Silvicultural Practices and Costs in Coastal British Columbia: A Case Study

Sen Wang, G. Cornelis van Kooten, and Bill Wilson

Forest Economist, Canadian Forest Service, Victoria, British Columbia, Canada,
Professor, Department of Economics, University of Victoria, Victoria, British Columbia, and
Director, Industry, Trade, and Economic Programs, Canadian Forest Service, Victoria, British Columbia, Canada

In 1987, the Government of British Columbia transferred responsibility for basic silviculture from the Provincial Ministry of Forests to the major forest licensees, and the introduction and implementation of the Forest Practices Code in 1995 intensified forest company responsibilities for silvicultural activities. The highly prescriptive Forest Practices Code also dictates how silvicultural objectives of public forest lands are to be operationally delivered. In this paper, primary data on silvicultural practices and costs of a forest company operating in Coastal British Columbia are analyzed. Our findings indicate that, although British Columbia forest companies have accepted the legislated transfer of postharvest silvicultural obligations, public policy encourages companies to treat silviculture as a cost of doing business rather than an investment. Because of these institutional signals, forest companies seek to confine their operations to basic silviculture. Furthermore, silvicultural costs are positively correlated with the intensification of government regulations, particularly the Forest Practices Code. Finally, the research indicates that innovative approaches are required to efficiently deliver socially desirable silvicultural investments. Tree Planters' Notes *50(1): 50-57; 2003.*

In British Columbia (BC), more than *95%* of forest land is publicly owned. Before *1987,* the Provincial Government, as owner, was responsible for all postharvest silvicultural activities, including planting. Because of economic factors, the government amended forest land legislation and transferred responsibility for basic silviculture (getting trees to the free-to-grow stage) to the major forest companies, which hold timber-harvesting licenses on public forest lands. Then, in response to growing pressure from environmentalists and social interests, the BC Government took steps to reduce the environmental impacts of commercial timber operations. The most important step was the Forest Practices Code (BC *1994)* (hereafter, the Code), which passed into law in *1994* and came into effect in *1995.* The Code established a stratified set of legislative and administrative rulesregulations, standards, and field guides-that collectively govern public forest land practices. The Code stipulated that all regulations and standards were mandatory, whereas field guides provide recommended procedures, processes, targets, and evaluation criteria. Once inserted into forest management plans, prescriptions, and contracts, the field guides are interpreted as rules that are legally binding and subject to enforcement (Wang and van Kooten *2001).*

The rationale of the Code was to simplify institutional complexities by consolidating and updating regulations and guidelines, but its purpose was to establish mandatory requirements for forest practices and to set compliance and penalties. The Code brought about many positive changes in BC forest practices, such as spatially defined adjacency conditions, inter-temporally specified green-up requirements, and administratively mandated planning procedures. However, while the Code contributes to the protection of nontimber amenity values of the forest, as well as timber values, it significantly increases operating costs of forest companies (Thibodeau *1994;* McIntosh and others *1997).* For instance, a BC forest industry survey estimated that to comply with the Code, forest companies collectively generated nearly half a million sheets of planning materials in the 1st *2 y* following the introduction of the Code. The burden was not only felt by the industry, but also by the Province as more resources and staff time were required by the Ministry of Forests to process "an avalanche of information"(Gregory *1997).* Further, a comprehensive, social cost-benefit analysis of the Code, that included nonmarket values, indicated that society lost more than it gained (van Kooten and Bulte *2000).*

Prior to *1987,* the BC Forest Service directly hired workers to deliver the silvicultural activities, which were limited to seedling production and small-scale tree planting. With an expansion in the scale and scope of silvicultural operations, the government increasingly opted to use the emerging silvicultural contractors for financial and administrative reasons. Wang and others *(1998)* provide an account of the historical forces shaping the evolution of the BC silviculture sector.

While responsibility for silviculture was shifted to the private sector in *1987,* silvicultural practices further changed in response to newly adopted government policies, including a joint Federal-Provincial initiative to fund reforestation of a backlog of lands that had not been satisfactorily restocked (Thompson and others *1992).* The Code was subsequently designed to guide forest management in the light of sustainability principles and as a response to environmental and social pressures. From an industry perspective, however, it was the financial implications of these policy shifts that were important. Given the rising costs associated with meeting the various requirements of the Code, it is important to understand the structure, determinants, and actual levels of silvicultural costs.

