form. The equivalent rates would have to be substantially higher, however, to recover the subsidy. The bias against capital would then become severe, and cycles artifically shortened.

5. Direct Assessment of Site Value

The good results of expensing may be achieved, and the major moral hazards avoided, by assessing site value directly and levying an annual change on the value of this base. It may seem that this restricted base could not raise enough revenue, but if site rent is the upper limit of taxation in any event then this tax can raise as much as any. In fact it can raise more, for it is the only tax that can tap all the supramarginal rent without destroying much other rent near the margins. This tax has no excess burden.

Let:

Φ (Phi) = Site Value after tax on site value

w = Corresponding tax rate on Φ

$$\Phi = S - \frac{\Phi w}{i}$$

$$\frac{\Phi}{S} = \frac{i}{i + w} \qquad (18)$$

Note the capitalization effect at work in deriving (18). $\underline{w}$ is levied on $\underline{\Phi}$, not $\underline{S}$, and erodes its own base. Thus it can rise to seemingly high levels without taking as much of the base as one might think. As (18) shows, the rent is divided between the owner and the fisc in the same ratio that $\underline{w}$ bears to $\underline{i}$. The absolute value of $\underline{w}$ means nothing without reference to $\underline{i}$.

The level of $\underline{w}$ equivalent to p = .01 is figured as before. When m = 50, what value of $\underline{w}$ is required to make $\Phi = \Theta$ when p = .01? Following again the model of (13):

$$\frac{i}{i + w} = \Omega - \frac{C}{S}\Psi$$

$$w = i\left[\frac{1}{\Omega - \frac{C}{S}\Psi} - 1\right] \qquad (18)$$

If m = 50 and C/S = 1 are normal values, then the required $\underline{w}$ is:

$$w = .07 \left[\frac{1}{.62 - .40} - 1 \right] = .07\ (3.55) = .25 \qquad (19)$$

A 25% site tax is the equivalent of a 1% tax on timber alone (exempting the site).[10] The actual figure could be substantially less, however, because of the much higher efficiency of collecting taxes this way. There is no excess burden. It is not that the site tax will collect more than shown, but the property tax collects a good deal less. Table 3 makes it clear that there is great excess burden in the property tax. Therefore it does not collect anything like what it would if no one invested less to avoid it. To avoid letting the 25% figure stand, with its spurious accuracy, let us say 15% is probably high enough and further studies are needed to come closer.

A problem with site taxes may be liquidity effect. Growers must pay taxes for some years before they sell. The problem is the same as with the property tax. Although

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10 It is tempting, but wrong, to say now the equivalent of 2% is 50%, etc. One must recompute values of Ω and Ψ for the higher tax rate. The same is true for different values of $\underline{i}$. Do not hasten from one to another without adjusting Ω and Ψ.

time-distribution is different, the accumulated values with interest are calculated by (18) to be the same by cutting time. The comments made there hold here as well.

If we classify land and apply the site tax only to the forest class, there are two problems. One is dismissable. The marginal productivity of capital in forestry will be lower than elsewhere because the marginal investment need cover only $\underline{i}$, not the full $\underline{i} + \underline{p}$. This is not a problem however to the local open economy where the marginal capital comes from outside. There is no internal loss. Too, there is much other untaxed capital.

The other is more serious. Land may be drawn at the margins into forest use, where the exemption of capital is more important; and out of it where the high rate on land results in disproportionate high taxes because the tax base is raised and sustained by expected furture higher non-forest use. The best solution is to convert all lands to the site-value basis. Short of that one must face up to extra problems in many zones of supersession.

Either alternative, however, would be superior to other options surveyed here, and either one would provide a model for future broader application of the principles involved. My final conclusion, then, is to recommend that the property tax be modified to exempt new-growth timber, and the rate on site value be raised to compensate. Old-growth is something else, and could bear high tax rates on the yield, inventory, or site basis, or all together.