ENVIRONMENTAL REGULATION AND INCENTIVES TO COMPLY: REVIEWING THE ECONOMICS BEHIND FOREST PRACTICES ENFORCEMENT STRATEGIES IN BRITISH COLUMBIA

by

GLENN DOUGLAS FARENHOLTZ, R.P.F.

B.Sc.F. The University of Alberta, 1989

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTERS OF SCIENCE

in

THE FACULTY OF GRADUATE STUDIES

FOOD AND RESOURCE ECONOMICS GROUP
FACULTY OF AGRICULTURAL SCIENCES
UNIVERSITY OF BRITISH COLUMBIA

We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

December 2003

© Glenn Douglas Farenholtz, 2003
In presenting this thesis in partial fulfillment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Glenn Douglas Farenholtz 22/12/2003
Name of Author (please print) Date (dd/mm/yyyy)

Title of Thesis: Environmental Regulation and Incentives to Comply: Reviewing the Economics Behind Forest Practices Enforcement Strategies in British Columbia

Degree: Masters of Science Year: 2004

Department of Agricultural Economics, Faculty of Agricultural Sciences
The University of British Columbia Vancouver, BC Canada
Abstract

Government, as the Principal in the Principal-Agent theory model, can maximize social welfare in setting up an enforcement structure that provides incentive for an Agent to adopt diligent behaviour. Also, society is better off providing opportunity for development and harvesting of resources on those lands where diligent behaviour will result in social welfare gains. Penalties provide incentive for firms to expend on precautionary strategies to lessen the social welfare loss of environmental damage and allow for the maximization of social welfare.

Using a partial equilibrium model of social welfare from forest management activities, a definition of what penalties should be to provide optimal incentive is developed. Penalties levied under the Forest Practices Code of British Columbia Act have been described as low by the Forest Practices Board and by environmental groups due to not recognizing the value of environmental damage in the sanction. As penalties are negligence-based under the Code, they do not explicitly consider environmental damage as is shown in the derivations from the partial equilibrium model. The model describes that penalties should be greater than the difference in the cost of being diligent relative to the increased likelihood of environmental damage from non-diligent behaviour. The relative effects of that ratio are subject to social value constraints, and some consideration as to proportionality of this relationship has bearing on whether the "penalty fits the crime".

Government may elect to pursue other non-financial strategies to effect compliance, as the cost of pursuing an enforcement action exceeds the expected social gains of enforcement, and therefore would be a welfare loss with a low probability of successful sanction. Economic incentive to comply is more sensitive to the probability of a penalty being applied than the size of the penalty and therefore actions that increase the successful application of a sanction, for example making regulations and standards clearer and more enforceable, will assist in providing for increased incentive to comply.
Table of Contents

Abstract .................................................................................................................. ii
Table of Contents .................................................................................................. iii
List of Tables and Figures ..................................................................................... iv
Acknowledgements ............................................................................................... v
Dedication .............................................................................................................. v
1.0 Introduction ..................................................................................................... 1
2.0 Background ..................................................................................................... 2
  2.1 The Economic Context of the Forest Industry in Canada ......................... 2
  2.2 Compliance and Enforcement ................................................................... 4
  2.3 An Economic Description of the Incentive System .................................. 7
  2.4 Describing the Social Welfare Function .................................................... 9
  2.5 The Concept of Due Diligence .................................................................. 11
3.0 Literature Review ............................................................................................ 13
  3.1 Monitoring and Enforcement Strategies ................................................... 13
  3.2 Why do firms comply with environmental regulations? ............................ 14
  3.3 What is the optimal penalty? ...................................................................... 15
  3.4 Recommended Enforcement Strategies .................................................... 19
  3.5 When are penalties low? .......................................................................... 23
4.0 Economic Model of the Compliance Regime ................................................. 26
  4.1 The Principal-Agent Model – Moral Hazard or Hidden Action ................ 27
  4.2 The Principal-Agent Model ..................................................................... 30
  4.3 Forest Lands – Optimal Management Zones ............................................ 32
  4.4 Penalties relative to enforcement success ................................................. 39
  4.5 Government, enforcement success and penalties ...................................... 40
5.0 Data Analysis .................................................................................................. 42
  5.1 Pertinent Legislation and Policy ................................................................. 43
  5.2 Average Penalties and Enforcement Success ........................................... 45
  5.3 Data Analysis by Section of the Forest Practices Code of BC Act ............ 48
  5.4 Data Summary Statistics ......................................................................... 55
6.0 Discussion ....................................................................................................... 57
  6.1 Why penalties might be lower than expected under the Code ................. 57
  6.2 Perfect Enforcement ................................................................................. 63
  6.3 Imperfect Enforcement ............................................................................. 64
  6.4 General Application ................................................................................... 69
7.0 Conclusions .................................................................................................... 72
References ........................................................................................................... 77
Appendix A ........................................................................................................... 81
  Context with Principal-Agent Theory ............................................................... 81
  Hidden Action – Monopoly Solution ............................................................... 82
  Optimal Incentive Scheme .............................................................................. 83
List of Tables and Figures

Table 1  Statistical description of sanctions levied under Section 17(1) ..................49
Table 2  Statistical description of sanctions levied under Section 45(1) ..................51
Table 3  Statistical description of sanctions levied under Section 45(3) ..................52
Table 4  Statistical description of sanctions levied under Section 47(1) ..................54
Table 5  Average Penalty and Sanction Rate for Selected Sections ....................55
Table 6  Comparative analysis of costs not borne by licensee, relative to the increase in likelihood of environmental damage .....................................................56
Table 7  Estimate of Cost of Ministry of Forests Enforcement Activities for Inspection through Appeal Process .................................................................65
Table 8  Comparative analysis deriving likely level of environmental damage ........67

Figure 1  Graph of penalty distribution for sanctions levied under Section 17(1) ........49
Figure 2  Graph of penalty distribution for sanctions levied under Section 45(1) ........51
Figure 3  Graph of penalty distribution for sanctions levied under Section 45(3) ........52
Figure 4  Graph of penalty distribution for sanctions levied under Section 47(1) ........54
Figure 5  Graph of principal’s problem with agent’s indifference curves ..............86
Acknowledgements

First of all, thank you to Ian Wood, Data Resource Officer for all the work querying and linking data from various government databases for this project. Also, thank you to Cassandra Mann, R.P.F. and Dan Graham, L.L.B. for approving the use of the data for this project.

Thanks also to Jim Vercammen who inspired and helped work through the development of the initial idea for the thesis and had the patience to coach me through the model. Special thanks to Pascal Ghazalian, PhD candidate (USask) for perspectives on the Principal-Agent theory and providing me a starting point. Unbeknownst to him, thank you to Mark A. Cohen of Vanderbilt University for his significant work in reviewing the literature relevant to this dissertation – although dated, the leads it provided were invaluable.

Finally, thank you to my committee: Sumeet Gulati, George Hoberg, Kathy Baylis and Rashid Sumaila for their time during the transitions occurring in the faculties of Agricultural Economics, Forestry and the Fisheries Centre at the time of this dissertation.

Dedication

This thesis is dedicated to my mom and my sister, the two constants in my life. Live your dreams they said…
1.0 Introduction

In March of 2002, the Forest Practices Board (FPB) of British Columbia, released a report on *Forest Practices Code Penalties and Environmental Damage* (FPB, 2002). In their report, the FPB states “the Board has become concerned about the occasional failure of government officials to give adequate weight to environmental damage when setting penalties for Forest Practices Code contraventions.” In consultation with the public when the B.C. government introduced implementing new results-based forest practices legislation, submissions to the process maintained that penalties levied under the Code had been inadequate (Forest Futures, 2002; Sierra Legal Defence Fund/ForestWatch, 2002) and would not then provide incentive for firms to comply with the regulations. If licensees and government came to accept environmental damage and penalties as the norm, damage and penalties become just the “cost of doing business” in B.C. and forest harvesting would happen at the expense of the environment (West Coast Environmental Law, 2002).

When firms make decisions to maximize profits they must consider the risk of liability associated with regulations prohibiting any environmental damage resulting from operational activities. Sutinen (1999) represents that firms will violate “up to the point where the marginal profit of violating equals the expected marginal penalty augmented by the risk factor. Questions that arise in determining what costs firms are willing to incur to mitigate this risk reflecting what precautionary efforts they are willing to expend, and will their efforts be enough to be considered diligent in the eyes of the government or public? With diminishing marginal returns to compliance expenditures, a firm will choose their optimum compliance efforts and precaution (Kolstad, 1990) based on their expectations of penalties and enforcement success.

---

1 The Forest Practices Board is an independent agency acting as a public watchdog for sound forest practices in B.C., auditing forest licensee management and government enforcement practices. Established in 1995 and recognized under the *Forest Practices Code of British Columbia Act*, the Board publishes reports about compliance with the Forest Practices Code and the achievement of its intent.
Government, in considering the risk management strategies of firms, can set penalties higher to offset a lower likelihood of successful enforcement action (Becker, 1968; Cohen, 1998; Giannakis, 2002). According to the Ministry of Forests (1999) risk is a challenge in forest management where the “underlying goal is not to avoid or eliminate it, but rather to assess and manage it” with the objective being to “achieve optimal or at the very least acceptable levels of risk, where the benefits flowing from a particular action or decision outweigh the potential loss or damage.”

This thesis provides an overview of the existing Forest Practices Code framework to investigate what economic and policy reasons might provide opportunity for penalties to be lower than would be expected. An outline of what is currently considered in levying a penalty is described within the framework of the investigation. A principal-agent model is developed to describe the government to licensee relationship and a discussion about the appropriate social reference point as a participation constraint is constructed. A proposal for enforcement policy where harvesting is optimal is introduced consistent with recent land use zoning literature. Finally, actual penalties and enforcement success of sanctions levied under the Code is reviewed. The valuation of environmental services, especially in aggregate, and evaluating whether penalties adequately reflect those values is left for future investigations.

2.0 Background

2.1 The Economic Context of the Forest Industry in Canada
The production of pulp, paper and wood products in Canada makes up over 13% of the shipments to other countries. In total, there is approximately 180 million cubic meters of timber harvested annually from Canadian forests, contributing over $62 billion in forest products sales to the national GDP per year. In British Columbia, an average of 72.2 million cubic meters harvested annually generates over $2 billion in Crown revenues and over $20 billion in forest products sales in the form of logs, lumber and chips (COFI, 2000).
Provincial governments in Canada are responsible for the management of natural resources on lands held in the public's trust. Ninety-six percent of forestry activities in British Columbia occur on these public lands, with over 200,000 hectares harvested annually in interior and coastal forests (COFI, 2000). The protection of other resource values and public interests on these harvested lands occurs through a variety of statutes governing industry practices on provincial lands. In these Acts and Regulations, government agents are empowered to administer or levy sanctions in the form of financial penalties through an administrative process (quasi-judicial) or the non-complying firm is liable for fines and/or internment through the judicial system.

In Canada, and especially in B.C., it is important to understand that firms operate on lands they do not own. Legally, the role of the provincial government on these lands, as paraphrased from the B.C. Ministry of Forests Act\(^2\) is to:

(a) encourage maximum productivity of the forest and range resources in BC;
(b) manage, protect and conserve the forest and range resources... having regard to the immediate and long term economic and social benefits they may confer on BC;
(c) plan the use of the forest and range resources of the government, so that... resource values are coordinated and integrated...;
(d) encourage a vigorous, efficient and world competitive timber processing industry in BC; and
(e) assert the financial interest of the government in its forest and range resources in a systematic and equitable manner.

With this, the Ministry of Forests (MOF) has the authority to allocate harvest quotas in the form of licences to harvest timber to firms under (d) and (e), and government has implemented regulations per (b) and (c) to protect the public's interests in land and resources impacted by forest management activities.

Licensees operate milling facilities based on timber licence allocations from Crown lands in the form of volume-based (m\(^3\)/yr) or area-based (ha) tenures. These tenures are as described in the Forest Act\(^3\) where Forest Licences, Pulpwood Agreements, and BC Timber Sales (formerly the Small Business Forest Enterprise Program) volume-based tenures make up 76% of the provincial Allowable Annual Cut (AAC) harvested within Timber Supply Areas. The remaining 24% of the provincial AAC is harvested within Timber Supply Areas. The remaining 24% of the provincial AAC is harvested within Timber Supply Areas.

\(^2\) Ministry of Forests Act, RSBC 1996 (Consolidated to June 20, 2003) CHAPTER 300, Section 4
\(^3\) Forest Act RSBC 1996, c. 157 (Consolidated to June 20, 2003), Sections 14 and 35
from Tree Farm Licences, BCTS on TFL’s, Woodlots and Community Forest area-based tenures. Market wood, sold competitively by the Ministry of Forests through the BC Timber Sales program, amounts to 15% of the provincial timber supply in British Columbia.

2.2 Compliance and Enforcement
In British Columbia, the MOF has created a branch of government to ensure monitoring and enforcement occurs as required in the provincial environmental statutes. Monitoring as coordinated by Compliance and Enforcement Branch of the MOF occurs in the form of inspections to ensure compliance with the plans and permits authorized by government. If an incident of non-compliance is discovered, there are a range of enforcement options available, including non-financial sanctions such as warning tickets, violation tickets, instructional orders, and stop-work orders applied in the field, through to a statutory decision-maker administratively determining financial penalties, forfeiture, quota reduction, or in extreme cases, a licence cancellation.

The Sierra Legal Defence Fund (SLDF) and ForestWatch, environmental lobby groups in B.C., claim that the amount of financial penalties levied against companies since 1995 under the Forest Practices Code of BC Act for environmental damage is the same as the amount of money collected in overdue book fines by the Vancouver public library in the same period (Page and O’Carroll, 2002). Despite the incongruent nature of the comparison, what is implied is that the penalties levied by government are inadequate in valuing environmental costs of non-compliance (economically, B.C. is compensated for environmental damage in the province as little as Vancouver alone values overdue library books...). West Coast Environmental Law (WCEL) suggests

---


5 Soon to be more, as announced in the current negotiations over 20% tenure takeback initiated to develop a true log market allowing competitive sales under the MoF Timber Sales Program to help determine market-based stumpage pricing for B.C. Indications are that up to 8% will be allocated to First Nations, another 8% to the Timber Sales Program, and the remainder to provide additional Woodlot areas and Community Forests. (MoF, 2003)
that the "monetary penalties in the current Code should be strengthened, and jail penalties actually used. In addition, more innovative penalties should also be included" (Clogg, et. al., 2002), and in discussions at the meetings on the results-based Code, represented that penalties must consider compensatory, deterrent, remedial measures, economic profit and the economic value of the resource in determining the appropriate amount of penalty to levy to 'make the Crown whole'.6 This means that environmental groups believe that penalties can offset the economic welfare losses resulting from environmental damage such that there is no net loss of welfare if a company can compensate the public for damage on Crown lands.

Environmental penalties levied by government may appear to be low when considering the potential risk to the environment of non-compliance with environmental standards (Lear, 1998) with a low number of firms fined, and a high level of compliance. However, this may be as a result of internalizing the costs associated with mitigating environmental risks to the firm through regulation as the most effective tool for ensuring environmental standards are met (Cohen, 1998).

With the Forest Practices Code of BC Act, government has taken the approach that regulation will stipulate process and forest management activities required, thereby internalizing the costs of compliance to firms operating on public lands consistent with Cohen (1998) introduced above. Government then approves higher level plans to set the environmental management objectives for resource extraction in a given area and licensees then submit operational plans consistent with the regulatory framework for government review and approval. The operational plans propose methods to protect and conserve the resource values outlined in the higher level plans while allowing the licensees to harvest timber as per their licence agreements. Government then monitors company compliance with the approved operational plans. If a company is found to be in non-compliance with the Code, a forest officer representing the District Manager (DM) for the area investigates the incident and the DM determines the appropriate

---

enforcement action, including the level of penalty to levy subject to a maximum as defined by regulation.

It is worth mention that the Forest Practices Code of BC Act does not explicitly provide for a district manager to require more precautionary effort from higher risk licensees – if they could, then higher risk licensees would then directly experience higher costs of doing business. Policy does however allow the district manager the flexibility to require more information or process requirements for activities that are perceived to be higher risk (and not approving a plan until the appropriate level of information and proof of intent of precautionary effort is provided). This discretionary requirement can be considered an implicit tool in environmental conservation, but begs the question of consistency and transparency in its equitable application across the province.