Our objectives in this paper are to investigate trends in the changing structure and components of corporate silvicultural programs and costs in the decade after 1987, and to review the effect of the Code on silvicultural activities and costs. We gathered information from a case study of a forest company operating on the BC Coast (referred to as the Company). As a significant player, this company is seen to be reasonably representative of major timber-harvesting licensees in the coastal region with regard to silvicultural performance. We conducted in-person interviews, and reviewed and analyzed Company data on silvicultural activities from 1987 through 1996. We then used regression analyses to examine the link between government policy and silvicultural costs and performance. The effects of the Code on silvicultural activities and costs were analyzed by comparing costs before and after the Code went into effect. Finally, we discuss BC's silvicultural strategy in light of recent Provincial forest policy.

Company Profile

The Company is composed of several divisions that operate primarily on the BC Coast, and it has an allowable annual cut exceeding 3 million m^3 (1.27 billion board ft). In addition to some private forest land, it has timber cutting rights on public forest land in the form of tree farm licenses, timber licenses, and forest licenses (see Wang and van Kooten 2001 for a description of these tenures). A separate silviculture division exists at both the corporate and operations levels. In total, the Company has over 50 permanent silvicultural employees on staff. Each operation (also known as a woodlands division) typically has less than 10 silviculturalists, with 2 or 3 having registered professional forester status.

The silvicultural program of the Company consists of 3 components: planting, brushing and weeding, and regeneration surveying. Based on terminology from the BC Ministry of Forests, these activities are classified as basic silviculture (BC 2000). Planting and brushing and weeding are primarily contracted out, although some seasonal workers, mostly summer students, are hired directly to do the planting. The Company's employees undertake the majority of regeneration surveying but, in some operations, contractors perform 30% or more of surveying work. The payment methods that the Company uses for directly hired, seasonal workers include hourly wages, piece rates, and salary. While the Company uses piece rates and hourly wages to pay for planting and brushing and weeding, surveyors are on salary. Summer students are paid a monthly salary, with many doing supervisory work due largely to their university training and forestry knowledge. Many students use summer employment as a form of internship, with some subsequently becoming permanent employees after 2 or 3 summers. Seasonal employment ranges from 3 to 6 mo each year.

When contracting out, the contract period averages about 2 mo. There are 2 major types of contracts, "preferred contractor" (used in Company-funded projects) and "lowest bid" (used in projects funded by the BC Ministry of Forests). Usually 4 to 7 contractors are available, with 30% to 70% coming from local communities. The selection criteria are, in descending order of importance: (i) successful relationship in the past, (ii) reputation, (iii) local community employment, and (iv) competitive price. Practically all silvicultural contracts are short term; some contracts have built-in provisions for revision or renegotiation, while others allow settling of disputes anytime upon request from either party. During the 10-y period from 1987 through 1996, the Company and its operations did not resort to arbitration or litigation; disputes were settled by negotiation.

Silvicultural Programs

During 1987 through 1996, the Company undertook planting, brushing and weeding, and regeneration surveying (figure 1).

Planting. The area planted by the Company increased over the study period. On average, 3467 ha (8567 a) were planted each *year* using some 3 million seedlings. However, the average planting density of 845 stems per ha (340 stems per a) is considerably lower than the provincial average of 1186 stems per ha (480 stems per a) over the same period. Possible explanations for this include the use of larger seedlings, different species, partial natural regeneration, and adoption of company-specific harvesting and silvicultural methods (for example, the use of seed-tree methods).

The Company's planting costs increased considerably during the 10-y period (figure 2). Contract costs are the largest portion, representing 65.8% of the total (table 1). In comparison, Company labor and seedling costs represent 10.3% and 23.9%, of total planting costs, respectively. The average overhead cost of $0.18 is embedded, but not listed separately in table 1. The average overall planting costs per tree is $0.92. On average, 708 person-days were spent managing the planting program each year, or 0.2 person-days per regenerated hectare.

