Differences in Silvicultural Investment Under Various Types of Forest Tenure in British Columbia

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ABSTRACT. This paper presents empirical evidence on the relationship between forest tenure and investment in silviculture. Silvicultural activities and expenditures on a large number of recently logged tracts in British Columbia, under four distinct forms of tenure, are assessed using a silvicultural investment model based on the conventional theory of capital. The empirical results indicate that silvicultural investment is correlated with security of tenure, and the level of investment under the most secure form—private land—is more than 67% greater than that under the least secure form—Forest Licences. For. Sci. 42(4):442–449.

Additional key words: Economic incentives, policy, timber, property rights.

In Canada, where most forestland is held in public ownership by provincial governments, the way rights to timber are allocated to private companies is a central and controversial issue of forest policy. Tenure systems vary among provinces and territories, but all the major timber-producing provinces have developed long-term licensing arrangements which are intended to encourage private companies to develop and manage, as well as to utilize, public ("Crown") forests (Pearse 1990a). Recently, new concerns have been raised about tenure policies. With the end of the original natural timber in sight in many regions, forcing the forest industry to turn to new managed crops, the question is whether tenure arrangements provide licencees with adequate incentives to invest in long-term forest production (Pearse 1993).

This concern is heightened in some regions by the decline in timber supplies as the original stock of natural timber is depleted, and regulated harvest rates are adjusted to the long-run sustainable yield—the so-called "falldown" phenomenon. The sustainable yield depends heavily on the amount of silvicultural effort devoted to enhancing forest growth. Thus the concern about future timber supplies leads to concern about the adequacy of private silvicultural effort on public forestlands.

The usual presumption is that, other things being equal, the more secure the tenure, the more the tenure holder will invest in future forest production. This view is reflected in the design of long-term management licences in British Columbia and elsewhere (Pearse 1976). Recently, the government of British Columbia set out to convert certain types of licences to a more secure form, explicitly to "create a positive environment for investment in the forest industry" (Ministry of Forests 1987, p. 30). This belief continues to produce advocates for more secure forms of timber rights, not only from within the forest industry but also from public agencies such as the British Columbia Forest Resources Commission But assertions that weakness in the current tenure system impedes silvicultural investment are rarely supported with quantitative evidence.

The influence of tenure on silvicultural investment has been a subject of much speculation but very little empirical study. The only significant empirical investigation is a comparison of silvicultural spending under certain forms of tenure in British Columbia based on answers to questionnaires given by officers of forest companies (Luckert 1988, Luckert and Haley 1990). There have also been a number of theoretical and policy studies (Posner 1977, Cotter and Ulen 1988, Pearse 1990a, 1993). However, despite its importance to public policy, the quantitative influence of tenure arrangements on investment behavior has not received nearly the attention in forestry that it has received in other sectors—notably agriculture (e.g., Feder et al. 1988).

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Acknowledgments: The authors are indebted to Messrs. Henry Benskin, Mike Blackstock, Bruce Bell, Steve Hunt and Ms. Meiching Tsoi of the Ministry of Forests in Victoria for their generous assistance in providing data for this study. Helpful comments and suggestions on earlier drafts were provided by Clark S. Binkley, Russell Uhler, and two referees and one associate editor of this journal.

Manuscript received November 15, 1994. Accepted November 2, 1995.

This paper presents the results of an initial attempt to measure, directly, the influence of forest tenure on silvicultural investment in British Columbia. The study differs from other investigations of this question insofar as it is based on econometric analysis of recorded silvicultural expenditures under a variety of tenure forms, utilizing a very large sample of data. The paper begins, in the next section, by describing the theoretical framework and econometric method adopted. This is followed by a discussion of the data used in the study. The remaining sections present empirical findings, conclusions, and discussion of policy implications.

Analytical Framework

Investors in silviculture, like other investors, respond to expectations about future returns. The expectations of a silvicultural investor are affected by the nature of his or her property rights over the forest. For example, if his rights extend for a long time into the future, like the infinite term associated with freehold ownership, he can expect to capture all the benefits of investment in increased forest growth. Conversely, if his rights are of short duration, as with a 5 yr Timber Sale Licence, he cannot. Forest tenures can blunt incentives to invest in other ways, as well. Volume-based licences do not convey exclusive rights to a defined area of forest even for their term, so licencees cannot benefit from enhanced growth on any particular tract. Other licences provide that licencees must pay for timber they harvest, including enhanced production, thus reducing their expected benefits from silviculture.