With the current evolution of the Code towards a more “results” based approach under the Forest and Range Practices Act (FRPA), it is anticipated that the Forest Service will shift its focus more towards compliance and enforcement activities (Ministry of Forests (MoF), 1999) while licensees should manage their operations and submit plans based on the underlying risk assessment and risk management decisions. Approval of any plans by a statutory decision-maker does not “shift liability away from the licensee who “owns” the plan, or the forester who prepared it”, maintaining the liability with the company conducting activities or the professional who prepared the plan.

The Compliance and Enforcement officials within the Ministry of Forests conduct compliance activities with three main purposes (MoF, 1999): these are to “promote compliance; to avert non-compliance before it occurs; and to detect and address non-compliance when it does occur”. Inspection and investigation roles for the officers, and the sanctioning role of statutory decision-makers are to provide certainty that government enforces the incentive strategies for firms to incur precautionary costs in

---

7 B.C. Forest Service is an older, traditional name used to refer to the Ministry of Forests. The origins of the B.C. Forest Service can be traced back to the Royal Commission of Inquiry on Timber and Forestry, appointed July 9, 1909. Much later the Ministry of Forests was formally established in 1979 based on recommendations provided by the British Columbia Royal Commission on Forest Resources (1975-76) and with the passing of the Ministry of Forests Act, RS1979-272-1.
meeting the regulatory requirements introduced under the Code, as penalties without effective sanction do not provide adequate incentive to comply (Becker, 1968).

Administrative remedies under the Code are available to the Forest Service to address contraventions regardless of whether or not a licensee is at “fault”. While the primary function of these penalties is to compensate the Crown when the risk lies with the licensee, penalties have a blended “compensatory” and “deterrent” nature and function. The administrative penalties cannot be used solely as an indicator of poor performance, as they can also consider extra incentive to ensure future activities don’t result in the same contraventions.

2.3 An Economic Description of the Incentive System

The system that has evolved to provide incentive for licensees to adopt adequate environmentally sensitive practices can be described in a step-wise progression of three-stages or levels of decision-making. Firstly, government makes a decision around policy regarding regulating operational standards that apply to forest practices, sets penalty levels and determines how often to inspect as a strategy to observe outcomes of forest management practices. Second, licensees choose their expenditure levels on the level of precautionary effort to incur while trying to maximize profits based on their beliefs on the likelihood of increased environmental risk, probability of environmental damage, and the government’s enforcement effort and likely success of their sanction bid. Lastly, government then applies sanctions in the form of non-monetary and monetary penalties after inspecting operational activities for actions discovered that are in non-compliance with the regulations, or for actual environmental damage. In this thesis I’ve chosen to model that Government’s behaviour is social welfare maximizing, and that penalties are applied in order to minimize inordinate risk to, or actual damage to the environment as a social welfare loss.

There are several key assumptions to consider in applying penalties under the model introduced in this thesis:

- sanctions are applied in all cases where an inspection has explicitly found a contravention of the regulation that has resulted in environmental damage.
Note that in the data analysis, the penalty may take a non-monetary form (i.e. no action, warnings, reporting, or orders to comply);

- the probability of environmental damage ($\pi$) is a decreasing, convex function of the level of precautionary effort ($e$), or expressed as $\pi(e)$ where $\pi'(e) < 0$ meaning the likelihood of environmental damage falls with increasing precautionary effort and $\pi''(e) > 0$ which describes a graphical curve relationship that is convex and shows diminishing marginal returns to incremental precautionary effort. It is not necessary that the relationship be convex, but is more interesting and probably more true to the reality of the returns to effort;

- the perceived magnitude of risk of environmental damage is consistent with actual damage to the environment such that penalties and enforcement strategies are appropriate to the risk. Later, when the district manager levies a penalty, the sanction is based on the actual increase in likelihood of environmental damage and not automatically assumed to go to 100% given there is always a risk of environmental damage beyond the control of the licensee. In this, $\pi_0 > 0$, or can never equal zero; and

- inspectors and decision-makers make no errors in judgement nor any misappropriations reflecting bias, lack of judiciary diligence or other social inefficiencies of effort (consistent with Bose, 1995).

According to a report written by Roberta Reader, the then Director of Compliance and Enforcement Branch (2000), enforcement powers established under the *Forest Act* and the *Forest Practices Code of British Columbia Act* impose a broad range of penalties or sanctions that:

- curtail independence of action (i.e. remediation order or stopwork order);
- take away property rights (i.e. seizure, access to security deposits);
- suspend or cancel rights of access to resources (e.g. suspension or cancellation of tenure agreement under the *Forest Act* or the *Range Act*);
- impose a financial burden (e.g. as an administrative remedy under the Code); and
- take away a person’s liberty (i.e. quasi-criminal offences and conferred power on courts to sentence a person to imprisonment or a fine).
What is important in Ms. Reader’s summary is that government has established statutory powers to ensure there is real risk and incentive for a firm to meet regulatory requirements while operating in the forest of British Columbia.

2.4 Describing the Social Welfare Function

The current timber volume allocation or “tenure” system relies on government disposition of Crown timber in the form of licences to manage public lands for timber extraction. Firms then pay stumpage (call this “S”) to the Crown (to government in this case) for volume harvested under agreement. The government account in this thesis includes specific factors, including costs ($k_i$), of administering and managing the Crown portion of the forested land base (known as the “Provincial Forest”), with enforcing regulations related to forest management. General government administration costs are not considered in this analysis (i.e. those related to delivering other programs like social services, health care, education, etc.).

Enforcement activities are a direct cost to society and include all of the administration, inspection, investigation, application, review and appeal costs associated with levying penalties and sanctions for non-compliance with the Code. The most easily and intuitively recognizable loss to social welfare is in the risk of environmental damage ($E$). A penalty levied by government ($\rho$) is to provide incentive for firms to adopt precautionary behaviour to protect the environment and considers elements of compensation and remediation (in Section 4 I will derive an optimal penalty function in specific context to B.C.). Penalties attempt to remove any net economic gains from not being precautionary to ensure there is at least an economic incentive for companies to comply with the regulations designed to protect the environment. The penalty or sanction levied by government is a function of the investigation-determined (not directly observed) firm’s level of precautionary due diligence ($e_i$), and how the level of risk or probability ($\pi_i$) of environmental damage ($E$) increases.

8 “Stumpage” is a term derived from early revenue collections by the B.C. Forest Service based on a $0.25 fee per “stump” harvested from Crown lands. The term has continued in use but now reflects the rate paid per cubic meter of volume based on value by species and grade of log and considers harvest cost factors required to deliver the log to the mill. This valuation is done consistent with MOF valuation processes as described in the Coastal and Interior Appraisal Manual.
Where a licensee has not been duly diligent and government inspects and applies a penalty, the penalty may require the licensee to pay a fine determined by the district manager who may also direct or “order” the licensee to remediate the area. A record of the determination is then entered in the government database (which is published publicly every year) and a bill for the amount of the penalty determined by the statutory decision maker (SDM) is sent to the licensee. The revenues from the fine or penalty go into the government’s “consolidated revenues” account and contribute to the government’s annual general balance sheet. Intuitively, this means any penalties collected compensate the Crown who manages the lands on behalf of the public for operational externalities impacting negatively on the environment.

Ask what penalty would be levied if (1) firms choose not to comply, (2) there is no environmental damage discovered, and (3) no inspection occurs to determine compliance? This can and will happen, for example, when a contractor includes organic debris (that are undetectable) in a road sub-grade on unstable slopes which is inspected only after the road grade is complete. If the road fails, it can be a very high-risk situation endangering human life, causing loss of growing site, affecting visual aesthetics, and stream water quality and/or fish habitat below. Hence, the application of a sanction or penalty by government is dependent on the likelihood (a probability function) of successful inspection, investigation, sanction and unsuccessful appeal (call this factor ‘delta’, or use the notation ‘δ’).

As society gains wealth in harvesting from the natural resource endowment in B.C., social welfare function (W) to describe that wealth would consider firm profits, the cost of any gains or losses through impacts to the environment, government revenues and taxes including penalties collected as restitution for damages that may have occurred minus the cost of enforcement (as a deadweight loss), plus the infrastructural gains effected by investments in forest management. Net social welfare will be a function of licensee profits and government revenues net of possible environmental damage and government expenditures.
2.5 The Concept of Due Diligence

Due diligence is a concept that was much debated in the review of forest statutes that occurred in 2002\(^9\) when drafting the new *Forest and Range Practices Act* that will replace the current *Forest Practices Code of British Columbia Act*. According to Black's Law Dictionary (Garner, 1999) due diligence is defined as "Such a measure of prudence activity or assiduity, as is properly to be expected from, and ordinarily exercised by, a reasonable and prudent man under the particular circumstances; not measured by any absolute standard, but depending on the relative facts of the special case. This is a legal term that can be simply stated as acting reasonably and responsibly."

Environmental interests in the debate were adamant government should hold firms strictly liable\(^{10}\) for environmental damage and effect penalties that reflect the full economic costs of poor management practices and provide an additional deterrent to ensure licensees comply.\(^5\) Instead of strict liability, industry expressed supported a limited liability model that considered reasonable actions to prevent environmental damage and imposed a negligence-based penalty only when the firm did not take an appropriate level of care or precaution, and allowing due diligence as full defence in any non-compliance assessment.

Unlike an offence tried under a judicial process governed by the *Offence Act*, due diligence is not currently considered a defense to an administrative penalty levied by a statutory decision-maker under the Code. However, due diligence can be considered when a statutory decision-maker determines the amount of the penalty levied. If a company has done everything reasonable within its power to assess, plan and execute operations to minimize the risk of non-compliance or environmental damage, the government maintains that a licensee can still be held responsible and partly liable for any environmental damage that might have occurred. This is the essence of the model developed in this thesis.

Land has inherent value in its undeveloped state, both in resource value and land productivity, and as property rights are allocated there must be incentives provided

\(^9\) Personal communication, Cassandra Mann R.P.F., C&E Branch, Ministry of Forests, 2002
\(^{10}\) For a complete legal and economic description of "strict liability" see Vandall, 1989
such that losses to the Crown due to environmental damage are minimized. This will imply later that government shares the risk of resource development and thereby does not incur the full risk of land development made available through license agreements. As forestry is conducted on public or "Crown" lands in B.C., intuitively government must necessarily offer manageable land for licensees to operate on, or that government must provide information regarding the relative risk of environmental damage to correct for any asymmetric information and management uncertainty. As an example, overview-level terrain stability mapping done by the province provides licensees an indication of where unstable terrain exists within the management area and stipulates in regulation that licensees are to assess, design and conduct their operations consistent with the level of sensitivity. This defined level of due diligence makes the land available to forestry activities and thereby reduces the risk of landslides on public lands as the licensee is then expected to act with all reasonable efforts and precaution identified in their diligence process.

Economically, the cost of precautionary effort to a firm of due diligence is to offset the risk of impacting negatively on the productive land base and other resource values. Firms must risk-manage such that the marginal cost of the level of precaution directly reflects the marginal likelihood and magnitude of risk of any consequences (consistent with Becker, 1968) resulting from timber development. If the firm's level of due diligence is determined to be appropriate by the statutory decision-maker, then it is assumed the licensee will not be penalized and government incurs the social cost of the non-compliance or environmental damage. Later in Section 3.0, the cost of bearing fault is shown to be borne by government through recognition of these costs in the comparative value stumpage system.

There is a positive relationship between risk and sanction, inferring that government penalties increase with the potential for environmental losses and thereby are indirectly a function of a firm's precautionary efforts ($e$) as well. Implicit is that the level of precautionary effort ($e$) a firm adopts affects the likelihood of environmental damage $\pi(e)$, and is considered in the Code as an argument to lower penalties by the relative amount of due diligence incurred, making penalties, $\rho(e)$, a function of effort as well. The expected penalty must increase proportionately (Harrington, 1988, Cohen, 1998).
when a reduction in a firm’s level of precautionary level of due diligence results in a higher risk of environmental damage.

Given the level of environmental damage represented by $E$ remains constant for this analysis, and that the likelihood of successful enforcement activities ($\delta$) will decrease with government budget reductions, government has promised “tougher new penalties” to ensure incentive for firms to incur precautionary costs through effort, and the relative risk to resources remains constant or is lowered through more effective legislation. To date it is unclear how much penalties will increase with the new *Forest and Range Practices Act* and regulations, and whether increasing the maximum and taking actions (i.e reducing C&E efforts) that could reduce the “expected” penalty will have any additional incentive effect at all.

### 3.0 Literature Review

#### 3.1 Monitoring and Enforcement Strategies

Regulatory decisions determine the structure of incentives faced by regulated firms (Garvie and Keeler, 1994) and the expense of monitoring relative to the regulator’s power to levy penalties helps to explain the differences between compliance and deterrence enforcement styles. *Deterrence* regimes apply to discrete episodes of environmental damage wherein firms actively conceal their actions making the discovery and verification of violations both difficult and expensive. These regimes are consistent with expensive monitoring and strong societal sanctions for violations. *Compliance* regimes are characterized by more frequent contact between firms and regulators and by relative tolerance for intermittent non-compliance or some level of continuing non-compliance as part of a negotiated schedule for improvement. These regimes are characterized by weak regulatory powers and relatively inexpensive monitoring systems.

Stigler (1970) defines the role of enforcement as “to achieve that degree of compliance with the rule of prescribed (or proscribed) behaviour that the society believes it can afford.” Consistent with Garvie and Keeler, monitoring and enforcement are defined as: *monitoring* is the process of discovering and verifying actual compliance with
regulation. *Enforcement* will be considered actions that comprise the notification, administrative and quasi-judicial expenditures which, contingent on the results from monitoring, affect firm profitability.

### 3.2 Why do firms comply with environmental regulations?

Firms respond to both positive and negative incentives (Cohen, 1998). Penalties levied for non-compliance should be an adequate reason, however informal community pressure and social norms play an important role in affecting the levels of firm emissions and/or compliance (Pargal and Wheeler, 1996; Hettige et al, 1996; Arora and Carson, 1996; Brooks and Sethi, 1997; Konar and Cohen, 1998), and that the ability of communities to play this role appears to be an increasing function of their income and education level.

Sutinen and Kuperan (1999) identify the following factors that a firm may consider: potential illegal gain, severity and certainty of sanctions, individuals’ moral development and their standards of personal morality, individuals’ perceptions of how just and moral are rules being enforced, and social environmental influences.

Uncertainty in product variety encourages consumers to look at reputational signals to differentiate their choices. Public disclosure of pollution levels can generate public pressure to reduce pollution levels according to Arora (1993). A key message of his paper is that market forces are important if information on the environmental records of firms is publicly available. Arora and Gangopadhy (1995) assume that for the same physical quality, a consumer may be willing to pay a higher price if the product is produced with a technology that is environmentally friendly.

Information that a firm has been sanctioned for violating environmental laws may also be of interest to shareholders or lenders of that firm. (Cohen, 1998) If a sanction has a possibility of reducing the expected value of the firm, it will affect the share price and/or bond rating of the firm and may also give lenders pause about risking more capital as the firm may incur additional costs in the future. There may be a risk of loss of goodwill to employees or customers, thus reducing the long run profitability of the firm and may signal that the firm is not as well managed as they thought.
3.3 What is the optimal penalty?

Cohen (1987), Polinsky and Shavell (1992), outlines optimal penalty per Gary Becker’s (1968) model based on the amount of harm divided by the probability of detection. Cohen’s approach involves accounting for environmental damage and infrastructural losses relative to the probability of detection. In the model introduced in this thesis, the penalty is described as a function of both the probability of environmental damage and of successful sanction (involving detection, investigation, sanction and withstanding appeal).

According to Polinsky and Shavell, an agency will incur additional investigation costs and may even have to drop enforcement action against a violator due to procedural problems or lack of evidence, thus the optimal penalty can be modified to include costs of sanctions if the costs are to be considered in the overall social welfare function.

The optimal penalty in Cohen’s model does not depend on the level of effort undertaken by the firm, and is based solely on the level of harm and not on whether it was deliberate or beyond his control. This is a strict liability penalty that economizes government resources that might otherwise be devoted to an ex post investigation and potential adjudication or litigation costs associated with determining the level of care a firm actually took.