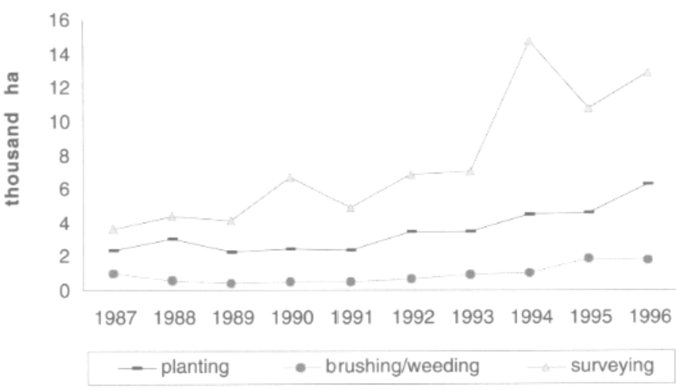

Figure 1—*The Company's silvicultural programs during the decade 1987 to 1996. One acre equals 0.4047 ha.*

Figure 2—*Planting costs, in Canadian dollars, during the decade 1987 to 1996. One acre equals 0.4047 ha.*

Table 1—*Average planting costs incurred by the Company from 1987 through 1996, based on an average planting density of 845 trees/ha (340 trees/a)*

Planting component	Cost[a] ($/tree)
Seedling cost	0.221
Contract cost	0.607
Company labor cost	0.095
Total planting cost	0.923

[a]In Canadian dollars.

Planting costs for the Company are compared with planting costs for the Vancouver Forest Region (the BC Coast) rather than the Provincial average; cost data were not available for other Coastal licensees (figure 2). Silvicultural activities in the Coastal region are undertaken by a variety of licensees, that consist of several large-scale timber companies as well as a significant number of independent loggers. In addition, the Provincial Ministry of Forests conducts silvicultural activities through its Small Business Forest Enterprise Program. For a better understanding of the licensee composition and related issues in the BC Coast, **see** BC Ministry of Forests (1995), Drushka (1999), and Wang and van Kooten (2001).

Concerning planting costs, during the 1980s and the early 1990s, the Company's unit area costs were basically on a par with the regional average. These costs include average on-site operating costs such as equipment, transportation, and wages, but do not include overhead costs. However, from 1993 onwards, a significant divergence occurred (figure 2). While regional average costs declined slightly, the Company's unit area costs rose.

During the 1990s, in view of the green-up and adjacency constraints required by the Code, forest companies adopted a variety of strategies to comply with the new regulations while attempting to contain costs. Benskin and Bedford (1994) report the wide **use** of partial cutting and "quick-fix" regeneration, which includes planting more trees per hectare, using larger seedlings, and planting fast growing species. However, the Company took a different approach. Instead of increasing planting density in response to the requirements of the Code, the Company chose to pay greater attention to prompt crop establishment by promoting natural regeneration, as well as planting the appropriate tree species at various sites. This strategy was perceived to lower silvicultural costs over the entire phase leading to the freeto-grow stage.

Brushing and weeding. Over the decade ending in 1996, the Company undertook, on average, 927 ha (2290 a) of brushing and weeding per year. In 1987, it was 1,004 ha (2480 a), but then dropped to below 400 ha (988 a) 2 y later (figure 1). Although the decreasing trend was reversed in the early 1990s, this aspect of silviculture did not recover to its 1987 level until 1994, but it did nearly double in 1995 to 1,845 ha (4557 a). The variation in the brushing program from year to year was primarily due to Company staffing, employee workload, and changing regulations with respect to the use of chemicals, rather than with acreage needing brushing treatment. For example, the Company reduced its use of chemicals dramatically in the late 1980s, and steadily thereafter, due to changes in societal values and increasing difficulty in obtaining pesticide **use** permits for aerial operations. The corporate strategy was to reduce aerial application and shift to ground spraying, manual brushing, and other methods, such as girdling.