The primary dimensions of property rights over land and resources have been identified as exclusivity, comprehensiveness, duration, transferability and degree of economic benefit conferred. There is a range of possibilities for each of these dimensions, and each form of tenure incorporates a certain combination of these (Pearse 1990b, Zhang 1994, 1996).

For purposes of this study we examined silvicultural activity under the four most important forms of forest tenure in British Columbia, listed in Table 1 with their characteristics most relevant in determining the economic security they afford their holders.[1]

Tree Farm Licences combine Crown forestlands with private lands and Timber Licences held by the licencee to form large, geographically defined, sustained yield units. All categories of land are subject to the same silvicultural regulations. Other private lands, not included in Tree Farm Licences, are subject to different rules, so to avoid distortions resulting from differing regulatory requirements we confined our observations on private lands to those within Tree Farm Licences.

Timber Licences are old forms of tenure with varying terms, intended to give the holder time to remove the original timber according to an approved plan, and then expire. Some are included within Tree Farm Licences; when they expire they become part of the other Crown lands within the licence. [2]

Forest Licences convey a right to harvest a specified volume of timber each year within a broad administrative area. The specific tracts to be harvested are identified from time to time, but the licencee does not have an exclusive right to a defined area for the term of the licence. Forest Licences have shorter terms than Tree Farm Licences, but both are renewable on an "evergreen" basis: that is, the licencee has a right to call for a new licence to replace his existing licence when its term is only partly expired (Pearse 1976).

All these forms of tenure are subject to similar silvicultural regulations. In September 1987 these regulations were changed in important respects, making all licencees and owners responsible for ensuring reforestation by natural or artificial means after logging, and for bearing the cost. Accordingly, to avoid distortions resulting from regulatory change, we confined our observations to areas logged after September 1987.

These four forms of forest tenure differ in the various dimensions of property rights noted earlier (Pearse 1990a). However, with respect to the features that determine the security of the holders' rights—the term, renewability, comprehensiveness of resource rights, obligation to share financial returns with the government and the scope for regulatory intervention—private lands are clearly the most beneficial to the holder, and Forest Licences are the least beneficial. Timber Licences lack the "evergreen" renewal provisions of Tree Farm Licences and Forest Licences, but they convey exclusive rights to a defined area, which

Table 1. Some characteristics of tenure relevant to economic security of its holder.

Form of Tenure	Term	Renewability	Rights conveyed	Governmental charges
Private land in Tree Farm Licences	Forever	Not applicable	All freehold rights	Property taxes based on timber harvested
Crown land in Tree Farm Licences	25 yr	Replaceable every 10 yr	Allowable annual harvest for a defined area	Stumpage
Timber Licences	Varies	Not renewable	Original timber within a defined area	Royalty on timber harvested
Forest Licences	15 yr	Replaceable every 5 yr	Allowable annual harvest	Stumpage on timber harvested

1 For a detailed examination of the various forms of forest tenure in British Columbia, see Pearse (1992) and Zhang (1994, 1996).

2 Of the Timber Licences included in this study, the number that are within Tree Farm Licences is not known. However, roughly half the timber harvested under Timber Licences in British Columbia originates on Timber Licences within Tree Farm Licences (Zhang 1994).

Forest Licences do not (Zhang 1994). Thus our four types of tenure can be considered to be listed in Table 1 roughly in order of declining security of the rights they afford their holders.

In another study, we examine differences in certain indicators of forest management performance among these same types of tenure (Zhang and Pearse 1994). The findings indicate that lands classed as "not satisfactorily restocked" occur less frequently, and comprise a smaller proportion of cutover areas, on private lands than on licenced Crown lands, and that private lands are more often planted, and reforested more quickly than licenced Crown lands. Forest Licences, the least secure tenure examined, showed the poorest performance by these indicators. In contrast to these indicators of the results, or output, of forest management, the present study examines inputs, in the form of silvicultural investment, and its variation among the forms of tenure.