A negligence-based penalty, on the other hand, could be applied when it is shown that the polluter did not take an appropriate level of care in preventing the environmental damage. A negligence standard results in a lower expected penalty to potential violators of stochastic pollution, so a negligence standard has an advantage over strict liability when regulating stochastic pollution in the presence of risk aversion or a wealth constraint (Cohen, 1987).

The choice between using a strict liability standard versus a negligence standard is the subject of much discussion in the law and economics literature (Shavell, 1980).

Earnhart (1999) defines the optimal monetary fine as the difference between the optimal level of remediation and the total penalty. By his definition, remediation includes due diligence and precautionary effort over and above firm costs of production. Implied in this is that there is a budget for the ex ante costs of due
diligence and *ex post* penalties, and that the optimal penalty is equal to the total penalty minus the cost of diligence, recognizing that the participation constraint will bind.

In equation form, the optimal monetary penalty would be:

\[
m^*(x, \alpha) = \frac{1}{\alpha} \left[ \frac{D(r, x)}{P} + \frac{1 - P}{P} r^*(x, \alpha) - k \right]
\]

where:

- \( P \) = probability of detection
- \( x \) = stochastic externality (i.e. environmental damage)
- \( \alpha \) = the conversion factor of monetary resources into real resources \( \alpha \in [0,1] \)
- \( r \) = remediation costs (consistent with \( c_i \), or the cost of diligent effort)
- \( D \) = external damages, a function of due diligence effort and damages
- \( k \) = base compensation to ensure the agent receives its minimum utility

In terms that will be consistent with the model introduced later in this thesis, penalties must equal environmental damage plus the proportion of diligence costs not incurred minus base compensation (an allowance for profit). The real resource conversion factor accounts for the fact that all value of a resource is not converted into monetary gains. Implicit in this equation is that penalties must be higher than market value for the products generated, and consider non-market values not explicit in the penalty. I would argue that \( \alpha \) is lower to environmental groups than what would be contemplated by government and/or industry as this would describe how externalities are not recognized in the full cost accounting of conversion, thereby requiring penalties to be higher given the lower efficiency or conversion return.

*The dynamics of penalties as represented in the literature*

Gary Becker (1968) quotes from the social literature of the time, a "common generalization by persons with judicial experience is that a change in the probability [of conviction or punishment] has a greater effect on the number of offences [committed] than a change in the punishment" (Shawness, 1965). This is supported by Grasmik and Bryjak (1980) whose results support the hypothesis that perceived severity, at relatively high levels of perceived certainty, has a significant deterrent effect. The perceived severity of punishment if sanction occurs is a significant variable in the social control process, having an inverse effect on involvement in illegal
behaviour, concentrated among those people who believe the certainty of punishment is relatively high.

Fang, et al (1997) seem to challenge that with their findings in that to deter violations, penalties should increase at least linearly with the gain for violation. Other obvious steps toward increased compliance to regulations, such as improvements in the accuracy of inspections and increases in a firm’s perceived reward for a clean inspection, do tend to reduce violations, but appear to be less effective than the selection of the appropriate penalty levels. Later we will see that expected penalty levels are a function of probability of sanction as much as they are amount of the penalty.

Becker’s analysis develops the idea that the monetary penalty levied against a firm convicted of an offence would equal the marginal harm caused by the offence at the social welfare level, whereas at the firm level the marginal value of the penalties has to equal the marginal private gain of committing the offence. Penalties are viewed as compensation to victims, and optimal penalties at the margin fully compensate victims and restore the status quo, such that they are no worse off than if offences were not committed. Offenders also have to compensate for the cost of catching them as well as for the harm they directly cause (inferring that both social and private costs in the determination of a penalty).

Maximum penalties, or should the penalty fit the crime?

Andreoni (1991) shows that as penalties increase, the probability of conviction falls and that if uniformly maximum penalties were applied it would encourage crime rather than deter it, concluding that optimal fines should rise with the severity of the infraction. There is threshold value for an optimum penalty that a jury would apply and still vote to convict a person on trial, inferring that the level of the fine must be reasonable and “fit the crime.” Higher penalties may encourage crime in wealthy criminals, Andreoni claims, and that the harshest penalties for wealthy criminals may be lower that the harshest penalties given to the less wealthy in order to maximize deterrence.
Court care is measure of the level of judicial diligence in applying sanctions for contraventions. Penalties and court care should not always rise smoothly with harm, and involves tradeoffs between the penalty’s cost and benefit (Rasmusen, 1995). The penalty and court care will not actually decline as harm increases, but they may jump sharply, even when the harm increases smoothly. The reason for the discontinuous jumps is that increasing the penalty has the good effect of reducing crime but the bad effect of increasing the cost of applying a penalty (cost of court care) for those criminals it still fails to deter.

Garoupa (2002) finds that when offenders are marginalized or poor, the deterrent value of monetary sanction is low enough such that government is limited in their ability to apply penalties. If offenders are rich however, the deterrent value of sanctions is high, so it is more profitable to prosecute them. Consequently, he finds that government should set the fine equal to an offender’s entire wealth and complement it with the appropriate probability in order to achieve optimal deterrence.

Png (1986) and Shavell (1987) note that excessive imposition of liability not only penalizes the innocent, but deters them from useful behaviour that courts might confuse with wrongdoing. For example, a licensee may be able to comply with environmental standards but not be able to afford all of the process-related administration requirements introduced under the Code. They could harvest, but the process requirements constrain them from doing so.

Rubinfeld and Sappinton (1987) show that lower penalties will reduce the social cost of legal expenditures by defendants and prosecutors, while Malik (1990) shows that lower penalties will decrease the social cost of apprehending offenders. Bose (1995) outlines how with a hierarchical structure of enforcement, regulatory errors cause the optimal penalty to be non-maximal even if offenders are risk neutral (and fines are pure transfers), and the private benefit from violation is strictly less than the social cost for all individuals.

Boyer, et al (1996) outline that the amount of effort enforcers exert will depend on the perceived likelihood that parties have violated standards, and the likelihood of violation will depend on how vigorously the law is enforced. Their analysis shows that
setting actual standards will positively influence compliance, and will also shape the behaviour of enforcers. When fines are allowed to vary in application, it may be counterproductive to set maximal fines which encourage overzealous law enforcement. According to Braithwaite (2002), a firm will adopt a sense of competition and a customer-service mentality over a “fixer” approach (rigging bids with competitors, forming cartels to fix prices or allocate markets). Competitor mentality provides incentive to compete for regulatory rewards, whereas firms with poorer capabilities will adopt a fixer mentality pleading for exemptions, fudge compliance data, bribe inspectors or complain to their political masters about regulatory unreasonableness – “play for the gray.”

Persuasion is a cheaper option than punishment, but must be backed up by punishment to be effective. If an actor is incompetent or irrational, incapacitation is the appropriate action. If an actor is rational, deterrence is appropriate, and if the firm is a virtuous actor, restorative justice (compliance-based justice as introduced by Garvie and Keeler, 1994) is the most appropriate enforcement action. Punishment for a non-compliance as an escalation up a regulatory pyramid will combat free-riding, whereas rewarding compliance in his model will exacerbate non-compliance in firms. Reward must only be used at the base of the regulatory pyramid and in association with movements down the pyramid.

3.4 Recommended Enforcement Strategies
Mookerjee and Png (1994) find that generally, there are two ways to deter individuals from causing greater harm: one is to raise the penalties for the more harmful acts, and the other is to reduce or legalize the penalties for the less harmful acts. When prosecution, punishment and monitoring are expensive, the enforcement threshold should be higher to induce individuals to shift away from acts that require higher prosecution and punishment costs. Since these costs rise with the penalty imposed and more harmful acts require heavier penalties, the optimal enforcement policy encourages individuals to shift from more to less harmful acts.

Kolstad (1980) and Cohen (1998) outline that ex ante monitoring and penalties, imposed if a firm hasn’t shown the optimal level of care, can effect the same level of
compliance as *ex post* penalties and have the added advantage of having smaller penalties compensating for an increased probability of harm rather than actual environmental damage. *Ex ante* monitoring, although costly, also has the added advantage of certainty for the firm in passing government regulatory standards than the uncertainty around *ex post* if some random environmental damage event occurs. Kolstad finds that both policies used in conjunction require *ex ante* regulation to be set sub-optimal and *ex post* regulation to deal with probable additional externalities.

Baron and Besanko (1984) outline that the optimal auditing policy involves auditing when the compliance signal of the firm is above or below a particular level and a penalty imposed when the observed compliance is low. Since the firm has a natural incentive to overstate or over-“signal” its compliance to obtain a lower probability of being audited, the threshold policy discourages a firm as it will likely be penalized as a result.

Giannakis (2002) describes that with penalties being exogenous, the only avenue policy makers have for influencing the agent’s behaviour is through the choice of audit probability. Since audit costs decrease social welfare by increasing the resource costs of enforcement, welfare is maximized when enforcement costs are minimized, and as Kahlil (1997) outlines the probability of audit is increased until the agent’s rent is reduced to zero. Sappington (1986) finds that by committing to administering a monitoring system, even if inefficient, the regulator can enhance welfare.

Uncertain regulatory policies, according to Viscusi (1983), impose additional opportunity losses as firms are discouraged from making irreversible investment commitments. Increasing the regulatory penalty will enhance the attractiveness of quality investments and will diminish the incentive to make capacity investments by raising the regulatory burden per unit of output.

*Firm Self-reporting*

The literature describes enforcement strategies where the firm conducts internal auditing self-reporting to government in their level of compliance with the regulatory standards. This literature, the majority reviewing the economic incentives around providing to minimize air and water effluent discharges, has some useful
considerations for a broader application to environmental damage on the whole. The model in this thesis considers broader impacts in more subjective evaluation of damage to environmental resources (i.e. biological diversity, critical wildlife habitat, visual quality objectives, etc.) that are difficult to quantify and prove reasonable and appropriate levels of diligence — enforcement is based on interpretation of environmental damage, not on exceeding a certain level of emission. It is worthwhile however, to observe a few of the lessons learned in regulating emissive industries.

Cohen (1998) relates that in a self-reporting strategy, government expenditures are significantly reduced to auditing self-reports and imposing a penalty if the firm is found not to be truthful in their reporting. Malik (1993) finds that for a given level of firm effort, a self-report scheme involves less government monitoring but more frequent imposition of sanctions. Malik finds that firms need to be audited less when self-reporting is required, but punished more often.

Self-reporting is found to reduce costs when (1) the cost of monitoring is high, (2) the maximum feasible fine is low, or (3) the desired effort level is high. Self-reporting is likely to increase costs if (1) the cost of collecting penalties is high, (2) the regulator’s monitoring technology is extremely accurate. Livernois and McKenna (1998) note that penalizing a firm for polluting has the offsetting effect of providing an incentive for firms to evade detection, thus by lowering penalties the regulator may trade off some compliance for more reliable self-reporting. Heyes (1996) also suggests reducing the penalty to below the maximum, saving the maximum fine for firms that do not self-report with the penalty reduced from the maximum depending on the persistence of the pollutant.

According to Bose (1995) a regulator should not be rewarded based on the number or amount of fines, ensuring the regulator’s behaviour is unaffected by the level of the fine and thereby avoiding a revenue-maximizing as opposed to a compliance maximizing strategy for the agency.

*State-dependent enforcement (or focusing enforcement effort on the status of compliance history of a firm)*
Recent research has suggested assigning inspection probabilities dependent on a firm’s past compliance reputation (Hentschel and Randall, 2000). Friesen (2003) describes modified two-group enforcement model based on Harrington’s (1988) introduction to segregating compliance monitoring based on a rewards strategy whereby complying firms (in Group 1) enjoy low monitoring and regulatory control and non-complying firms (in Group 2) are monitored more regularly with tighter regulatory control and operational requirements to comply with environmental standards.

In reviewing Harrington’s (1988) work, Raymond (1999) concludes that the optimal level for a fine depends on the distribution of a firm’s costs of compliance, and that the lack of information about the distribution of costs presents a major challenge to regulators. If an industry has a large proportion of high cost firms, then optimal penalties at zero provides an incentive for high compliance costs firms to switch from a comply in both groups to a comply only in the first group policy. If industry has a high proportion of low cost firms, keeping fines set to the maximum is going to be optimal.

Harrington (1988) also introduces a three-group model consistent with Greenberg (1984) where an agency can threaten a non-complying firm with eternal compliance without having to commit to constant surveillance that would ordinarily be necessary to achieve that result. By making such a threat, arbitrarily good compliance could be achieved with arbitrarily small budgets. That outcome depends on the assumption that penalties are large enough to induce compliance when an inspection is certain. Russell (1990) modifies this idea a bit to allow escape after a period of time or some threshold to ensure the risk of being in Group 3 is prohibitive and that the potential for all firms to eventually enter into Group 3 resulting from a judicial error and thus overload the system does not exist.

Friesen (2003) describes that monitoring costs can be reduced where firms are randomly moved to the non-complying group and inspected, with escape back to the complying group only when an inspection reveals the firm is in compliance. By randomly selecting firms for the target group the agency can save on inspections in the non-target group. The application of this strategy is limited for high desired
compliance rates or large compliance costs as even certain inspection in Group 2 will be inadequate to induce compliance.

In support of stratifying by compliance history, Hentschel and Randall (2000) provide the caution that selecting firms for inspection completely at random ignores valuable information that was acquired in previous inspections. If a firm is known to be a notorious violator, inspectors could keep it under closer surveillance than if it is generally compliant, thus making the inspection probability endogenous.

3.5 When are penalties low?
Without an adequate picture of the value of externalities resulting from non-compliance, penalties will not adequately reflect the distribution of values society has in the environment. By far the greatest obstacle to finding the “socially correct” amount of monitoring and enforcement effort, and hence the socially optimal violation rate, is the requirement for estimates of damages avoided (Russell, 1990).

Polinsky and Shavell (1991) essentially say that any individual, when detected, should pay a monetary sanction given by the harm divided by the probability of sanction. Those that are able to pay the fine are completely deterred since their expected sanction equals the social damage they cause. They find that those firms that are not able to pay the fine and lose their entire wealth, are under-deterred since their expected sanction is less than the harm they cause. Garvie and Keeler (1994) claim that in most circumstances, firms with higher abatement costs will receive a larger share of regulatory resources and thus face higher penalties than firms with lower costs.

Arora and Gangopadhyay (1995) show that most firms choose to comply despite seemingly lax enforcement. Harrington (1988) explains this in the dynamic nature of the game between firms and the enforcement agency, which threatens violators with perpetual surveillance. The result is that the expected penalty in any period is lower than the cost of compliance in each period, firms comply with the law.

Sutinen (1999) outlines that in any social setting there is a core sub-group of chronic, flagrant violators motivated largely by the direct tangible consequences of their actions, where moral and social influence have no effect on their behaviour and the
only control mechanism available and effective is enforcement action. If not dealt with by the regulatory agency, signals are projected to other individuals that regulatory procedures are unfair and ineffective, thereby weakening moral obligation and social influence.

Arora and Gangopadhyay (1995) outline that government may set a minimum standard, specifying the abatement effort must be greater than a set level. Their caution, however, is that if that level is set too high firms will be forced to operate at lower and lower market sizes and at higher and higher costs.

A positive enforcement model allows for considerable discretion on the part of the enforcement agent provided the agent does not exceed or abuse their powers, meaning often they resort to extra-legal or non-legal devices to secure compliance (Fenn and Veljanovski, 1988). Discretion can be seen as a predictable response to key parameters of the regulatory system, and as a way of mitigating some of the inefficiencies of the law.

Garvie and Keeler (1994) assume the agency's goal is to achieve the highest level of compliance given their enforcement budget. Thus the agency must factor in if it chooses to impose a steep penalty, it will incur additional enforcement costs as firms challenge enforcement actions and/or sanctions in appeal processes. Their model predicts relatively low penalties and more frequent contact with enforcement officials and less formal negotiations when the regulated industry has a lot of political power or when there is a high probability of judicial leniency due to unclear regulatory standards.

Maximizing the benefits of compliance when firms have different compliance costs yields compliance rates that differ across firm type (Jones and Scotchmer, 1990). The result is that it is more difficult and costly to obtain compliance from a high cost firm, and that limiting an enforcement agency's budget induces a more socially optimal enforcement strategy of net benefit maximization, forcing the agency to shift its enforcement resources away from high cost firms.