Contract costs (on a per-ha basis) were the largest component of brushing and weeding costs, constituting 64% of entire unit-area costs. Chemical costs were relatively small, but Company labor constituted 12% of costs, which is, in relative terms, slightly higher than Company labor costs in the planting program. In terms of unit-area costs for brushing and weeding, the Company paid more during the period than the average for the Vancouver Forest Region (the BC Coast) and the Province as a whole (table 2), especially since the beginning of the 1990s. As expected, the BC Interior incurred lower costs than coastal companies due to differences in terrain and vegetation in the 2 regions. Within a region, larger companies generally incurred higher costs than smaller ones because larger companies are subject to a higher degree of public scrutiny for regulatory compliance (Wang and van Kooten 2001).

Regeneration surveying. On average, 7,607 ha (18,790 a) per year were surveyed by the Company for regeneration during the decade, reaching a peak in 1994 (figure 1). Regeneration surveying costs have 2 major components-labor and travel (including room and board). Due to the labor-intensive feature of this activity, it is not surprising that Company labor expenses account for 85% of total costs. Labor costs remained high relative to travel costs, and the difference between the two seems to have been growing.

Using the BC Ministry of Forests (2000) data as a baseline, the Company spent consistently more for regeneration surveys than the average for the Vancouver Forest Region and the Province as a whole (table 2). Interestingly, as with planting and brushing and weeding, the discrepancy in the unit area costs for surveying widened after 1993. However, the magnitude of the divergence is difficult to quantify due to differences in the terminology and categorization employed, and the unavailability of disaggregate data for forest regions and the province.

In summary, although costs increased for all 3 silvicultural activities over the decade 1987 through 1996, brushing and weeding exhibited the most cyclical pattern. The 10-y average costs incurred by the Company

Table 2—*Comparison of costs per hectare for basic silviculture incurred by a specific company or groups of companies*[a]

Company(s)	Planting	Brushing/ weeding	Surveying
BC Coast case study Company ($/ha)	749.7	725.8	29.5
Contract costs ($/ha)	518.2	468.4	none
Labor costs ($/ha)	52.2	86.6	19.8
Labor (person-days/ha)	0.204	0.198	0.053
Vancouver Forest Region ($/ha)	432.8	437-598[b]	13.1-14.5[c]
BC Province average ($/ha)	490.1	324-538[b]	12.0-13.3[c]

[a]Source: Interviews and data provided by a major British Columbia (BC) Coast licensee; BC (1997, 2000). Costs are in Canadian dollars. One acre equals 0.4047 ha.
[b]The 2 figures for brushing and weeding refer to per-hectare costs by chemical and manual means, respectively.
[c]The 2 figures for surveying refer to basic regeneration and incremental silviculture surveying, respectively.

for these activities are 1.2 to 2.5 times the average for the Vancouver Forest Region and the Province (table 2). However, a note of caution is in order. As emphasized in our interviews by a corporate-level silvicultural manager of the Company, to make meaningful comparisons in silvicultural costs, contract costs must be used. Since independent contractors perform the majority of BC's basic silvicultural activities (Wang and others 1998), the competitive nature of the Province's silvicultural contracting market tends to reduce differences in the levels of payments by various licensees. As shown in table 2, the relative proximity of the Company's contract costs to the regional and provincial average costs is a case in point. This means that variation in overhead is the biggest difference in costs. Although the size and composition of overhead costs of the Company's silvicultural activities can be determined, comparable information on the structure and levels of overhead costs for forest regions and the province is unavailable. Thus, it is not possible to definitely conclude that the average costs of the Company's silvicultural operations are higher than the regional average. Aggregate costs for basic silviculture cannot be determined from the available data, because costs for individual activities are not additive.

Empirical Analysis of Silvicultural Costs

Regression analyses provide insights into the costs of silvicultural activities undertaken by the Company. To the extent that this company is representative of other firms on the BC Coast, the results provide insights into more general silvicultural activities. In particular, the results provide insights into the impact of government policy emphasizing silvicultural investments by private firms on public land. Since management and institutional factors are of interest (rather than estimating economic cost functions), simple linear functional forms with average cost (denoted *Cost* in the equations below) as the dependent variable are used. The data used in the regressions comprise both time series and cross sectional data. Specifically, for the period 1987 through 1996, observations available for regression analysis include 477 for the planting program, 234 for the brushing and weeding program, and 386 for the regeneration surveying program. To control for the inflation rate, all silvicultural costs are converted to 1994 constant Canadian dollars using the Bank of Canada's GDP deflators. Cost functions were estimated for on-the-ground basic silviculture-planting, brushing and weeding, and surveying-followed by an analysis of overhead costs related to these silvicultural activities.