The hypothesis for this study is that, ceteris paribus, silvicultural investment differs among tenures having differing characteristics. There are, of course, other factors that will influence the potential investor's behavior in particular circumstances—the natural fertility of the land, its distance from market centers, the value of the species to be grown, and so on. Thus

$$I = f(T, C, L, S, P)$$

where

I = investment in silviculture, in dollars per hectare, since the area was logged.

T = the form of tenure.

C = the characteristics of the area, including its size and site quality.

L = the location of the area.

S = the species composition of the new crop.

P = the character of the firm holding the tenure.

The results of a regression of the above equation can reveal the influence on silvicultural investment of each of the independent variables. The maximum-likelihood method can be used to find the functional formulation of such equations.

Under each of the four forms of tenure considered here, the holders are required to ensure reforestation to a specified standard within a prescribed period following logging. However, subject to this basic result, they have wide latitude in selecting the reforestation method. They can be expected to choose methods other than the least cost method only where they will generate extra benefits in excess of the extra costs, and where their rights afford sufficient long-term security to allow them to capture the benefits.

Data

The unit of observation for this study is a cutblock, which is a tract of forest designated by the Ministry of Forests for harvesting. Each cutblock is a separate obligation of the tenure holder, who is required to report, for each, annually or every 4 months, all preharvest prescription information and harvesting and silvicultural activities. Here, each cutblock is treated as a homogeneous unit with respect to its natural attributes and other characteristics.

The information about silvicultural activity needed for this study was based on 2,311 observations, each of a cutblock, obtained from the Ministry of Forests. Observations were restricted to cutblocks logged between September 1987 (when legislative changes made holders of all the forms of tenure considered here responsible for ensuring reforestation after logging) and December 1989.[3] Data on these cutblocks have been collected up to May 1993, providing information over a whole business cycle from the prosperous years of the late 1980s to the recession of the early 1990s. Silvicultural subsidies were not involved.[4]

The cutblocks examined were drawn from two broad regions—the coastal Vancouver Forest Region and the southern interior (the Kamloops and Nelson Forest Regions combined).

Table 2 describes the variables used in the statistical analysis, their mean values, and standard deviations. Table 3 presents the corresponding information for each form of tenure.

Silvicultural Investments

Data on silvicultural expenditures on the cutblocks (I) were obtained from tenure holders' annual reports to the Ministry of Forests. Expenditures were attributed to various silvicultural activities or "treatments" defined by the Ministry, of which there are 28 categories, grouped under four types—regeneration, surveys, site preparation, and stand tending.[5]

The Ministry requires tenure holders to report the area treated with each treatment in each cutblock. However, where they report on more than one cutblock within a particular forest district, they may, in their reports, aggregate the costs they incur. To protect the confidentiality of tenure holders' information, the Ministry releases only the aggregate amount of each silvicultural treatment in each district each year and its cost.

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3 Cutblocks harvested since December 1989 have not yet been fully reforested, and so the silvicultural investment on them is inconsistent and misleading.

4 Silvicultural subsidies under the first phase of the federal-provincial Forest Resource Development Agreement (FRDA I, 1986-1990) supported reforestation of "backlog" unstocked lands, i.e., logged before 1982, none of which are included in this study. The second phase of the Agreement (FRDA II, 1991–1994) supported stand tending—spacing, pruning, etc.—and so applied to stands older than those on the cutblocks included in this study.

5 Regeneration includes planting, replanting, fill planting, natural regeneration, mechanical planting, and seeding. Surveys include regeneration surveys, site preparation surveys, and free-growing surveys. Site preparation includes partial slashburning, whole cutblock burning, partial chemical treatment, whole cutblock chemical treatment, guard, partial mechanical treatment, mechanical treatment, and road rehabilitation. Stand tending includes chemical vegetation control, stem clipping, crop covering, fertilization, animal brush control, manual vegetation management, infected tree removal, density control, pruning, seedling protection, and spacing (Ministry of Forests 1991).