Livernois and McKenna (1999) develop that lowering penalties raises the proportion of non-complying firms that file truthful reports about their compliance status. This
increases the overall compliance rate because it leads to earlier detection of non-compliers and the regulator can rely on non-compliers to identify themselves. This allows the regulator to take actions to order these firms to return to compliance sooner than would otherwise be the case. This is contrary to what Stanley (1995) finds in that society should give criminals incentives not to conceal their criminal activity, and that society can deter concealment of crime by raising the sanction or raising the cost of concealing the crime.

Calfee and Craswell (1984) conduct an analysis where legal standards are uncertain and find that even a firm that is behaving in a socially optimal fashion will face some chance of being penalized for an environmental violation. They conclude that this firm can reduce the expected penalty by over-complying with the regulatory standard. Bose (1995) considers the case of an enforcement agency with a fixed penalty structure and concludes that regulatory error will result in over-deterrence, and also finds that firms will likely go beyond the standard in order to reduce the likelihood of being falsely accused. To compensate for this problem, he suggests that the regulator must fix the penalty below the “optimal penalty”.

Costly penalties or increasing the stringency of regulation (Kambhu, 1989; Kadambe and Segerson, 1998) can improve environmental quality as the expected penalty from non-compliance increases. An indirect effect is that there can be an incentive for the regulator and regulated party to affect the probability of detection. Thus, the firm that faces a higher penalty for non-compliance might challenge the fine in court or take other measures designed to reduce the probability that the fine will actually be imposed.

Reducing the value of penalties when there is a low probability of conviction will cause fewer of them to appeal, thereby saving administrative costs, while raising the value of penalties for high-probability convictions increases the principal’s expected payment and allows deterrence to be maintained (Polinsky and Rubinfeld, 1996).

Finally, Heyes and Doucet (1993) find that when pollutants are persistent and the polluter has private information regarding the occurrence of accidental releases and the cost of clean-up, the penalty regime which most effectively protect the environment
will involve penalties which are less than maximal. Penalties that are less than maximal cannot be taken as evidence that the enforcement agency has 'gone soft' on pollution, more that they have been subject to regulatory capture. Moreover, lobbying efforts by environmentalists which aim to secure the more frequent imposition of maximal penalties may, if successful, prove counter-productive in that they may provide incentive for actual polluters to not want to act responsibly once an accidental release has occurred.

Baron (1988) goes on to describe how regulation has both economic and political dimensions, and the study of one in isolation from the other may yield an incomplete understanding of the sources of efficiency or inefficiency in regulatory setting. Legislative choice that exhibits a strong electoral connection will yield a regulatory mandate that does not maximize expected total surplus, favouring consumer over producer interests, even though the regulation itself is (interim) efficient. The political manifestation of producer and factor interests thus acts to increase aggregate surplus when environmental damage is minimized.

4.0 Economic Model of the Compliance Regime

In Laffont and Martimort (2002), the authors recount the development of incentive theory as it developed in the literature of the day. According to them, incentive contracts were first written about by Adam Smith (1776) in his discussion of the determination of wages in designing incentive contracts in Agriculture, recognizing the contractual nature of the relationship between the masters and the workers. Babbage (1835) took Smith's work further with understanding the need for precise measurement of performances to set up efficient piece-rate and profit-sharing contracts.

Barnard (1938) introduced to the literature a broader view of incentives, including both monetary and non-monetary incentives. Wicksell (1896) recognized the economic implications of the free-rider and designed a voting system to determine public financing and taxes necessary to run services. Marschak (1955) recognized the problem of incentives and chose not to study it, identifying that organization rules can be devised in such a way that if every member pursues his own goal, the goal of the
organization is served. Good (1952), McCarthy (1956) and later Savage (1971) as statisticians looked for payment formulas leading forecasters to announce their true estimated probabilities and discovered the incentive constraints for revelation of information. Clarke (1971), Groves (1973) and Groves and Loeb (1975) brought about strong restrictions on preferences and provided mechanisms with monetary transfers inducing truthful revelation of preferences.

Fines, penalties and tithes have been around since there was money to trade, and likely even before that back to primeval man where negative incentives and social norms modified others behaviour. Not until Gary Becker's seminal article on the economics of crime and punishment, had the theory of incentives been stretched into a field other than contract analysis. Vickery (1960) described how welfare functions are vulnerable to strategy where individuals “gain by reporting a preference differing from that which the actually hold” Later it was Ross (1973) who expressed the pure principal-agent model with only moral hazard and an individual rationality constraint for the agent before it received its modern treatment in Mirrlees(1975), Guesnerie and Laffont (1979), Holmstrom (1979), Shavell (1979), and later in Grossman and Hart (1983).

4.1 The Principal-Agent Model – Moral Hazard or Hidden Action

Some of the words used to describe economic concepts do not adequately lead the reader to understand what ideas are being represented – it is the language of the profession that must be learned to communicate. In the context of this thesis, moral hazard is described as a moral dilemma resulting from the temptation to not comply with expensive regulation or contract requirements, reap the benefits of not complying and make it “look” as if the firm actually is complying. This requires the firm or the “agent” to misrepresent or “signal” the government (“principal”) differently than their actual level of compliance, and is playing on the “asymmetric” or unbalanced access the principal has to information while the firm is conducting a “hidden action.”

The Principal-Agent model is a useful analysis tool to model and describe actions, policies or other forms of persuasion to provide incentives necessary for an agent to adopt the preferred action such that the principal is able to maximize their “utility” or what they get out of the agent in their contract arrangement. If the action is
observable, as in our case government would be present and involved in monitoring all operational activities conducted on forest lands, and there would be no informational problem as principals would directly observe an agent’s revealed “risk-type”. But because it is too costly (and impossible) for government to fully observe and police all activities having economic impacts, regulatory or contract-based policies provide incentive for firms and individuals to adopt the appropriate behaviour.

The classic principal-agent relationship from the literature is described in the insurance industry with policy-buyers who are put in a moral dilemma if they may want to signal they’re young, conservative, non-smoking, healthy, low-risk individuals to secure lower insurance premiums for their policy. The principal cannot observe their potential client’s lifestyle, so needs to design a contract that provides incentive for the client to either “signal their risk-type” and insure appropriately, or for the client to adopt the lower-risk attributes that makes society better off as a whole. From an economic efficiency point-of-view, too little insurance means that people bear a lot of risk, and too much insurance means that people have incentive to take inadequate care.

Risk-types are represented in the literature as “risk averse”, “risk-neutral” or “risk loving”. A risk averse agent, in this thesis, has a higher utility in complying with the regulations rather than risking the potential of being inspected and sanctioned for non-compliance. A risk neutral agent cares only about the expected value of his actions, so will comply with the regulations or gamble depending on the probability and the payoff. A risk loving agent would prefer the uncertainty of playing on asymmetric information rather than adopting compliant behaviour. For this analysis the agent is assumed to be risk neutral and rational, complying with whatever policy maximizes his expected value.

Government can be characterized the same way. A risk averse government, as the principal in this case, would prefer to ensure any potential losses due to environmental damage are mitigated up-front, structuring ex ante policies that make firms signal their type prior to operations and compensating any potential environmental losses through stumpage rather than risking the uncertainty of sanctioning and collecting penalties. A risk-neutral government would be realistic about the probability of successfully
applying sanctions and their amounts and would pursue courses of action where their expected payoffs were maximized. Finally, a risk loving government would likely prefer to risk environmental damage and structure the incentive program such that penalties are collected *ex post*.

Incentives in this thesis are tools that provide the impetus for firms or licensees to conduct their activities the way the government would want them to. Government, as an agent of the Crown, is saddled with the responsibility to maximize social welfare and requires penalties to ensure welfare losses do not result from operational activities. Government, as the principal and licensees the agents, provides regulatory incentives to ensure licensees comply with the protection measures described in the regulations.

There are two other micro-economic concepts used in this thesis. The first is that in order to provide adequate incentive for the agent to conduct their business, government must consider that any costs they put on the agent are going to drive their profits down. When costs are too high, all profit is removed and the licensee does not have any incentive to conduct economic activity. If government can increase social welfare through providing the opportunity to harvest trees without adversely impacting on environmental values, then it is in its best interest to ensure a licensee will participate in harvesting activities. The idea that government is constrained in being able to load all costs on the licensee is referred to as the "participation constraint", and requires that firms at least receive their reservation utility, or minimum profit from conducting their businesses.

The second idea to introduce is the "incentive compatibility constraint", whereby government constructs the regulation and compliance activities such that the highest utility to the agent is to comply with the regulations, and that the expected utility from any other less-compliant activity is less. The literature is rife with examples where principals and agents set up incentives systems to maximize their utility subject to the participation and incentive compatibility constraints outlined above.

4.2 The Principal-Agent Model

Social welfare can be increased by providing opportunity for firms to generate profits by allocating the portions of the renewable natural resource endowment in British Columbia. As developed in Section 2, net social welfare will be a function of licensee profits, government revenues and capital infrastructure net of possible environmental damage and infrastructure loss, firm and government expenditures.

The notation used in setting up the model for optimal penalties is as follows:

\[ i \in \{ D, N \} \] where \( D \) = firm diligence and \( N \) = firm non-diligence

\( W_i \) = level of aggregate social welfare, diligence dependent

\( e_i \) = level of precautionary effort, diligence dependent

\( \pi_i \) = probability environmental damage will occur, diligence dependent

\( c_i \) = cost of firm precautionary effort, diligence dependent

\( k_i \) = cost of government enforcement action, diligence dependent

\( \delta \) = the likelihood of successful sanction based on government effort

\( P \) = price of output, or revenue generated by firm activity

\( S \) = stumpage charged by the Crown for timber sold from public lands

\( \rho \) = penalty sanction extracted from firm for environmental damage; in the model, \( \rho \) represents the maximum penalty and \( \underline{\rho} \) represents the minimum penalty available to the decision-maker

\( \delta \) = the probability of government successful sanction

\( E \) = inordinate risk or actual environmental damage

\( V \) = value added to the forest through investment and infrastructure (i.e. access development, stand conversion, plantations, inventory, ecological and other resource information)

Setting up the problem as a general equilibrium model of aggregate social welfare \( W_i \), the public will realize benefits and costs in the form of:

firm profits as \[ [(P - S - V) - c_D - \pi_D \delta \bar{\rho} - (1 - \pi_D) \delta \underline{\rho}] \]

environmental damage and infrastructure loss as \[ -[\pi_D (E + V)] \]

government revenue and compensation as \[ +[\pi_D \delta \bar{\rho} + (1 - \pi_D) \delta \underline{\rho} + S - k_D] \]

and capital invested in infrastructure as \[ +V \]

when \( W_D > 0 \).

Firm profits are a function of price minus stumpage and operational costs (in the costs of production and in developing the infrastructure), minus penalties levied when there
is probability of environmental damage even when a firm is diligent (under the Code these take the form of remediation costs).

Within the social welfare function penalties and stumpage revenues are both a cost to the firm and a government revenue, and therefore cancel out of the function which reduces to

\[ W_D = P - c_D - \pi_D (E + V) - k_D \]  \hspace{1cm} (1.1)

when a firm is diligent, and

\[ W_N = P - c_N - \pi_N (E + V) - k_N \]  \hspace{1cm} (1.2)

when a firm is not diligent. The following conditions are assumed in the background behind the model:

\[ c_D > c_N, \]

which describes that the cost of being diligent is greater than the cost of not being diligent is strictly less than the cost of being diligent,

\[ \pi_D < \pi_N, \]

where the probability of environmental damage when a licensee is diligent is less than when a firm is being non-diligent, and

\[ k_D < k_N, \]

that the cost of administration and enforcement is greater when a firm is not being diligent. Harford and Harrington (1990) describe the cost function relating to the reduction of pollution (or more broadly in our case, environmental damage) "is a convex function for most cases of interest", meaning diminishing marginal returns relative to increasing enforcement effort.

Within the social welfare function, government is not successful in enforcing every action they initiate under the Code. Hence enforcement probabilities affect the firm's expected liability in the model, interpreted as \( \delta \rho \). This implies that the government has to use the expected penalty while encouraging diligence, not just the nominal penalty as expressed in the equation. Delta \( \delta \) is implied in the social welfare function, however is left out of the initial analysis for clarity.

This said, from the social welfare statements in equations (1.1) and (1.2), a minimum social welfare utility is positive \( W > 0 \) when welfare exceeds the social cost of likely damage.
environmental damage. Forestry activities are then economically (but not necessarily socially) justified, such that:

\[ W_D = P - c_D - \pi_D (E + V) - k_D > W. \]

### 4.3 Forest Lands – Optimal Management Zones

It is important to understand that not all lands are made available to forest management activities in British Columbia. In the early 1990’s an initiative called the Protected Areas Strategy was borne out of the B.C. Parks Legacy Project and the Commission on Resources and Environment processes, and it endeavoured to describe and protect lands that were representative and had significant values that required full protection from resource development. These Protected Areas are now reserves and enjoy a status that precludes timber harvesting and most commercial development.

Other lands, subject to forest development, were brought under the *Forest Practices Code of B.C. Act* in 1995, introducing new environmental standards that brought consistency and transparency to the public and to timber companies operating across the province. These environmental standards, introduced as a system of statutes, regulations and guidebooks, described processes for forest development planning and management. These requirements loaded onto and internalized significant planning and operational requirements as prescribed precautionary effort increased administrative and operational costs to mitigate environmental risk and externalities resulting from inconsistent planning and assessment processes.\(^{11}\) Of note, the current direction government is exploring is to establish standards and move away from the prescriptive process-based precautionary approach to regulating forest practices.\(^{12}\)

A third category of lands, essentially having their highest value in timber production and robust or barren enough in ecological values such that forest harvesting can occur with minimum consideration to ecological values as their value to society is high

---


12 See the newly introduced *Forest and Range Practices Act* and regulations at [http://www.for.gov.bc.ca/mof/acts.htm](http://www.for.gov.bc.ca/mof/acts.htm)
enough in timber production to offset any level of environmental damage on those lands. Regulation exists to describe where activities on those lands cannot impact on adjacent values (i.e. streams, water quality, private lands, etc.), however it is limited in the level of regulation associated with environmental protection. Examples of these lands in B.C. may be Private Managed Forest Lands or highly productive privately held fee-simple properties. These three categories of lands are given economic context below.

Krcmar, et al (2003) describe a situation on the Central Coast of British Columbia where rent maximization can occur by optimally zoning land use into intensive, integrated and preservation zones (the TRIAD model). These zones provide for the optimal allocation of capital resources to maximize social welfare, but require that regulations in the “intensive forest management zone” be relaxed (but not altogether dropped) to allow for planning, operational and administrative efficiencies. In the second zone, integrated use is allowed where development is highly regulated (where necessary) while preserving the integrity of ecological values on forested lands. In the third zone environmental and ecological values are preserved with no harvesting or resource development allowed in the zone. With this framework established, in this thesis these zones will be referred to as Category 1, Category 2 and Category 3 lands respectively.

The recent draft of the Ecosystem-Based Management Planning Handbook (Cardinall, et. al., 2003) consider that forest development activities can contemplate higher levels of risk and potential disturbance in areas with low cultural, ecological and or social values. These areas, along with ecosystems that are robust and not sensitive or dependent on old growth values can be classified as Category 1 lands. On these lands,

---

13 There is considerable debate in the ecology literature regarding species resiliency based on expected natural disturbance levels, requiring more old-seral representation providing coarse-filter framework to support biological diversity, and a fine-filter approach to preserving species specific habitat needs. This would in effect require stronger regulatory protection of these values on Category 2 lands (Species at Risk Act for federal lands and the Identified Wildlife Management Strategy and General Wildlife Measures on provincial forest lands), and increase the amount of area shifted from Category 2 to Category 3 lands in British Columbia.

14 The Ecosystem Based Management Planning Handbook is a product of the Coast Information Team, a scientific panel describing forest management practices within the coastal B.C. context that will preserve the ecological integrity of forests while providing for socio-economic opportunities that will enhance community well-being over time.
social welfare gains are experienced whether and firm is diligent and/or environmental damage occurs or doesn’t – the value of harvesting the resources is greater than the potential damage to the environment that could occur from development or extraction.

Category 2 lands, as described below, reflect the idea that diligent behaviour on the part of firms is required, as the social welfare losses that would result from non-diligent behaviour do not exceed the social reservation utility of keeping those lands in the harvesting land base. If environmental damage occurs, it is likely the value of the environmental losses will exceed the social gains in the value of the resources extracted.