Basic silviculture. Separate regressions are required for the 3 silvicultural activities because comparable data are not available for identical sites. For the planting program, we expect planting costs to be a function of the area planted, site conditions, and specific methods of regeneration. Stone (1992) used average slope as an indication of site conditions. Because the Company did not record topography data for the sites involved, and because data on regeneration methods were unavailable, planting density was used as a proxy. Planting density is expected to encompass information about site conditions, methods of regeneration, and so on. The regression equation for planting is:

(1) $Cost\ (\$/\text{ha}) = a_0 - a_1 \times \text{area planted} + a_2 \times \text{planting density} + a_3 \times \text{Code dummy}$

where the coefficients to be estimated are all positive (a_i?0). The plus and minus signs preceeding the parameters reflect the a priori expectations regarding the positve or negative nature of the correlation with cost. Average cost is expected to fall with increasing area planted due to hypothesized economies of scale; as more acreage is planted, per unit costs (for example, supervisory costs) fall. Average cost increases with increasing planting density. Finally, a dummy variable represents the period when the Code was in effect; it has a value of 1 when the Code was

(2) $Cost\ (\$/\text{ha}) = b_0 - b_1 \times \text{area treated} - b_2 \times \text{treatment dummy} + b_3 \times \text{Code dummy.}$

in effect (starting in 1995) and zero otherwise.

Similarly, the cost function regression equation for brushing activities is:

Since the parameters are positive, the a priori expectations are indicated by the signs. Brushing cost is negatively correlated with area treated because of economies of scale. Treatment methods consist of conventional approaches like ground and aerial treatments, plus other methods such as girdling and biological control (for example, with sheep). The treatment method is a dummy variable (I =conventional treatment, O=alternative methods), with the sign on this variable hypothesized to be negative. Thus, we expect nonconventional methods to be associated with higher treatment costs due to lack of experience and the extent of human attention required. Again, a dummy variable represents the impact of the Code.

Finally, the data also permit an estimate of the costs of regeneration surveying as a function of the area surveyed, which is expected to be negative as a result of scale economies, and the implementation of the Code. The regression equation for regeneration surveying is:

(3) $Cost\ (\$/\text{ha}) = c_0 - c_1 \times \text{area treated} + c_2 \times \text{Code dummy.}$

The error terms (not shown) for each of the 3 regression equations are assumed to be independently and identically distributed, with a mean of zero. Statistical tests indicated that heteroscadasticity, but not autocorrelation, might be a problem; it was corrected for in the regressions using the method outlined by White (1980); see also White and others 1990.

Regression results obtained from the ordinary least squares estimation for each of the 3 silvicultural activities (table 3) confirm that there are economies of scale in planting, brushing and weeding, and, to a lesser extent, silvicultural surveying. Specifically, planting costs are positively correlated with planting density, and the Company paid a premium for using nontraditional methods in brushing treatments. Further, the highly significant and positive coefficient for the Code dummy variable indicate that the Code did indeed raise basic silvicultural costs. Admittedly, the values of the coefficient of determination, R^2, are not high (table 3). Possible explanations for this are the omission of other explanatory variables because of data limitations, or the highly disaggregated level of the observations; generally, the higher the aggregation level, the higher the R^2 value.