Table 2. Variable definitions and sample statistics.

Variable	Definition	Mean value	Standard deviation
Silvicultural investment			
I	Silvicultural expenditure per hectare in constant 1992 dollars	750.58	622.45
Form of tenure			
PFL	Private land in Tree Farm Licences (dummy: 1 if applicable, 0 otherwise)	0.02	0.14
TFL	Crown land in Tree Farm Licences (dummy: 1 if applicable, 0 otherwise)	0.26	0.44
TL	Timber Licence (dummy: 1 if applicable, 0 otherwise)	0.13	0.34
Cutblock characteristics			
SIZE	Size of the cutblock in hectares	29.29	29.24
SOIL_G	Site quality class "Good" (dummy: 1 if applicable, 0 otherwise)	0.07	0.26
SOIL_M	Site quality class "Medium" (dummy: 1 if applicable, 0 otherwise)	0.88	0.32
Location			
BGC1	Coastal Douglas-fir, coastal western hemlock, or montane hemlock biogeoclimatic zones (dummy: 1 if applicable, 0 otherwise)	0.39	0.49
BGC2	Englemann spruce–subalpine fir, montane spruce or subboreal spruce biogeoclimatic zones (dummy: 1 if applicable, 0 otherwise)	0.28	0.45
BGC3	Interior Douglas-fir biogeoclimatic zone (dummy: 1 if applicable, 0 otherwise)	0.09	0.28
Species regenerated			
BALSAM	Percent balsam regenerated	6.27	14.93
CEDAR	Percent cedar regenerated	9.97	19.23
D-FIR	Percent Douglas-fir regenerated	5.55	19.22
HEMLOCK	Percent hemlock regenerated	13.66	25.56
SPRUCE	Percent spruce regenerated	22.91	36.82
Other variables			
PRODUCER	Cutblock within tenure held by integrated firm (dummy: 1 if applicable, 0 otherwise)	0.66	0.47
DATE	Number of months from January 1987 to completion of logging	20.16	6.87
INT	Risk-free interest rate (%) (3-month average rate on Canadian treasury bills)	8.46	2.45

Thus, for purposes of this study, the silvicultural investment in each cutblock was calculated by multiplying the area of each treatment reported by the licence holders by the average cost of that treatment in that district in that year (there are 23 districts in the study area).[6] These costs were inflated or deflated to their equivalent December 1992 dollar values using the Canadian consumer price index. The sum of these outlays for each silvicultural treatment over all years provided the total real value of silvicultural investment for each cutblock since it was harvested and up to May 1993.

The mean value of silvicultural investment calculated in this way for all cutblocks is, as indicated in Table 2, $750.58/ha.

Form of Tenure

Of the four forms of tenure (*T*) examined, three were given dummy variables, as indicated in Table 2. The Forest Licence is treated as the base type, against which variations in the other forms are measured. Since the other three forms of tenure are considered more secure than Forest Licences, the presumption that security of tenure promotes silvicultural investment suggests that the coefficients for these other forms will have positive signs.

Cutblock Characteristics

The size, in hectares, of each cutblock (*C*) was included as a variable. In addition, the site quality of each was identified according to the Ministry's three categories "Good," "Medium," and "Poor." Of these, "Good" and "Medium" were ascribed dummy variables to compare them with cutblocks of "Poor" site quality. Insofar as higher site quality offers more attractive silvicultural investment opportunities, these variables can be expected to have positive signs.

Location

The cutblocks were identified by biogeoclimatic zone (L) to recognize broad differences in location and natural site characteristics. Four groups of biogeoclimatic zones were distinguished, of which three were given dummy variables (Table 2) to compare them with the fourth (interior cedar-hemlock) zone. The expected signs of these variables are not obvious.

[6] This method of estimating the costs of silviculture involves an assumption that there is no systematic difference among tenure holders within a given district in the quality and cost of their silvicultural activities. The relatively small size of forest districts (and hence the homogeneity of conditions within them) and vigorous competition among silvicultural contractors may make this assumption reasonable.