Protected areas, parks, and reserves are current examples of policy decisions that preserve Category 3 lands. In these areas, the environmental values of the ecological, spiritual, cultural, recreation, carbon sequestration, wilderness, water quality, visual quality, option, and quasi-option values are greater than any harvesting or development values, whether a licensee is diligent or not.

Consistent with the framework of the model described above, as diligence varies the following optimal welfare \( W_t \) relationships describe the key attributes for consideration in determining the conditions for harvesting over the risk to environmental damage:

\[
\begin{align*}
1. \quad & \begin{cases} 
[P - c_D - W - k_D] > \pi_D (E + V) \\
[P - c_N - W - k_N] > \pi_N (E + V)
\end{cases} \quad \text{harvesting is supported and does} \\
& \text{and does not depend on} \\
& \text{diligence,} \quad (1.3)
\end{align*}
\]

\[
\begin{align*}
2. \quad & \begin{cases} 
[P - c_D - W - k_D] > \pi_D (E + V) \\
[P - c_N - W - k_N] < \pi_N (E + V)
\end{cases} \quad \text{harvesting is supported only} \\
& \text{when a firm is diligent,} \quad (1.4)
\end{align*}
\]
In describing the relationships in equations (1.3) to (1.5) above where \( \pi_N E > \pi_D E \) as \( \pi_N > \pi_D \) and as \( c_N > c_D \), this supports that environmental losses from non-diligent behaviour are strictly greater than diligent behaviour. In Category 1 lands, society could be better off with a firm being not diligent even if environmental damage is considered. Practically speaking, this ‘damage’ would be necessarily light and inconsequential, or the market value for timber extraordinarily high, to justify the social welfare gain.

In the Category 1 relationship described in equation (1.3), if the market price in harvesting timber is high enough, the value to society will be greater than any environmental damage that may occur. This is likely only realistic in forested areas that provide limited in, or have a significant surplus of ecosystem services and benefits that ensure that \( \pi_N E > \pi_D E \), or that those services would have to be very low in value and world prices for lumber very high for this situation to occur. In the third category above, environmental damage is likely and the values housed in \( E \) are too valuable to society to put at risk by allowing harvesting activities to occur.

Category 2 lands express the likely situation in forest management in British Columbia, in that when welfare from firm due diligence exceeds that of firm non-diligence which is greater than keeping the land in an undeveloped state, this then implies that \( W_D > W_N \). This situation describes where social welfare is less when a firm is not being diligent, or \( W_D > W_N \). The lands where the social value of diligent development is greater than non-diligent development and is greater than keeping the land in an undeveloped state, describes the following relationships based on the following assumptions from equation (1.4):

\[
P - c_D - k_D - \pi_D (E + V) > \underline{W}
\]

\[
P - c_N - k_N - \pi_N (E + V) < \underline{W}
\]
the social welfare cost of a firm not being diligent is (much) greater than the negative social welfare impact that incorporates all other costs combined, in
\[ c_N > c_D - (k_N - k_D) - (\pi_N - \pi_D)(E + V). \] (1.6)

the social costs experienced by the firm being diligent are by definition lesser than those of not being diligent which exceed them by the amount of the difference in government enforcement costs and expected environmental and infrastructural damage as shown in
\[ c_D < (k_N - k_D) + (\pi_N - \pi_D)(E + V) + c_N. \] (1.7)

further described in this relationship is that the social costs of environmental and infrastructural damage are greater than the increased costs of diligence and enforcement effort relative to the increase in probable environmental damage, or
\[ E + V > \frac{(c_D - c_N) - (k_N - k_D)}{(\pi_N - \pi_D)}. \] (1.8)

lastly from this relationship is the result that the level of effort for government to expend in ensuring diligence is necessarily more than the value of firm diligence minus the probable environmental damage and infrastructural losses, or that
\[ k_N - k_D > (c_D - c_N) - (\pi_N - \pi_D)(E + V). \] (1.9)

which describes that government expenditures on enforcement actions are necessarily greater than the cost to firms of diligence less the expected social welfare losses experienced through environmental damage.

If the net environmental damage is less than the difference in diligence costs per equation (2.2), how then does the government provide incentive such that the firm chooses to be diligent (chooses \( e_D \))? The incentive constraint for the firm can be expressed by using the firm profit function from the model described above.

\[ (P - S - V) - c_D - \pi_D \delta \rho - (1 - \pi_D) \rho > (P - S - V) - c_N - \pi_N \delta \rho - (1 - \pi_N) \rho \]

and for simplicity \( \rho = 0 \), where the government does not sanction when the risk is not the fault of the licensee. As a result
\[ \delta \rho (\pi_N - \pi_D) > c_D - c_N \]

(1.10)

or that penalties must be greater than the difference in the cost to the firm of being diligent versus non-diligent relative to the difference in the likelihood of environmental damage from being diligent.

To ensure participation of the firm, incentives must consider that price minus costs must be greater than the firm’s reservation utility, which in a competitive industry can be considered to be zero

\[ P - S - V - c_D - \pi_D \delta \rho > 0, \text{ or } \]

\[ \frac{P - S - V - c_D}{\pi_D} > \delta \rho \]

(2.1)

such that

\[ \frac{c_D - c_N}{\pi_N - \pi_D} < \delta \rho < \frac{P - S - V - c_D}{\pi_D} \]

(2.2)

Following from equations (1.6 - 1.8), to ensure social welfare is not negative, the cost to the firm of not being diligent must be more than the costs to society outlined in equation (1.4) to ensure social welfare is not lost due to environmental damage and increased enforcement costs. The incentive constraint sets up that penalties must be greater than the differences in costs relative to the differences in probability of environmental damage as per equation (2.2), however, socially this is not enough as the aggregate social welfare function would require that

Note that Cohen (1998), p.15, consistent with Becker (1968) and Polinsky and Shavell (1991) assumes full compensation as the optimal social welfare penalty to induce the firm to take the optimal level of effort equal to \( \frac{\pi_D (E + V)}{\delta} + k_D \) using the nomenclature introduced above, and does not consider the marginal costs or benefits gained by increased precautionary effort. This model, whereas it would internalize the externalities to the firm, would violate the participation constraint set in the model. Further research into the ecological implications of marginal versus total cost recognition in the penalty function needs to be explored.
The interesting dynamic that is introduced in equation (2.2) is that penalties and stumpage serve to capture surplus in the profit function and distribute it to the Crown in the form of compensation for timber volume and risk or damage to the environment. Combining equations (2.2) and (2.3) for Category 1 and 2 lands, the resultant relationship describes

\[ P - S - V - c_d > \pi_d [(E + V) + k_d] \]

or that socially, firm profits from diligence contribute more to social welfare than the costs of likely environmental damage and extra enforcement costs – not a surprise given where it comes from, on the positively contributing lands from Category 1 and 2. The RHS of this equation is close to the penalty recommended by Cohen (1998) to compensate for environmental damages, inferring that profits must be greater than penalties to ensure activities create gain in social welfare. Again, this all depends on the relative value of \( W \) where the non-market values of the ecological services are known and truly reflected in market prices.

If stumpage is set too high and captures most of the available producer surplus (limited by the participation constraint), will necessarily force penalties to be low by

\[ \delta \rho \leq \frac{c_d - c_N}{\pi_N - \pi_D} \text{ which by (1.5) } \leq (E + V) + \frac{(k_N - k_D)}{(\pi_N - \pi_D)} \]  

(2.4)

High stumpage rates will limit the level of penalties available by capturing the available producer surplus and will thereby compensate the public less than the value of environmental damage AND the increased cost of enforcement. If penalties are not bound by equation (2.2) above, the participation constraint will not hold and firms will be driven out of business, or the land base needs to be moved from the Category 2 land area into the Category 3 type lands described above in relationship (1.5). To keep the operable land base constant, government would allow penalties to be less than environmental damage plus the increased cost of enforcement caused by the penalty incentive to ensure companies can financially operate and social welfare is maximized.
Equation (2.4) describes a situation where penalties will not adequately compensate the Crown unless government sets stumpage rates and penalties together in order to optimize the distribution of surplus and thereby maximize the social welfare function. If penalties are too low, then the incentive for a firm to adopt due diligence breaks down and the operable land base shrinks to Category 1 lands only. Given the model developed above and that government is assumed to be risk neutral, stumpage rates must be set in consideration of the likelihood of environmental damage and to provide room enough in the distribution of surplus for effective penalty-based incentives to have meaning – licensees have economic incentive to be diligent and government can maximize social welfare.

Risk aversion would mean that government would prefer to adopt certainty in stumpage collection that reflected the expected environmental damage and set administrative penalties low with high fines and jail time as a deterrent. A risk-loving government would collect low stumpage and rely on administrative penalties to redistribute producer surplus, with little in the way of judicial fines or jail time for offences. Government may be able to afford to be risk averse on Category 1 lands, risk neutral on Category 2 lands and risk loving on Category 3 lands to effect a cost-minimizing strategy to effective enforcement on public lands.

4.4 Penalties relative to enforcement success

When delta (δ) is included in the equation to determine optimal levels of government enforcement effort it cancels out of the optimization just as penalties do as a distributional effect of social welfare, and not a determinant of social welfare. Enforcement effort to increase sanction success is applied only to make credible the threat of penalty to provide incentive in the incentive constraint for the firm, otherwise does not affect social welfare. Enforcement cost (k), a proxy for effort, is a determinant for likelihood of successful sanction (δ(k)) and needs to be optimized over the level of incentive it provides as the returns to likely success decrease as effort expenditure increases. To prove this, from the firm incentive constraint modified by delta,

\[ P - S - V - c_D - \pi_D \delta \rho > P - S - V - c_N - \pi_N \delta \rho \]
results in the relationship
\[
\bar{\rho} > \frac{1}{\delta} \left( \frac{c_D - c_N}{\pi_N - \pi_D} \right) \text{ where } \delta \neq 0;
\]
\[
\frac{\partial \bar{\rho}}{\partial \delta} = -\frac{1}{\delta^2} \left( \frac{c_D - c_N}{\pi_N - \pi_D} \right) < 0, \text{ and is therefore a decreasing function}
\]
\[
\frac{\partial \bar{\rho}}{\partial \delta} = \frac{2}{\delta^3} \left( \frac{c_D - c_N}{\pi_N - \pi_D} \right) > 0, \text{ and is therefore a convex function},
\]
meaning diminishing or decreasing marginal penalty incentive relative to increasing sanction success. When \( \frac{\partial \bar{\rho}}{\partial \delta} = 0 \), to find the optimum, the only defined option would be that \( c_D = c_N \) which violates the assumption that the cost of being diligent is more than the cost of not being diligent, requiring then that the penalty must then equal \( (c_D - c_N)/(\pi_N - \pi_D) \) as described in equation (3.3). As a result of this breakdown, penalties cannot be optimized at the firm level or over a function of enforcement effort and must be considered independent of enforcement success from a social welfare point of view. But as a firm approaches diligent effort levels, or that \( c_N \to c_D, \bar{\rho} \to 0 \) or expected penalties approach zero.

4.5 Government, enforcement success and penalties
Looking at a partial equilibrium portion of the overall aggregate function, government welfare (call it "G") part of the general equilibrium function where, as defined above successful sanction is a function of effort expenditure (\( \delta k \)),
\[
G = \pi_D \delta(k_D)\bar{\rho} + \pi_N \delta(k_N)\bar{\rho} + S - k_D - k_N, \text{ and}
\]
\[
\frac{\partial G}{\partial k_N} = \delta(k_N)\pi_N \bar{\rho} - 1 = 0, \text{ such that } \bar{\rho} = \frac{1}{\delta\pi_N}
\]
or that any increase in enforcement success as a result of changing enforcement effort expenditure will have a positive constant effect on government welfare (at a diminishing rate), and that penalties must change equivalently and inversely with the change in likelihood of successful sanction. Conversely, if enforcement effort is decreased, so too will overall government welfare decrease (at an increasing rate).
Aggregate social welfare will however remain the same as the distribution of the penalty amount is transferred between the government and the firm. Penalties therefore, are collected by government from a firm on behalf of the public, such that any gains made by non-diligent behaviour do not benefit the firm and are redistributed to the public through Crown collections. This is what is termed as compensation for damages and has more to do with equitable distribution of producer surplus than it does with maximizing social welfare.

Government is currently restructuring the Compliance and Enforcement sections of the new Forest and Range Practices Act to reflect the results-based focus of the new legislation. As it is expected that the new Act and Regulations will stipulate thresholds and targets for forest management practices to comply with, these limits will likely make enforcement more successful just through the advent of changing the wording of the laws, making them auditable, measurable and defendable. With this change, enforcement and sanction will likely be more successful allowing government to reduce enforcement effort while keeping the same level of incentive for deterrence.

In summary, applying penalties provides incentive for firms to be diligent and minimize social welfare losses due to environmental damage. If diligent, Category 2 lands contribute to the managed land base and increase social welfare through their diligent development. Penalties still must apply even when a firm is diligent in order to share the risk of operational development and provide incentive for diligence. This is achieved through S. 118 of the Code where remediation of an area may be required, which will work towards minimizing social welfare losses. Penalties will consider a firms’ reservation utility to ensure they will continue to operate and must be greater than the cost difference between being diligent and not being diligent relative to the change in likelihood of environmental damage to provide incentive for the firm to comply.

Penalties must also be greater than likely environmental damage that may occur, but will be necessarily less than the actual environmental damage when the participation constraint binds. Setting stumpage and penalties concurrently in policy will help to

---

16 need to reference the legal Bill or Section...
maximize the capture of producer surplus and ensure equitable distribution between firms and the Crown. Government must expend at least as much on enforcement as the difference in the cost of diligence to the firm minus the cost of probable damage to the environment.

5.0 Data Analysis
As mentioned previously, during consultation meetings with stakeholders on government's proposed results-based legislation, the Forest Practices Board and environmental groups expressed concern that penalties and fines levied under the current Code did not consider environmental damage resulting from forestry activities. Building on the findings examined in the principal-agent problem in Appendix A, penalties are to be consistent with the maximum or fixed amount as outlined in the regulation. The following analysis uses descriptive statistics to compare the determinations made under several sections of the Forest Practices Code of BC Act and its regulations with the maximum as outlined in the Administrative Remedies Regulation (ARR) established under the Code. With this information we can establish a firms' expectation of a penalty for contravening sections of the FPC of BC Act based on those levied by the statutory decision-makers.

The data source for the analysis is information summarized from Compliance and Enforcement Branch's ERA\(^\text{17}\) records system, which outlines only the administrative information pertaining to the contravention and determination made by the statutory decision maker. As the rationale for each determination is housed in one of 47 individual district offices around the province, the only information available about the determination in the ERA system as queried related to the magnitude of the penalty, the type of enforcement action, and the number and results of appeals to the enforcement action.

\(^{17}\) Enforcement Action, Administrative Review, and Appeals system for tracking all suspected cases of non-compliance with provincial statutes relevant to forestry activities in British Columbia. The ERA system was recently updated, with all data transferred into the new Compliance, Enforcement, Determination and Administrative Review system, or CEDAR for short.
Because of privacy issues, the data could not be compiled by geographic region without significant research into timber marks, licences and permit numbers, which belies the scope of this analysis. As a result, data will be handled as a provincial aggregate.

To follow up on this study, a thorough review of some of the determinations in the ERA database (and potentially each variance administered by the Forest Appeals Commission) will be required to determine the rationale behind the variances in the relationships to the social welfare optimum. The relative correlation associated with each variable will provide valuable insight as to the consistency and relative importance of each portion of the determination.

5.1 Pertinent Legislation and Policy

Since its inception in 1995, the Forest Practices Code of BC Act (the "Code") and regulations under that Act have been the main policy guidelines and statutes to govern forestry practices in British Columbia. Enforcement provisions are introduced in the Act itself, and relative penalties are outlined in the Administrative Remedies Regulation (ARR) introduced by the Act.

Compliance and Enforcement Branch of the Ministry of Forests lists that 1,071 Administrative Penalties have been determined between June 15, 1995 and March 31, 2000, totalling $5,071,023. The Administrative Remedies Regulation lists the maximum administrative penalty that can be levied by a statutory decision-maker when a person is found in non-compliance with the statute. The regulation introduces criminal legal proceedings and indictment under the Offence Act for incidents such as theft, wilful damage and deliberate illegal actions as well.