To determine the effects of the Code on silvicultural costs, the costs are estimated from the regressions for both the pre-Code (dummy variable set to 0) and postCode (dummy variable set to 1) periods. The difference

Table 3—*Regression analysis (simple linear) of basic silvicultural activities as performed by the British Columbia Coast case-study Company*

Variable	Estimated coefficient	*t*-ratio[a]
Planting		
Area planted (ha)	-1.1695	-5.36
Planting density (trees/ha)	0.3199	2.44
Code dummy (1=1995, 1996; 0=other)	409.33	6.34
Constant	621.17	5.30
N = 477		
R^2 adjusted = 0.164		
Brushing/Weeding		
Area treated (ha)	-3.273	-4.25
Treatment method (1=aerial/ground; 0=other)	-343.62	-4.31
Code dummy (1=1995, 1996; 0=other)	161.82	1.82
Constant	1115.4	12.38
N = 234		
R^2 adjusted = 0.171		
Regeneration Surveying		
Area surveyed (ha)	-0.015	-2.191
Code dummy (1=1995, 1996; 0=other)	23.928	7.517
Constant	30.622	16.58
N = 386		
R^2 adjusted = 0.181		

[a]All estimated coefficients are statistically significant at the 5% level except for that of Code dummy under the brushing program, which is significant at the 10% level. One acre equals 0.4047 ha.

is assumed attributable to the Code. The regression results indicate that the Code has increased planting costs by $409 per ha, brushing and weeding costs by $162/ha, and surveying costs by less than $24/ha. However, the estimates of the impact of the Code could be exaggerated because the results are based on observations from the 1st 2 y of the existence of the Code (1995 and 1996). Since it is usually a learning process for forest companies when responding to new regulations, opportunities are likely to emerge for firms to adjust their costs under new circumstances.

Project management and supervision costs. Data on overhead costs are available for both planting and brushing. It is hypothesized that program management and supervision costs are a function of contract size, which is indicated by the amount of contract costs or the payments made to contractors. These payments increase in proportion to the size of the silvicultural activities undertaken. Additionally, it is hypothesized that, with the introduction of the Code, major licensees incurred higher overhead costs related to compliance. The respective regression equations for planting and brushing and weeding are:

$$\textit{Overhead Cost}\ (\$) = d_0 - d_1 \times \text{area planted} - d_2 \times \text{planting density} + d_3 \times \text{contract cost} + d_4 \times \text{Code dummy},$$

and

$$\textit{Overhead Cost}\ (\$) = e_0 - e_1 \times \text{area treated} - e_2 \times \text{treatment method} + e_3 \times \text{contract cost} + e_4 \times \text{Code dummy}.$$

The other variables are as in the earlier regressions. The results provided only partial evidence that the Code also increased overhead costs because the results confirm this only for the planting program (table 4).

Table 4—*Regression analysis (simple linear) of silviculture overhead costs incurred by the British Columbia Coast case-study company*

Variable	Estimated coefficient	*t*-ratio[a]
Planting		
Area planted (ha)	-0.0007	-7.26
Planting density (trees/ha)	-0.0002	-4.54
Contract cost for planting per ha	0.1025	2.92
Code dummy (1=1995, 1996; 0=other)	0.1469	5.33
Constant	0.3309	5.55
N = 477		
R^2 adjusted = 0.425		
Brushing		
Area treated (ha)	-1.0557	-2.93
Treatment method (1=aerial and ground; 0=other)	-8.5953	-0.21
Contract cost per ha	0.245	4.63
Code dummy (1=1995, 1996; 0=other)	-9.2683	-0.24
Constant	107.69	2.006
N = 234		
R^2 adjusted = 0.15		

[a]All estimated coefficients are statistically significant at the 5% level except for that of treatment method and the Code dummy under the brushing program. One acre equals 0.4047 ha.

Discussion

Using data on silvicultural expenditures by a BC Coastal forest company over the study period, we show that changing Provincial forest policies significantly increased private silvicultural costs. First, policies shifted responsibility for silviculture from the public owner to the private tenure holder. Second, increasing government environmental regulations in the forest sector, manifest in the Code, led to increased silviculture costs. The transfer in silviculture accountability to the forest licensee did not alter the structure with respect to the security of tenure. In addition to the standard risks inherent with investing in long-term timber rotations (for example, fire, pests, and storm events), the licensee investor must assume a high degree of institutional risk due to the uncertainty in a renewable forest license on public forest lands. Growing trees is capital-intensive, and encouraging investment without secure tenure is highly problematic. Given the forest tenure structure, forest companies treat silviculture as an expense rather than an investment, and, as a result, make no effort at silvicultural treatments beyond the bare minimum required under the law, essentially basic silviculture. Focusing on planting, brushing and weeding, and regeneration surveying, the Company operated to minimize silvicultural activity.