Table 3. Sample statistics of the explanatory variables by each form of tenure for silvicultural investment

Variable	Private Lands		Timber Licence		Tree Farm Licence		Forest Licence	
	Mean value	Standard deviation	Mean value	Standard deviation	Mean value	Standard deviation	Mean value	Standard deviation
Investment	893.07	470.83	645.38	572.39	800.69	812.62	745.92	607.22
Cutblock characteristics								
SIZE	31.47	31.70	30.66	27.15	30.66	28.29	28.36	27.69
SOIL_G	0.07	0.25	0.09	0.28	0.13	0.34	0.05	0.22
SOIL_M	0.93	0.24	0.86	0.35	0.83	0.37	0.90	0.29
Location								
COAST	0.98	0.18	0.88	0.33	0.42	0.49	0.26	0.44
BGC1	0.98	0.15	0.88	0.33	0.42	0.49	0.25	0.43
BGC2	0.00	0.00	0.02	0.15	0.27	0.44	0.35	0.48
BGC3	0.00	0.00	0.00	0.00	0.06	0.23	0.13	0.33
Species regenerated								
BALSAM	8.50	12.92	11.41	19.12	6.65	15.56	4.88	13.16
CEDAR	18.85	27.03	22.85	25.23	11.68	19.91	6.05	15.20
D_FIR	26.07	36.79	9.99	24.64	5.47	18.61	3.91	16.55
HEMLOCK	21.04	21.03	37.94	32.96	17.08	27.48	6.48	18.05
SPRUCE	4.04	8.05	0.11	27.31	20.38	35.38	27.35	38.94
Other variables								
PRODUCER	0.91	0.29	0.84	0.37	0.75	0.43	0.57	0.50
DATE	21.37	6.41	18.28	6.35	20.54	6.85	20.34	6.95
No. of observations	46		306		601		1,377	

Cutblocks were also identified by the two broad geographic regions noted earlier. However, this location variable was dropped because of the high correlation between the Vancouver Forest Region and the coastal Douglas-fir biogeoclimatic zone.[7]

Species Regenerated

To measure the influence on silvicultural spending of the species (*S*) being regenerated, five species were identified along with the percentage of each in the new stands being established. These species—balsam, cedar, Douglas-fir, hemlock, and spruce—account for more than 70% of the timber harvested in British Columbia and some 60% of new crops. Each was ascribed a dummy variable to assess its effect on silvicultural investment relative to "other species" (a residual mixture of mainly pine, cypress, and hardwoods).

Other Variables

To examine possible differences in silvicultural investment between large and small firms, the holder (*P*) of the tenure that included each cutblock was identified. The relevant dummy variable was given a value 1 if the tenure holder was among the largest 20 companies which collectively hold more than 74% of the province's regulated allowable annual cut, and 0 otherwise. Fourteen of these firms appeared in this study. Heavier silvicultural investment by large integrated firms will give this variable a positive sign.

7 Their correlation coefficient is 0.9724. Their high correlation can also be seen by comparing their values in Table 3.

To examine any time trend in silvicultural behavior, a variable (*DATE*) which measures the number of months from January 1987 to the completion of logging was identified for each cutblock. A variable for the current rate of risk-free interest, identified as the 3 month average rate paid on Canadian treasury bills, was added to represent the financing cost of silvicultural investments. It was expected to have a negative sign.

Empirical Findings

The empirical findings rely on linear OLS techniques The functional form of the equation described earlier in this paper was selected empirically by applying the Box-Cox technique to the most common forms (linear, semilog, inverse semilog, and log-linear). The semilog form was found to be preferable.[8]

Highly correlated variables that may cause multicollinearity are dropped. None of the correlation coefficients for the variables included exceeds ±0.30.

8 Since maximizing the Box-Cox likelihood function is equivalent to minimizing the residual sum of squares for the regression where the independent variable is divided by its geometric mean prior to transformation (Judge et al. 1988), the functional form with the smallest residual sum of squares has been chosen. The residual sum of squares was 2965 for the linear; 2584 for the semilog; 3027 for the inverse semilog, and 2672 for the log-linear model. Note that the logarithmic transformation is consequential with respect to the dependent variable, but inconsequential to the independent variables.