The statutory decision-maker under the Code is charged with considering all evidence collected and presented when determining the appropriate enforcement action to take. When a fine is levied as a penalty under the Code, consideration is given to making the Crown whole and compensating for damages to the environment, cost of remediation and/or rehabilitation, as well as a deterrent to dissuade future non-compliance of the

---

same nature. The decision-maker also considers whether the person was purposeful in their actions, exercised due diligence in responsible planning, design, consultation, action, monitoring, notice, and remedial works.

Until recent government changes in British Columbia, the Code had been administered (for the term of the data used in this study) by the Ministry of Forests in six regions and 47 district offices. Each of the district offices houses a statutory decision-maker in the form of a District Manager or a designate. Each regional office houses an appeal officer, usually the regional manager or a designate. Each decision made by any of the statutory decision-makers can be subject to an administrative review by the Regional Manager, the Forest Practices Board (an independent public watchdog allowing public access to government decisions) or the Forest Appeals Commission (the direct avenue of appeal for any person having had a determination made against them).

Guidelines for the statutory decision maker in their determination come from the Ministry of Forests Policy Manual.\textsuperscript{19} The decision-maker may consider, in making a determination under the Code, factors such as:

1. relevant evidence presented by the investigating official
2. relevant evidence presented by the person responsible
3. any relevant information provided by regional or branch staff
4. previous contraventions by the person
5. the gravity and magnitude of the contravention
6. whether the violation was repeated or continuous
7. whether the contravention was deliberate
8. any economic benefit derived by the person from the contravention
9. the person’s cooperativeness and efforts to correct the contravention
10. the Minister’s policies with respect to the determination; and
11. any other factors the senior official deems to be relevant.

If we were able to conduct an analysis on factors considered in the penalty determination, information on the above-listed variables would be required to determine the extent and variability around their application. None of this information is available in the ERA database and instead would require a visit to each respective district or regional office to review and compile the data in a consistent format from

\textsuperscript{19} Ministry of Forests, \textit{Ministry Policy Manual}, Volume 1, Chapter 16, Policy 16.10 Determinations, Effective Date: 31-July-97
each determination rationale. In the rationale, government policy outlines the statutory
decision maker must provide:

- a brief outline of the incidents;
- a summary of evidence presented;
- a list of the statutes and section determined to be contravened;
- a list of the factors the senior official felt were relevant;
- a list of the maximum penalties allowed...; and
- a list of the Minister's policies the senior official considered in making the
determination.

In the Notice of Determination, the statutory decision maker must “state the amount
(and breakdown, if appropriate) of any monetary penalty”. The amount of the penalty
levied per contravention specific to a section under the Code, dependent on the many
variables outlined above, could lend itself well to economic analysis if “the list of the
factors the senior official felt were relevant”, and “a list of the Minister’s policies the
senior official considered” were provided in the ERA database (they are not).

A significant literature resource exists regarding penalties, game theory and optimal
regimes for pollution resulting from industrial processes. Heyes, 1995, and Saha and
Poole, 1999 found that penalties are most effective when they are less than maximal in
a hierarchical enforcement structure. Heyes goes on to relate the level of penalty to
the persistence of the pollutant (in our case the environmental damage), with the
highest penalty being most effective on enforcing pollutants of ‘medium’ persistence.
In forest practices, it would be interesting to determine if the environmental impacts
resulting from non-compliance in forest practices could be dealt with in a similar
manner.

5.2 Average Penalties and Enforcement Success

According to Compliance and Enforcement Branch, during the period from April 1,
1999 to March 31, 2000, 44,869 scheduled and unscheduled harvest and road
inspections were completed. These inspections identified 1,835 problems/incidents that
were dealt with in the field or required further investigation. Of these, 227 are still
under investigation, while 1,475 have been the subject of formal or informal measures.
Informal measures, such as compliance notices issued by field staff, are useful and
practical mechanisms to help avert contraventions and ensure compliance with the
Code. Formal measures are used when an official determines that the Code has been contravened and a formal sanction is warranted. It is important to note that the number of administrative remedies specified for the reporting period are subject to revision depending on the outcome of reviews or appeals.\textsuperscript{20}

In dealing with penalties levied under the Code, the statistical summary presented in this thesis focuses on the positive data describing the characteristics of the determinations made under each of the sections of the Act and regulations. Normatively, penalties levied under the Code should reflect the cost difference in expected diligent precautionary effort as described in regulation and actual effort determined by investigation relative to any increase in environmental risk as defined in Section 4. Any \textit{unsupported} deviation from those maximum penalties erode at the compensatory nature of the sanction, the economic consistency and social equity of penalties administered to date and would economically ‘subsidize’ the firm in non-compliance. An analysis of the "difference" between the maximum and the actual determination was deemed to be more meaningful.

A listing of the information requested from the Ministry of Forests Compliance and Enforcement Branch is included in Appendix B. It should be noted that the MoF was extremely accommodating in providing the data, subject to removing all references to personal data or in files considered a risk to ongoing enforcement actions.

From the data, of the 19,584 \textit{ERA} case files, each file may have up to 8-10 violations listed per case. Each violation can have up to 5 enforcement actions (33 in one case), each with up to 3 determinations depending on the status and number of appeals. In one case there were 7 appeals, with an average of just under 2 appeals per case for all enforcement actions on record - appeals aren’t the exception, they are the norm. Any query on this database does not result in a clean dataset, as the number of each nested case, violation number, enforcement action, determinations, and appeals is very limiting when trying to track each resultant determination.

\textsuperscript{20} \url{http://www.for.gov.bc.ca/enforce/annual_report_1999/ar1999_statsum.html}
For each article section queried under an Act or regulation, the data was cleaned by the following actions:

- if violation number, enforcement number, determination number and appeal number, enforcement amount (penalty) and date were the same value, one was kept, the other deleted – this is likely due to overlapping table information in the query;
- if the same information repeatedly occurred, the data described by the most recent date was kept, the other(s) deleted;
- if the same enforcement amount (penalty) for the same CASE_SKEY appeared under queries on different ARTICLE sections, the information was kept under the most appropriate Section only and not included under other Sections (no double-counting); and
- descriptive statistics were generated only for the successful sanction amounts, with the perspective that if the sanction was successful it was proven the agent was in non-compliance.

Problems with the data

- several Sections of the Code are referred to under one case, with the same enforcement amount (penalty) listed under each Section. What weighting that each section contributes to the total sanction amount is unclear;
- useful data in the VIOLATION_SEVERITY_CD is inconsistent, sporadic and incomplete. This code had the potential to differentiate the data and provide valuable insight into the rationale behind the enforcement amount. It is assumed the ministry found it irrelevant to provide information in this column as the interpretation of relative severity is likely inconsistent and unreliable at a provincial scale;
- no value was estimated for REMEDIATION or INSTRUCTION orders, instead a value of $0.00 was entered, providing no data for analysis;
- if a $0.00 amount is reported, and yet there are up to seven (7) appeals on a $0.00 amount, what was the original determined ‘Enforcement Amount’? Was it confirmed or varied in the 2nd through 7th appeal and if so what amount did it vary to? Upon final and successful appeal it appears that if the enforcement
action is rescinded the enforcement amount is entered as $0.00 for **ALL** fields.

In the analysis, it was arbitrarily chosen to look at some of the sections of the Code that pertained to actual damage or non-compliance that would directly impact or have consequences on forest values. This was chosen over reviewing sections dealing with not meeting the administrative requirements of the ministry in order to mitigate the risk in order to avoid interpreting for differences in perceptions of risk on top of an increased likelihood of environmental damage due to the non-compliance.

From the Code, sections 17(1), 45(1), (3) and (4) and 47(1) are listed along with some descriptive statistics that outlined the character of the data compiled from the Compliance and Enforcement ERA database. Delta (δ) is calculated as a straight ratio of (number of successful sanctions/total number of enforcement actions).

### 5.3 Data Analysis by Section of the Forest Practices Code of BC Act

The following data analysis is a review independent of the model for optimal penalties generated in Section 4.0—**the model derived “what should be”, the data analysis describes “what is”**. The Sections chosen for review as enforced under the *Forest Practices Code of B.C. Act* involve those where the maximum penalty is fairly robust ($50,000) and that there are enough enforcement actions listed under the section with penalties levied such that a functional average can be derived from the data. Other Sections, for the most part, involved many non-financial sanctions in the form of Stopwork Orders, notices to comply, instructions or general non-compliances not judged to be worth an officer’s time to do anything more than provide verbal instructions and note the incident in the ERA database.

**Section 17.** (1) Before the holder of an agreement under the Forest Act or the Range Act prepares an operational plan or amendment for submission to the district manager, the holder **must carry out the assessments required by the regulations** and collect and analyze the data required by the regulations to formulate operational plans, and

---

21 **bold and italics** emphasis added to highlight the main idea of the Section
make the assessments, data and analyses available to the district manager. The maximum penalty described under the *Administrative Remedies Regulation (ARR)* for a contravention of this section is $50,000.

![Graph of penalty distribution for sanctions levied under Section 17(1)](image)

**Figure 1** Graph of penalty distribution for sanctions levied under Section 17(1)

<table>
<thead>
<tr>
<th><strong>Section 17(1) Descriptive Statistics</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Penalty</td>
</tr>
<tr>
<td>Standard Error</td>
</tr>
<tr>
<td>Median Penalty</td>
</tr>
<tr>
<td>Mode Penalty</td>
</tr>
<tr>
<td>Standard Deviation</td>
</tr>
<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Skewness</td>
</tr>
<tr>
<td>Minimum Penalty Levied</td>
</tr>
<tr>
<td>Maximum Penalty Levied</td>
</tr>
<tr>
<td>Sum Total of all Penalties</td>
</tr>
<tr>
<td>Count &amp; Delta ($\delta$) =</td>
</tr>
</tbody>
</table>

**Table 1** Statistical description of sanctions levied under Section 17(1)

Given that penalties are meant to exceed the difference in the cost of diligence versus non-diligence relative to the difference in likelihood of environmental damage, and be less than the amount that ensures participation in harvesting activities, means an average penalty of
or that a statutory decision maker must balance the penalty with what the firm can afford to pay. If the firm does not represent the average efficient operator, any penalty that does not reflect the cost of due diligence or the increased likelihood of environmental damage can be considered a subsidy at the expense of the environment.

Arguably a section that consistently defies measurement is Section 45(1), as it leaves latitude for what can be interpreted as environmental damage that could change in application and context as established in case law over time. However, as an effective policy it does not adequately guide forest management nor define thresholds or results to achieve, instead defining a very broad and indeterminate result to avoid in operational activities.

**Section 45(1)** *A person must not carry out a forest practice that results in damage to the environment.*

A district manager has valued the difference in the level of diligence relative to the higher likelihood of environmental damage to equal, on average, $3,626.08. If the probability of environmental damage was certain as a result of non-compliance, for example if a relatively low or non-existent threat became very real and imminent (i.e. \( \pi \rightarrow 1 \)), then a decision maker at most would have expected on average a licensee to incur approximately $3,626 in precautionary costs to avoid the damage.

The fact that the mode is $500 and that rarely will the difference in probable damage be so extreme, that licensees must either generally be mostly diligent and require only a small penalty to mitigate damages, statutory decision-makers are undervaluing the precautionary costs required to be diligent, or the available producer surplus is captured in stumpage and operational costs and there is limited surplus available to apply a penalty or use economic incentives to comply.

Landslides, loss of growing site or other environmental impacts such as loss or damage to fish habitat, critical or endangered species habitat constitute a loss that
erodes at the productive capability of the land base. More specific than Section 45(1), Section 45(3) states a **person must not carry out a forest practice** if he or she knows or should reasonably know that, due to weather conditions or site factors, the carrying out of the forest practice **may result**, directly or indirectly, in

(a) **slumping or sliding of land,**
(b) **inordinate soil disturbance,** or
(c) other **significant damage to the environment.**

---

**Table 2 Statistical description of sanctions levied under Section 45(1)**

<table>
<thead>
<tr>
<th>Section 45(1) Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Penalty</td>
</tr>
<tr>
<td>Standard Error</td>
</tr>
<tr>
<td>Median Penalty</td>
</tr>
<tr>
<td>Mode Penalty</td>
</tr>
<tr>
<td>Standard Deviation</td>
</tr>
<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Skewness</td>
</tr>
<tr>
<td>Minimum Penalty Levied</td>
</tr>
<tr>
<td>Maximum Penalty Levied</td>
</tr>
<tr>
<td>Sum Total of all Penalties</td>
</tr>
<tr>
<td>Count &amp; Delta ($\delta$)</td>
</tr>
</tbody>
</table>

**Figure 2** Graph of penalty distribution for sanctions levied under Section 45(1)
Graphically, the data on sanctions successfully applied under this section shows that government again successfully sanctions less than 25% of the enforcement actions undertaken, and that the mean penalty is less than 8% of the maximum penalty.

Figure 3 Graph of penalty distribution for sanctions levied under Section 45(3)

Table 3 Statistical description of sanctions levied under Section 45(3)

available to them under the Administrative Remedies Regulation. Cohen (1998), Polinsky and Shavell (1991), and Livernois (1999) represent that penalties should be a reflection of the damage divided by the likelihood of getting caught. In this case, environmental damage would be valued at $3,389*0.247 = $837. The cost of
government's time in investigating, determining and applying the sanction, as well as administering appeals would be much less than this, and therefore would be a net social welfare loss. There must be another reason for enforcement actions other than compensating the public.

One consideration not allocated in the model is the idea that negative press, or a public announcement of non-compliance or environmental damage would have an impact on the firm's ability to market its product internationally. With forest certification attempting to provide a market signal of sustainable forest practices, any black mark on a licensee's record could jeopardize the sunk costs of becoming certified. All certification standards in B.C. dictate that a firm complies with environmental regulations as described by government as a minimum requirement.

The reporting under this Section, as in all sections, requires one to look at the nature of the enforcement actions listed along with the $0.00 penalty amount. Stopwork Orders administered under Section 123 of the Code Act requires a licensee to comply with S. 45(4)(a) and does not imply a penalty determination has been made – there are likely costs incurred by the firm associated with loss of production, access to the area, costs of moving machinery, etc. that are sunk costs or inefficiencies to production resulting from the order.

**Section 45(4)**
A person who contravenes subsection (1) or (3) must

(a) stop the forest practice in the area affected,
(b) prevent any further damage to the environment,
(c) promptly notify the district manager, and
(d) take any remedial measures that the district manager requires.

**Note:** No graph or table can be drawn based on penalty amounts as no financial penalties were assessed. Penalty descriptions include Stopwork Orders, No Action Field, No Action Administration, Instruction Orders, Remediation Orders and Penalties.

Given the wide range of policy tools available to a Compliance and Enforcement Officer or statutory decision-maker, financial penalties are not always required to motivate licensees to comply with the standards established in plans or under regulation.
In addition to that outlined under Section 45(2), this section relates to inordinate soil disturbance relative to the amount described in an operational plan (usually a Silviculture Prescription). If a penalty is levied under both Sections, then there is opportunity to capture more of the available producer surplus by doubling up on

![Section 47(1) Distribution of Penalties](image)

Figure 4 Graph of penalty distribution for sanctions levied under Section 47(1)

<table>
<thead>
<tr>
<th>Section 47(1) Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Penalty</td>
</tr>
<tr>
<td>Standard Error</td>
</tr>
<tr>
<td>Median Penalty</td>
</tr>
<tr>
<td>Mode Penalty</td>
</tr>
<tr>
<td>Standard Deviation</td>
</tr>
<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Skewness</td>
</tr>
<tr>
<td>Minimum Penalty Levied</td>
</tr>
<tr>
<td>Maximum Penalty Levied</td>
</tr>
<tr>
<td>Sum Total of all Penalties</td>
</tr>
<tr>
<td>Count &amp; Delta (d)</td>
</tr>
</tbody>
</table>

Table 4 Statistical description of sanctions levied under Section 47(1)

applicable penalties. This is unlikely however, as there is no evidence in the dataset to indicate successful sanction under both Sections for any individual enforcement action.
Note that Section 47(1) has defined a measurable, auditable standard as outlined in an approved plan, and that Delta (\(\delta\)) at over 30% is higher than in other more vague Sections outlined above without.