Further, in the actual performance of silvicultural activities, companies rely on contracting out as the main vehicle for the delivery of silvicultural programs. For instance, the Company contracted out most of its planting and brushing and weeding activities, while using its directly hired workers to undertake regeneration surveying. The rationale for such a delivery is to minimize transaction costs (Wang and van Kooten 2001).

Policy changes result in the restructuring of the institutional environment in which firms operate. It is frequently argued within the forest industry that company silvicultural costs tend to be positively correlated with the intensification of government regulations. Our empirical results lend support to this argument because the dramatic post-Code increase in planting and brushing and weeding costs (table 3) provides evidence of a structural change in 1995, when the Forest Practices Code came into effect.

One legitimate question is: "What do companies do differently because of the Code?" The forest industry certainly has taken steps to adjust to the institutional changes resulting from the Code. For instance, helicopter logging, a rarity prior to the Code, now accounts for some 15% of the coastal harvest (Allington 1998). In addition to helicopter logging, companies also harvest more of their privately held lands, because private forest lands are subject to less stringent environmental requirements. A further incentive to harvest private forest lands is that log exports are less restricted by government controls. Admittedly, forest practices in the interests of sustainable development and environmental protection are not realized without additional costs. For instance, silvicultural prescriptions such as leaving wildlife trees, creating riparian zones, and using partial cutting systems tend to result in increased costs. It is estimated that meeting the information requirements of (paperwork associated with) the Code alone cost approximately \$10 per m^3 (\$23.60 per Mbf) of commercial wood (Gregory 1997).

There are lessons to be drawn from the case study. A new institutional environment often calls for the adoption of innovative approaches in firms' delivery of required programs, but new measures often result in higher costs. In the case study, as new brushing and weeding methods emerged, the adoption of these new methods tended to increase costs (table 3). However, high costs may not persist as firms move along the learning curve. Besides, if the institutional environment is such that firms have sufficient freedom to pursue their goals and perform their tasks, there will be opportunities for them to reduce costs. Indeed, the regression results suggest that there may be economies of scale in the performance of silvicultural activities. As the scale of silvicultural activities increases, forest companies appear to become more efficient in performing them, whether done in-house or contracted out to a silvicultural specialist.

Since early 1998, the cost implications of the Code have increasingly been recognized. As a result, efforts to streamline the Code to enable forest managers at the field level to use their judgment and location-specific knowledge in operational decisions have been included. The Ministry of Forests, recognizing the inefficiency of managing by prescription rather than by objective, has moved to introduce changes in delivery of the Code. In 2000 the Ministry introduced a pilot program that provided the option for licensees to develop forest land operational plans that would meet the objectives of the Code without implementing the dictates of the Code. The Forest Practices Code Pilot Project still requires the participation of all stakeholders in the design of any alternative to the Code and includes a formal approval by the government. The initiative seeks to test resultsbased forest management techniques on the ground to enhance efficiency and save costs for both the forest industry and the government (Wilson and Wang 2001). While this policy move has won widespread support from the forest industry, its effectiveness will depend upon, among other things, a genuine relaxation of stringent regulations. It is open to debate as to the extent to which regulations should be relaxed and implemented. Given the complexity of the Code, it is possible that new adjustments could initially complicate rather than simplify field-level forest operations because, to fully understand the meaning of each new policy change, forest managers have to be well versed in all existing and previous rules under the Code.

In addition, the Ministry is actively reviewing the Code in an effort to shift the *modus operandi* to a resultsbased code from management by prescription. This review is a challenge because it seeks to balance improvements in operational efficiency with the social and environmentalist expectations on public forest land protection. The Ministry of Forests' commitment to upgrading delivery of the Code is both necessary and commendable.