Table 4. Values for the explanatory variables for silvicultural investment

Variable	Coefficient	T-ratio
Form of tenure		
PFL	0.5134	3.101*
TFL	0.2135	3.848*
TL	0.1288	1.658**
Cutblock characteristics		
SIZE	0.0001	0.169
SOIL_G	0.3972	2.903*
SOIL_M	0.5399	4.812*
Location		
BGC1	−0.3609	−3.257*
BGC2	−0.2916	−4.462*
BGC3	−0.9469	−10.623*
Species regenerated		
BALSAM	−0.0121	−6.759*
CEDAR	0.0045	2.711*
D_FIR	0.0057	3.609*
HEMLOCK	−0.0095	−6.355*
SPRUCE	0.0053	7.282*
Other variables		
PRODUCER	0.2613	5.198*
DATE	0.0057	1.709**
INT	0.0288	3.059*
INTERCEPT	5.3905	32.080*
R^2	0.2059	
R^2-adjusted	0.2000	
D.W.	1.6870	
Breusch-Pagan χ^2 test for heteroskedasticity (df = 147)	90.1355	
No. of observations	2,311	

* Significant at the 99% level.
** Significant at the 90% level.

The results of the regression for the semilog form of the equation are presented in Table 4. Neither serial correlation nor heteroskedasticity is found in the model. Of the 18 parameters estimated, 16 are significant at the 90% level of confidence or better. Most of their signs and values appear reasonable. The relatively low R^2, however, shows that much variation remains unexplained. This could be because the model overlooks other variables or certain variables included inadequately reflect their true values.[9]

The low R^2 is not important for two reasons. First, cross-section equations, like this one, almost always generate lower R^2 than time-series equations (Lardaro 1993, p. 186). Second, the R^2 associated with a correct model is not necessarily large (McGuirk and Driscoll 1995). Since, as noted earlier, most regression coefficients are significant, and no multicollinearity, serial correlation, and heteroskedasticity appear in the model, the model itself is correctly specified and adequate for hypothesis testing purposes.

The variables for the form of tenure show that tenure is a significant influence on the level of silvicultural investment. Indeed, these parameters are significantly different from zero even at the 99% level of confidence for private and Crown lands within Tree Farm Licences and at the 90% level for Timber Licences.

These results indicate that, after allowing for other influences, all of the other three forms of tenure are associated with higher silvicultural investment than Forest Licences. Private lands show the highest investment, followed by Crown lands in Tree Farm Licences, Timber Licences, and Forest Licences in that order, consistent with their suggested ranking in terms of security. The coefficients imply that per hectare silvicultural investment on private lands, Crown lands within Tree Farm Licences and Timber Licences is 67, 24, 14% more, respectively, than that on Forest Licences.[10]

For example, if the level of silvicultural investment under a Forest Licence were (at the mean value of all Forest Licences in this study) $745.95, under similar forest conditions the level under Timber Licences would be $850.38, under Crown lands within Tree Farm Licences $924.98, and on private lands $1,245.74. Figure 1 presents these results.

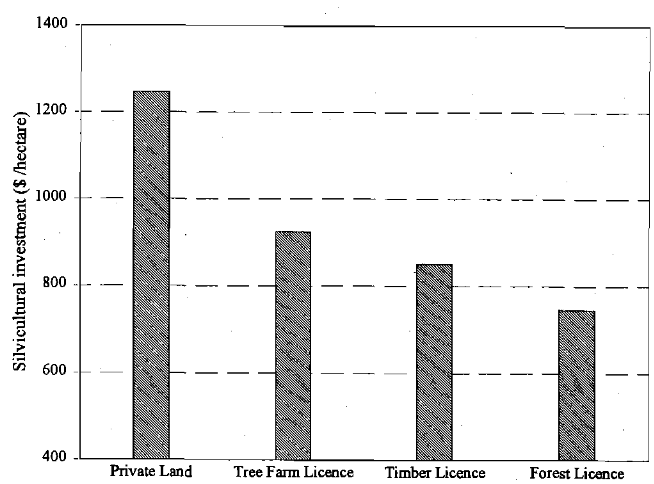

Figure 1. Silvicultural investment among forest tenures (given Forest Licence = $745.95/ha).