**Section 47(1)** A person carrying out a forest practice on an area under a silviculture prescription must not exceed the maximum amount of soil disturbance within the net area to be reforested that is specified in the prescription.

The maximum penalty for not complying with this Section is, again, $50,000 as listed in the ARR, however the average penalty applied for this contravention is less than any of the other penalties applied above likely because of the marginal impact over and above the limit defined in a Silviculture Prescription. Are the limits too liberal such that there are only 23 instances of enforcement actions taken for inordinate soil disturbance, or do other enforcement strategies provide for better compliance at lower cost.

### 5.4 Data Summary Statistics

In summary, the data is compiled below into a table to compare the relative success of government sanction, average penalty, and what this likely means relating to the assessment of penalties by the statutory decision-makers. The “Expected Penalty” in the table describes that the penalties successfully levied averaged $5,121.96, and that government was only successful in sanctioning 28.2% of the time, therefore in any one incident or contravention, a firm would expect \((0.282 \times 5,121.96)\) or $1,444.39 as a probabilistic liability on their books.

<table>
<thead>
<tr>
<th>Section of the FPC Act</th>
<th>Successful Sanction Rate ((\delta))</th>
<th>Average Penalty</th>
<th>Expected Penalty ((\delta p))</th>
<th>Penalty Levied Most Often</th>
<th>Maximum Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>17(1)</td>
<td>28.2 %</td>
<td>$ 5,121.96</td>
<td>$ 1,444.39</td>
<td>$ 1,500</td>
<td>$ 50,000</td>
</tr>
<tr>
<td>45(1)</td>
<td>17.1 %</td>
<td>$ 3,626.08</td>
<td>$ 620.06</td>
<td>$ 500</td>
<td>$ 50,000</td>
</tr>
<tr>
<td>45(3)</td>
<td>24.7 %</td>
<td>$ 3,388.89</td>
<td>$ 837.06</td>
<td>$ 500</td>
<td>$ 50,000</td>
</tr>
<tr>
<td>45(4)</td>
<td>0 %</td>
<td>$ 0.00</td>
<td>$ 0.00</td>
<td>$ 0</td>
<td>$ 50,000</td>
</tr>
<tr>
<td>47(1)</td>
<td>30.4 %</td>
<td>$ 2,571.43</td>
<td>$ 781.71</td>
<td>$ 500</td>
<td>$ 50,000</td>
</tr>
</tbody>
</table>

Table 5 Average Penalty and Sanction Rate for Selected Sections
The Average Penalty can be considered to be consistent with what is outlined in equation (1.7), or the equivalent of a determined $c_D - c_N$ (the difference in cost of diligence, consistent with Harrington, 1988). If this is the case, then licensees were mostly diligent and in the case of 17(1) would have had to spend the equivalent of approximately $5,120 to ensure adequate assessment of the impacts of development or harvesting. In the case of Section 45(1), an additional $3600 of precaution – about the equivalent of a couple of days for a professional and about two days of machine time - to ensure diligence in adequately protecting the environment. This implies that a licensee was mostly precautionary, however missed in some small way the necessary step or bit of work that would have ensured they did everything reasonable and responsible to limit the risk or the damage that occurred.

Now consider the relative increase in likelihood of environmental damage that should be considered in the penalty amount $(\pi_N - \pi_D)$. For Section 45(1) the following comparative analysis outlines what the implications may be to assessed costs, where $c_D - c_N > \rho (\pi_N - \pi_D)$ (note that this does not include $\delta$ as it outlines penalties where sanctions were successful, and does not build on the “expected penalty”):

<table>
<thead>
<tr>
<th>Section 45(1) Average Penalty</th>
<th>if $\pi_N - \pi_D$ is equal to:</th>
<th>the resultant assessed $c_D - c_N$ would be:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3626.08$</td>
<td>20%</td>
<td>$725.22$</td>
</tr>
<tr>
<td>$3626.08$</td>
<td>40%</td>
<td>$1,450.43$</td>
</tr>
<tr>
<td>$3626.08$</td>
<td>60%</td>
<td>$2,175.65$</td>
</tr>
<tr>
<td>$3626.08$</td>
<td>80%</td>
<td>$2,900.86$</td>
</tr>
</tbody>
</table>

Table 6 Comparative analysis of costs not borne by licensee, relative to the increase in likelihood of environmental damage

So given the above table and the average penalty determined under Section 45(1), is it likely that the increase in probability of environmental damage is 20%? 60%? 100%? As the statutory decision maker is not explicitly required (i.e. the closest is they must consider the “gravity and magnitude” of the contravention, but not how), nor are they even introduced to the idea of penalties being relative to the increase in likelihood of environmental damage.
6.0 Discussion
Penalties levied under the authority of the Forest Practices Code of B.C. Act provide economic incentive for firms to incur precautionary effort and comply with environmental regulations without causing undue losses to the firm. As a result, social welfare increases as it makes resource management practices possible on the expansive Category 2 lands of the province of B.C. Without an incentive program, the operable landbase would shrink to only those lands without significant environmental values affected by forest practices. As long as firms can afford the environmental protection requirements that ensure environmental values are maintained, overall social welfare gains by the inclusion of these lands in the managed forest of B.C.

6.1 Why penalties might be lower than expected under the Code
The literature is quite robust in analysis when the public has been critical of regimes that describe penalties that are lower than would be socially expected. Andreoni (1991) describes that penalties should not be uniformly high in their application, and that penalties levied by judges (or in this case, statutory decision-makers) should “fit the crime” but that the higher the penalty the likelihood of conviction falls and that higher penalties mean higher court costs when trying to sanction. If this were true in British Columbia, penalties are low because licensees mostly comply and that higher penalty sanctions are more costly and less likely to be successful.

Mookherjee and Png (1994) argue that it is optimal to set marginal expected penalties less than marginal harm, and that below some threshold there should be no penalties at all. Furthermore, Mookherjee and Png go on to claim that if enforcement effort is costly, then marginal expected penalties for minor acts should be still lower, yet marginal expected penalties for more serious acts should be stiffer with the idea to shift individuals away from the higher cost prosecution and punishment acts. Finally, they claim that if monitoring becomes more costly, then marginal expected penalties should be lower at every level, but if prosecution and punishment become more costly then expected penalties should also be raised (sic) for more harmful ones.
Under the Forest Practices Code forest practices standards are set relative to the standards and policies outlined as “best management practices” in the guidebooks for preparing operational plans for statutory decision-maker approval under the Code for activities proposed on Crown lands. Precautionary due diligence requires that licensees follow those plans as legislated under the Code - a part of doing business in British Columbia. Licensees are required to assess and plan their operational development in order to minimize the risk to the environment, submitting their plans to government for approval before being allowed to harvest timber, build road or reforest a cut-over area. Operational practices are also regulated, stipulating the process by which development and harvesting can occur. This planning and regulated practices legislation acts to provide the Crown certainty in a lower probability of environmental damage (\(\pi\)) resulting from due diligence, and thereby the magnitude of the expected penalty (\(\rho\)) will be lower consistent with that expectation.

Becker (1968) introduces the commentary that “a change in the probability [of conviction or punishment] has a greater effect ... than a change in the punishment]. Given the low penalties and low enforcement success, an increase in either penalty or enforcement success would provide additional economic incentive. However, consider that the equivalent increase is dependent on the expectation of the person in non-compliance. If government increases the likelihood of success (\(S\)) by 5% under Section 45(1), penalty amounts would have to increase 29% on average to have the same economic incentive effect.\(^{22}\) If the 5% increase in the likelihood of success costs less than the 29% increase in incentive (i.e. enforcement costs rise less than $181 on average), then there is a potential net social welfare gain in the technology change, everything else held constant (consistent with Boyer, Lewis and Liu (1996)). That said, Hentschell and Randall (2000) maintain that “if penalties are upper-bounded” (and they are under the Code) “and each firm is inspected randomly, compliance cannot be maintained with arbitrarily small inspection probabilities and hence, small agency costs” such that a change in enforcement strategy to random inspections may not help in maintaining compliance without other compensating changes to the system.

\[^{22}\] [(22.1%) x ($3,626.08)] / $620.06 - 1 = 29%, but maybe this is too simple.
Another gem from Becker's seminal paper on the economics of enforcement sees that "factories that pollute the air or lumber operations that strip the land, should be taxed or otherwise restricted in the level until the marginal external harm equalled the marginal private gain, that is, until marginal net damages equalled zero". The average penalties described in Section 4 of this thesis are just that, taxes on the producer that increase their marginal costs to the point where the value is equivalent to the marginal cost of the environmental damage.

Russell (1990) indicates that in order to effect a "technically" and "socially correct" penalty, information on the marginal value of damages in lost habitat are required, but values in carbon sink/sequestration, reduction of water quality, lost wilderness, existence, option or quasi-option value cannot be adequately determined on a "market value basis" given the stochastic variability and specific local determinants of their non-market values. In that statutory decision-makers are not explicitly required to may be set up to fail in then not being able to adequately value and therefore levy a penalty that recognizes the true social welfare implications of any resultant site-specific environmental damage.

Government, and more specifically the Ministry of Forests, is legally obligated to provide for and "encourage a vigorous, efficient and world competitive timber processing industry in BC". This gives credence to the "participation constraint" used in the principal agent model above. If market prices do not provide much room for profits after netting out operational and precautionary costs, stumpage and internal risks and uncertainty, then the available producer surplus to penalize a licensee is less or non-existent. Licensees may not be able to afford to be diligent or fully precautionary during low markets such that there may be a higher likelihood of non-compliance, but determined penalties will be necessarily lower.23 Higher cost licensees will likely have to shutdown before lower cost licensees if their precautionary efforts remain the same and at a level of due diligence. Arora and Gangopadhyay (1995) describe that if required precautionary effort is too high, then both diligent and

23 In the early 1980's this was called "sympathetic administration" where the Ministry of Forests relaxed its regulatory requirements to ease the financial burden on a struggling B.C. forest industry.
non-diligent firms may not be able to make positive profits, forcing them to operate in smaller and smaller markets with higher costs.

In most cases, the licensees have a better idea than government of what the environmental risks are, and what the likelihood of environmental damage is due to their involvement in ground-based assessments, inventories, and experience in working with the ecosystems and landscapes of the operating area. Government, during inspection, may have a higher perception of expected costs of diligence, and in the case where no environmental damage occurs and the licensee is deemed in non-compliance with the regulation, government must be certain in the differences in costs relative to the likelihood of damage occurring when a firm is diligent and when not. Baron and Besanko (1984) bring forward that the level of inspections (auditing in their case) is optimal when the reported effort of the firm is above a certain level, and penalties are imposed when the observed effort is low. From there, a sensitivity analysis around perceived probabilities and costs in equation 5.2.2 in Appendix A could provide a world of insight before proceeding with a sanction.

Environmental interest groups criticize government for undervaluing forest land in its undeveloped state ($W$), in that the ecosystem services, wilderness, option, quasi-option and existence values connote a higher social reservation utility. In the model, this would mean environmental interests would value the resource in the undeveloped state or on a global scale as greater than the benefits gained by development on areas described as Category 2 lands (where $W \geq P - c_D - \pi_D (E + V) - k_D$). Thus, environmental interests expect the penalty ($\rho$) determined for an incident of non-compliance to be much higher than government has determined in order to offset the social losses and global externalities resulting from current forest management practices. As related before however, penalties only serve to redistribute whatever surplus made at the expense of the environment to the Crown - net social welfare remains the same (or is reduced if the damage exceeds the firm's ability to pay). Baron (1988) outlines how government captures surplus depending on the political lobby power of public versus industrial interests.
Vandall (1989) in his section on the economics of strict liability, states that if economics relies on the function of the market, then he argues it is valid to say that “the prices upon which the market depends must reflect all costs.” That stated, how do lumber prices consider compensating for the externalities associated with forest development? Government realizes up to $4 billion in stumpage, taxes and spin-off revenue from forest development activities based on their perception of land and resource values \( P - c_D - \pi_D (E + V) - k_D \geq W \). If world prices reflected compensating for those externalities (dirty water, carbon loss, habitat loss, etc.) then stumpage and penalties would incorporate compensation for those lost values on a harvested tract of land. It is worth noting that forest certification is a tool to signal the market that sustainable forest management practices are being practiced, but producers have not as yet been able to charge a premium for lumber harvested under due diligence.

Contrary to the idea of strict liability is that the combined social and economic investigation by Braithwaite (2002) muses that firms respond to market incentives, that with regulatory control are more apt to adopt a fixer or game-playing mentality. As a result, he proposes that “consistent punishment of business non-compliance would be a bad policy, and that persuasion is normally the better way to go when there is reason to suspect cooperation with attempting to secure compliance”. Braithwaite’s paper mostly describes the effects of adopting a reward-based approach to providing incentives to comply with regulations, and concludes that in most cases, however, that punishment is a more useful tool that avoids many of the pitfalls reward-based system would offer.

Theoretically, licensees will not have economic incentive to adopt precautionary operational characteristics when the profits from non-compliance are greater than the expected penalty from non-compliance. To look at it another way, licensees will not incur precautionary costs until the expected penalty is very real and binding on their profit function. The current government initiative to reduce the number of government

---

24 Larry Pedersen, RPF, ADM Forestry and Chief Forester, Ministry of Forests, FRST 415 guest lecture, April, 2003
staff implies that a resulting decrease in enforcement activities (and thereby likelihood of successful sanction) will require an increase in penalties to compensate and ensure no change in the incentive for firms to comply with regulations. This is happening concurrently with a change in the regulations introduced under the new Forest and Range Practice Act (FRPA) governing forest practices in B.C. that is proposed to make those regulations more effective and enforceable.

Becker (1968) establishes that any improvement in enforcement technology does not increase the optimal penalty nor reduce the number of likely offences, but it does reduce the optimal enforcement effort and “thus the need to rely on severe punishments for those convicted.” This, in essence, builds a part of the case for the regulatory reform currently under way in government, establishing results-based standards to measure, audit and enforce against – i.e. in the current draft of the Forest Planning and Practices Regulation there is a lengthy and specific definition of what “damage to the environment” is - and will likely make the old Section 45 under the Code much more enforceable, increasing sanction success with little or no change in enforcement effort. Boyer, et al (1996) find that “the setting of standards may effectively substitute for the setting of fines”, providing both incentive for firms to comply and for regulators to inspect and enforce where penalties are fixed or limited. Given the lack of regulatory standards expressed in the Code (in comparison to the new FRPA), the new regulation will likely improve the economic efficiency and by reducing the deadweight loss of enforcement costs, increase social welfare.26

The data summarized in Section 5 of this thesis described the expected penalty for contravening various sections of the Code. When compared to the maximum penalty contemplated in the Administrative Remedies Regulation, the penalty defines the expected level of precautionary expenditures determined to be absent by statutory decision-makers under the regulations (the DM fines the difference in expected level of effort and actual effort determined in the investigation).

---

26 Environmental groups however, continue to express that the environmental standards are set too low, where \( P - c_D - \pi_D V < w + \pi_D E + k_D \) and constitutes an uncompensated externality on the ecological viability of the ecosystems from which timber harvesting occurs.
Under the Code there is recognition for the statutory decision-makers to consider penalties for 1) compensating the Crown, or 2) as a deterrent from future incidents (Reader, 2002). If a penalty is levied and no deterrent amount is added to the compensatory amount in the determination rationale, the sanction is viewed as “making the Crown whole” by compensating the public for undue risk to public resources or for environmental damage resulting from their activities. This assumption is easily understood by the public as it likely recognizes the sense of “fair play” and compensating the owners for damages.

In reality however, under the aggregate social welfare model developed, the truth is that compensation occurs only in the form of remediation required to fix the environmental damage, and that penalties constitute an incentive mechanism to ensure licensees adopt diligent behaviour and social welfare can be maximized. Penalties then redistribute the producer surplus realized by “unfair play”. Deterrents are also a redistribution of producer surplus and should be based on the likely future losses resulting from any firm’s non-diligence that did not learn the lesson the first time. An effective penalty scheme is sufficient to act as a deterrent as if the expected penalty is high enough, it will remove any potential profit realized by non-diligent behaviour. If these firms are wanton to continue operations of inordinate risk, then it may be more economically efficient to ensure the firm does not continue to operate and that their licence is re-allocated to a more efficient and environmentally friendly firm.