It is often argued that institutional changes have implications for costs at both the planning and operational levels, and that adequate economic incentives enable firms to operate more efficiently under less stringent institutional constraints. Based on this study, we conclude that, unless society deems it necessary, compliance-based regulations, especially those highly complex ones such as BC's Forest Practices Code (BC 1994), need to be assessed against alternative mechanisms to achieve the objective without the same degree of deadweight losses to society from inefficiencies. The inefficiency costs are, first and foremost, borne by the forest company, but ultimately they constitute a cost to all of society because the forests are publicly owned. BC is in the process of developing a Provincial silvicultural strategy to ensure sustainable forest management in the 21st century, which encompasses a triple bottom line of environmental, social, and economic objectives. Some important lessons can be learned from the Code in order that policies will emerge to protect the integrity of forest ecosystems, enhance the productive capacity of the resource base, and serve the long-term interests of the forest stakeholders.

Address correspondence **to:** Sen Wang, Natural Resources Canada, Canadian Forest Service, 506 West Burnside Road, Victoria, BC, Canada V8Z 1M5; e-mail: < senwang@pfc.forestry.ca >.

Acknowledgement

GC van Kooten was Professor, Department of Applied Economics and Statistics, University of Nevada, Reno, NV, when this paper was written.

References

Allington R. 1998. Chasing a bigger piece of a smaller, higher priced pie. Business Logger 8(5): 4.

Benskin H, Bedford L. 1994. Multiple purpose silviculture in British Columbia. The Forestry Chronicle 70: 252-259.

[BC] British Columbia Legislature. 1994. Bill 40 - 1994: Forest practices code of British Columbia. Victoria, BC

[BC] British Columbia Ministry of Forests. 1995. 1994 Forest, range & recreation resource analysis. Victoria (BC): Ministry of Forests.

[BC] British Columbia Ministry of Forests. 1997. Annual Report. Victoria (BC): Ministry of Forests.

[BC] British Columbia Ministry of Forests. 2000. Just the facts: A review of silviculture and other forestry statistics. Victoria (BC): Ministry of Forests. 118 p.

Drushka K. 1999. In the bight - The BC forest industry today. Madeira Park (BC): Harbour Publishing. 304 p.

Gregory R. 1997. More planning documents, less wood - the paper trail that leads to the harvest. Business logger 7(5): 19-22.

McIntosh RA, Alexander ML, Bebb DC, Ridley-Thomas C, Perrin D. 1997. Financial state of the forest industry and delivered wood cost drivers. Report prepared for the British Columbia Ministry of Forests. Victoria (BC): KPMG and Perrin, Thorau & Associates Ltd. 102 p.

Stone M. 1992. Estimating stand tending treatment costs in British Columbia. Victoria (BC): British Columbia Ministry of Forests, Economics and Trade Branch Working Paper. 58 p.

Thibodeau ED. 1994. Effects of environmental protection on forest management costs in the Nehalliston Creek watershed: An analysis. Victoria (BC): Canadian Forest Service. FRDA Working Paper 6-008. 55 p.

Thompson WA, Pearse PH, van Kooten GC, Vertinsky I. 1992. Rehabilitating the backlog of unstocked forest lands in British Columbia: A preliminary simulation analysis of alternative strategies. In: Nemetz PN, editor. Emerging issues in forest policy. Vancouver (BC): University of British Columbia Press. p 97-130.

van Kooten GC, Bulte EH. 2000. The economics of nature. Oxford (UK): Blackwell. 512 p.

Wang S, van Kooten GC. 2001. Forestry and the new institutional economics - An application of contract theory to forest silvicultural investment. Aldershot (UK): Ashgate Publishing Limited. 201 p.

Wang S, van Kooten GC, Wilson B. 1998. Silvicultural contracting in British Columbia. The Forestry Chronicle 74: 899-910.

White H. 1980. A heteroscedasticity-consistent covariance matrix estimator and a direct test for heteroscedasticity. Econometrica 48: 817-838.

White KJ, Wong SD, Whistler D, Haun SA. 1990. Shazam econometrics computer program - User's reference manual. New York (NY): McGraw-Hill Book Company. 352 p.

Wilson B, Wang S. 2001. Treading the path to sustainable forestry: New directions in Canada with particular reference to British Columbia. In: Niskanen A, Vayrynen J, editors. Economic sustainability of small-scale forestry Joensuu, Finland: EFI Proceedings No. 36. p 131-141.