[9] One of the former is log price. When a price variable (i.e., the volume-weighted log price in Vancouver log market) was included in the regression, its resulting coefficient was not significant and did not improve the model. This is possibly due to inefficient nature of the market (Pearse 1976) so that the recorded price could not adequately represent the true value of log transactions on the Coast. Moreover, the price cannot reflect true log values in the interior, where forest products firms are vertically integrated and no arm-to-length market exists. Thus we decided not to use the price variable. An example of the latter is the size of individual firms. We used the regulated annual allowable cut as a rough guide to distinguish big producers from small ones. A better indicator might be the annual sales of individual firms. However, more than 100 firms are included in this study (many of which are not public companies), making it difficult to collect annual sales information.

[10] The relative effect of a dummy variable on the dependent variable in a semilog equation is {exp(c)−1}, and the percentage effect is equal to {100*[exp(c)−1]}, where c is the estimated coefficient of the dummy variable (Halvorsen and Palmquist 1980).

Among other significant influences on silvicultural investment, the positive coefficients for good and medium site quality suggest that higher site quality induces higher silvicultural investment, as expected. The variables for biogeoclimatic zones show that these, too, are a significant influence on investment. The coefficient for the cutblock size variable is negative but not significantly different from zero.

The coefficient of the variable for firm size (*PRODUCER*) is positive and significant, indicating that large integrated firms invest more than small firms.[11] The positive relationship between investment and the date variable indicates increasing silvicultural activity over the study period.[12] The coefficient of the interest rate variable is also positive, suggesting (counter-intuitively) higher investment with higher interest rates. One possible explanation of this result is the lack of significant movement in interest rates during the study period (with mean of 8.46% and standard deviation of 2.45%).

Conclusions

The purpose of this study was to assess, quantitatively, the popular notion that the form of tenure influences investment in silviculture. The logic of this contention is clear enough: firms invest in future production when they perceive benefits in excess of the costs, and the form of tenure they hold over forestlands governs the extent to which they can expect to capture the benefits of investments in enhanced forest growth. Thus, forms of forest tenure that are longer term, more clearly defined, provide more of the economic benefits to their holders, and otherwise offer them more security are likely to stimulate more silvicultural investment.

The findings in this study support this general argument. To this extent they are broadly consistent with the conclusions of others (Luckert 1988, Luckert and Haley 1990), and with findings of superior resource management performance under more secure forms of tenure (Zhang 1994, Zhang and Pearse 1994).

More uniquely, the empirical findings in this study indicate the magnitude of the differences in silvicultural effort associated with different forms of tenure. Of the four most common forms of forest tenure in British Columbia the most secure form—private land—stimulates almost double the amount of silvicultural investment associated with the least secure form—Forest Licences.

The policy implications of these findings are significant. Forest Licences—the least secure form of tenure, associated with the lowest silvicultural investment—is by far the most important, accounting for well over half the timber harvested in the province and applicable to an even larger proportion of the province's forest resources. If the silvicultural investment observed on private lands can be assumed to be efficient and beneficial to the owners, the much smaller investment under Forest Licences means that substantial opportunities for beneficial silviculture are being lost on public forest lands.

This study was inevitably limited to observable forms of forest tenure, each of which is a unique combination of the various dimensions of property rights—exclusiveness, comprehensiveness, duration, transferability, and economic benefits provided to the holder. We have not been able to measure the contribution to the results of each of these dimensions of the property rights, though that would provide valuable guidance in designing tenure policy. Nor have we been able to measure (except in the crude fashion described in the preceding paragraph) the relationship between the level of silvicultural investment observed and the level that would maximize the economic rent to forestland. These important questions must be left for further research.

[11] This behavior is consistent with incentives generated by the well-known allowable cut effect, which enables the holders of regulated sustained yield units (mainly big firms) to increase their current harvest rate by enhancing the productivity of their cutover lands (Pearse 1965, Binkley 1980). However, there is no evidence of this behavior here.

[12] This may be related to the surge in timber values in the early 1990s and the increasing public and official attention to silviculture in recent years.

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