6.2 Perfect Enforcement
The likelihood of successful enforcement action is conditional upon the inspection, investigation, sanction and appeal processes pursued by government. Perfect enforcement implies there will always be an inspection only for every incident of non-compliance, the investigator conducts a perfect investigation, with the statutory decision-maker then constructing a perfect determination. Because of perfect information, there are no errors and the firm cannot pursue any avenue of appeal. The sanction is then fully implemented and the Crown is compensated completely for the risk to public resources and infers that from government’s social welfare function outlined in equation (1) the likelihood of successful sanction (δ) is equal to 1.
Consistent with equation (4.3) of Appendix A, as $\delta \to 1$ a licensee has more certainty in the likelihood of a successful enforcement action, providing for a higher expected penalty and moving precautionary effort closer to diligence ($e_N \to e_D$). The more credible threat of penalty then provides direct incentive for the firm to reduce the risk to the environment by adopting a higher level of precaution. When $\delta = 1$, expected penalties are true to value ($E(\rho) = \rho$) firms will have full incentive to adopt the appropriate level of due diligence if the expected penalty is greater than or equal to the cost of precaution ($E(\rho) > (c_D - c_N)/(\pi_N - \pi_D)$) everything else held constant – based on the incentive constraint for the model. With perfect enforcement, the expected level of penalty then directly infers the expected level of precautionary expenditure of the firm, providing incentive for the firm to incur the precautionary costs and not the penalty. Additional external non-value costs to the firm exist in public reporting and damage to reputation provided by the sanction.

6.3 Imperfect Enforcement

The cost of enforcement activities are subject to diminishing marginal returns where government must balance the independent variables and probabilities determining the likely success of sanction such that the marginal increase in the expected penalty from non-compliance is equivalent to any marginal decrease in a firm's level of expenditure in precautionary effort. This is balanced in the optimization where the marginal costs of enforcement are equal to the marginal benefits of enforcing the regulations. Bose (1995) notes that imperfect enforcement is more economically efficient, as regulatory errors cause the optimal penalty to be non-maximal and yet achieve full compliance, whereas only partial compliance is achieved under perfect enforcement.

With imperfect enforcement, government is not able to detect and enforce all incidents of non-compliance with the regulations. Considering that enforcement efforts are not perfect ($\delta < 1$) by definition, government must ensure that the optimal penalty will still provide full incentive for firms to take the necessary level of precaution. This means ensuring the expected penalty provides incentive for a firm to incur the socially optimal level of precautionary diligence ($e_D$), thereby
which shows that government policy must levy higher penalties to ensure economic
incentive exists for firms to conduct operations diligently. Diligent behaviour ensures
lower social costs of damage to the environment, corporate and social infrastructure
and likely remediation costs, thereby minimizing some of the costs to social welfare.

<table>
<thead>
<tr>
<th>Line Item for Core Businesses</th>
<th>2002/03 Restated Estimates</th>
<th>2003/04 Estimates</th>
<th>2004/05 Plan</th>
<th>2005/06 Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Expenditures</td>
<td>$34,288,000</td>
<td>$30,048,000</td>
<td>$26,783,000</td>
<td>$26,783,000</td>
</tr>
<tr>
<td>FTE's</td>
<td>376</td>
<td>317</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Capital Expenditures</td>
<td>$1,951,000</td>
<td>$2,366,000</td>
<td>$1,911,000</td>
<td>$1,911,000</td>
</tr>
</tbody>
</table>

= $438/FTE/day (see use in next table)

<table>
<thead>
<tr>
<th>Person</th>
<th>Role</th>
<th>Days</th>
<th>Day Rate*</th>
<th>Cost</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compliance Officer</td>
<td>Inspect</td>
<td>0.5</td>
<td>$438</td>
<td>$219</td>
<td>monitoring to discovery collect and present info to DM review and levy penalty</td>
</tr>
<tr>
<td></td>
<td>Investigate</td>
<td>3</td>
<td>$438</td>
<td>$1,314</td>
<td>average 2 appeals panel, twice appealed</td>
</tr>
<tr>
<td>District Manager</td>
<td>Determine</td>
<td>0.5</td>
<td>$438</td>
<td>$219</td>
<td>penalty</td>
</tr>
<tr>
<td></td>
<td>Appeal</td>
<td>1</td>
<td>$438</td>
<td>$438</td>
<td></td>
</tr>
<tr>
<td>Review Panel</td>
<td>Appeal</td>
<td>3</td>
<td>$438</td>
<td>$1,314</td>
<td>data entry, communications, collections</td>
</tr>
<tr>
<td>Support Staff</td>
<td>Support</td>
<td>3</td>
<td>$438</td>
<td>$1,314</td>
<td></td>
</tr>
</tbody>
</table>

11 Total $4,818

* day rate includes overhead and admin and is based on total expenditures/FTE based on a 220 work-day year from previous table

Table 7 Estimate of Cost of Ministry of Forests Enforcement Activities for Inspection through Appeal Process

In Section 4.1 the idea that government expenditures must be at least greater than the risk of losses if a firm is not diligent. For discussion purposes, a rough estimate of

\[ E(\rho) \geq \frac{1}{\delta} \frac{(c_D - c_N)}{(\pi_N - \pi_D)} \]

government costs involved in an inspection that results in investigation, sanction, and appeal is outlined in Table 6.3.1.

Friesen (2002) describes that greater compliance can be achieved by targeting enforcement efforts on specific regulated groups (Harrington, 1989; Russell, 1990; Polinsky, 1991; Cohen, 1998; Raymond, 1999). This target group concept introduces setting up 2-stage compliant versus non-compliant groups where regulatory efforts are spent ensuring compliance in the non-compliant group with the occasional, random inclusion of a compliant individual to confirm compliance. In this model, it is argued, compliance expenditures can be optimized and minimized by focusing efforts on non-compliant firms and providing a reward to compliant firms in reduced regulatory restrictions, monitoring and reporting requirements.

Returning to equation 1.9, where government expenditures must be greater than firm costs of diligence minus any increase in probable environmental damage or infrastructure losses, \( k_N - k_D > (c_D - c_N) - (E + V)(\pi_N - \pi_D) \), if the $4,818 in Table 6.3.1b above can be considered a reasonable average estimate of enforcement expenditures \((k_N - k_D)\) for contraventions, and \(c_D - c_N\) is the average penalty, then the resultant average increase in environmental and infrastructural damage might look something like:

\[ E + V > ($3,626) - ($4,818)/(80\%-20\%), \text{ or} \]

\[ E + V > -$4,404 \]

The dynamics of this equation gives rise to the question that if the $4,818 is a reasonable estimate of enforcement costs, then there is $4,404 of environmental damage expected by government that is not recognized in the penalty levied.

Obviously situations will vary, and each Section may require more or less enforcement time dedicated to resolving cases. However, on average the table above tells a story in that estimated environmental damage requiring penalties as an incentive to comply or to compensate the Crown have been relatively low, and that other more informal methods of sanction are the norm. Bringing back Table 4.5.2 consistent with equation (1.9),
### Table 8 Comparative analysis deriving likely level of environmental damage

<table>
<thead>
<tr>
<th>Section 45(1) Average Penalty</th>
<th>If $\pi_N - \pi_D$ is equal to:</th>
<th>Resultant assessed $c_D - c_N$ would be less than:</th>
<th>Likely Gov't Cost to Enforce</th>
<th>E + V Inferred Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3626.08$</td>
<td>$20%$</td>
<td>$725.22$</td>
<td>$4818$</td>
<td>$20464$</td>
</tr>
<tr>
<td>&quot;</td>
<td>$40%$</td>
<td>$1450.43$</td>
<td>$4818$</td>
<td>$8419$</td>
</tr>
<tr>
<td>&quot;</td>
<td>$60%$</td>
<td>$2175.65$</td>
<td>$4818$</td>
<td>$4404$</td>
</tr>
<tr>
<td>&quot;</td>
<td>$80%$</td>
<td>$2900.86$</td>
<td>$4818$</td>
<td>$2396$</td>
</tr>
</tbody>
</table>

I make no claim these numbers are representative or correct, they are simply developed for comparative discussion purposes.

What falls out of the comparisons drawn in Table 6.3.2 is that given the average $3,626 penalty levied under Section 45(1), is that the inferred damage to the environment and infrastructure would be very sensitive to the likely increase in probability of damage – the statutory decision maker would need to get it right if it was to be applied in developing a penalty. Given a 20% increase would not arguably be detectable given the subjectivity of expert opinion on determining quantitatively what the change in likelihood of damage would be if a person put more money into diligent behaviour, the 20% is likely not practical to use for comparison as the magnitude of the potential damage would have to be very large.

Comparatively, in the 40-60% range, where there is likely to be some agreement that an increase in diligent behaviour by the equivalent of an average $1,800 will make a difference in reducing the probability of environmental damage, and that the penalty incentive would likely result in the saving the equivalent of $6,400 of damage… that comparison is not unreasonable.

In another situation, using a stand example from an MoF stumpage paper* and implying a 150m3 and .25 hectares loss of growing site with an average log value of $115/m3. Assuming a probability of environmental damage that went from a diligent 20% to a non-diligent 80% likelihood, with a cost of diligence of $15,000 and of non-diligence of $10,000. Stumpage for the 150 m3 would be $26.94/m3 for a total of $4,041. What does this mean in the ways of compensation, removing economic profit, remediation and deterrence?
\[
\frac{P - S - V - c_D}{\pi_D} > 3.626 > \frac{(c_D - c_N)}{\pi_N - \pi_D}
\]

\[P - S - V - c_D = 725.20\]

\[(c_D - c_N) = 2,175.60\]

This would mean a potential economic gain of $2,175 through cost savings, an Opportunity Cost of $725 for timber not harvested and milled into product, $4,041 in stumpage as lost Crown revenue, and $1,050 in remediation costs. Environmental groups lobby that the penalty should then be

\[
\text{economic gain} + \text{compensation} + \text{remediation} + \text{deterrent}
\]

\[
2,175 + (725 + 4,041) + 1,050 = 7,991... \text{ and a deterrent?}
\]

And the question remains, in that should we fine a licensee $7,991 instead of $3,626?

1. If it won’t happen again... no deterrent
2. If no timber or other economic opportunity costs... -$ 4,766
3. If the licensee regenerates the site... -$ 1,050
4. economic gains relative to environmental risk... $ 2,175

If the change in likelihood of environmental damage from non-diligence is low (i.e. 20%), however the cost savings are high (i.e. $5,000), the penalty will be necessarily higher (5,000/0.20 = $25,000) than the expected damage to motivate a licensee to take precautionary measures. This artefact does not seem socially reasonable and likely would result in some other form of compliance procedure, in the form of a remediation order, instruction order, or other non-monetary sanction to motivate the licensee to comply.

The result is that there can be constructed a function where by when penalties are greater than the expected damage, an alternative enforcement strategy is to be used to provide compliance incentives. Alternatively, some consideration can be given to a proportionality rule requiring penalties to reflect the actual increase in likelihood and magnitude of the penalty – and the penalty would then “fit the crime” consistent with Andreoni (1991).
6.4 General Application

The undeveloped value for the land \( W \) is considered in differentiating where society can and cannot afford to risk damaged to the environment. Where there is opportunity for non-diligent behaviour to impact adversely on social welfare, no penalty can compensate society for this that doesn’t drive the company below profitability, so then lands are excluded from operability and protected as Category 3 lands (as introduced in Section 3), reserved in Category 2 lands, and/or heavily regulated as Category 1 lands. In Category 1 and 2 lands, penalties are required to provide incentive for due diligence in order to maximize social welfare. When the cost of being diligent approaches the cost of not being diligent, \( c_D \rightarrow c_N \), firms may not require economic incentives to comply with regulations (i.e. the argument for private managed forest lands or exclusive property rights that would mean firms “own” the damage they create and thereby compromise their own resource productivity in their losses).

6.4.1 Insights gained through the Model

In the model, if operational development is proposed on lands where the social profit is greater than the value of holding those lands in an undeveloped state, then regulation and enforcement will help to maximize social welfare in providing economic incentive for firms to be diligent (all Category 1 and Category 2) on those lands. On Category 1 lands, regulation and penalties would need to be minimal given that social welfare gains occur even in the instance of non-diligent behaviour. Krcmar, et al (2003) recommend some form of regulation on Category 1 lands to ensure critical values are maintained (i.e. hydro-riparian, or any resultant externalities to adjacent forest values). On Category 2 lands, regulation defines and requires diligence such that penalties are required and necessary to provide incentive for firms to adopt diligent behaviour. On Category 3 lands no operational activity is allowed (i.e. areas are protected as reserves) so the lands are set aside from broad-scale development and penalties are required at all times in order to preserve the higher values sensitive to broad-scale development, diligent or not. Arguably, some forms of operational development that minimize the affected land and resource base can provide for social welfare gains if regulatory requirements are met that ensure diligent behaviour and minimal environmental losses.
The relative level of penalty, government expenditure, firm-level expenditure on precautionary effort and the relative magnitude of environmental damage were all derived from the social welfare function. The factors eroding at the expected penalty, and therefore the relative effectiveness of that penalty in providing economic incentive to comply, are the likelihood of successful enforcement sanction and the perception in differences in relative environmental damage. The literature provided reasons for why penalties cannot be more than what would patently be expected to be reasonable.

The data from Compliance and Enforcement Branch provided little in the way of factors considered in each determination. Information provided the number of enforcement actions, the level of the penalty applied when sanction was successful, and the number of appeals when not. The finding that all of the enforcement actions that occurred under S. 45(1) were appealed describes a high value in licensees expending effort to not incur a penalty under that Section (expenditures exceeded the expected penalty), or that there is no incentive not to appeal with government incurring extra costs in reviewing and re-determining penalties. A review of the appeal rates and likely reductions in expected penalties would be an interesting analysis to determine if incentive to appeal exists inherently in the structure of the current system.

6.4.2 Findings in the Literature

Penalties do not need to be exceedingly high to provide incentive to comply with regulations. Often, just stating the regulatory requirements will ensure adoption as people comply because it is the morally right thing to do. Social norms, shareholder interests and expectations, access to markets for product and local, national and international reputation all add to the effectiveness of regulations and penalties in ensuring compliance. Other means of enforcement action, whether it be “coaching” through informal inspections, instructions or actual non-financial orders to comply with a record kept of contraventions, will assist in providing incentive to comply only if those strategies are backed up by very real and enforceable sanctions.

Viscusi (1983) outlines an important warning to governments proposing regulatory change, where uncertainty in the longevity of regulatory policies imposes additional opportunity losses as firms are discouraged from making irreversible investment
commitments. In short, regulatory uncertainty reduces output and expected opportunities for licensees whereby the ability of British Columbia to attract business activity to the province could be compromised. The regulations being considered under the new *Forest and Range Practices Act* need to be solid and economically efficient in the processes and standards they describe, and that the regulations need to be able to stand the test of time over successive political and market cycles to develop investor confidence over time.

If a firm has chosen the appropriate level of precaution, the penalty as described in Section 4 above would be zero to the firm and the no-fault increased level of environmental risk or damage is borne by government. Remediation is still required by the firm however, in the form of rehabilitating or restoring the area’s productivity or value, a function of the risk-sharing necessary to provide incentive for diligence when a government is incurring the costs of the environmental damage.

In current policy, there are no explicit guidelines for how to represent the nature and extent of environmental damage in guiding the district manager in their determinations. This approach, sensitive to the opportunity of fettering the statutory decision-maker, makes a vague and undefined reference to considering “the gravity and magnitude of the contravention” in their determination. Unfortunately the economic rent described by environmental and ecological services have not been adequately quantified to date, resulting in district managers relating their valuation to damage to the timber resource (Forest Practices Board, 2002) and not considering damage to environmental values. This is likely due to the lack of guidance and uncertainty in a definition of what actually constitutes “environmental damage” (is it irreversible or will the ecosystem recover naturally? is the disturbance consistent with what may naturally occur? what value of services does the marginal incremental loss of a small area impacted relative to the scale of ecosystem services provided in aggregate?) and in applying a market valuation to a non-market value in their determination.

Some chance of asymmetric information exists where companies have a better idea about the sensitivity of resources and the probability of environmental damage. If government has a higher perception of the likelihood of environmental damage than
firms, enforcement effort will likely exceed what firms would expect and seem economically unjustified. If government is lax in their enforcement activities relative to the actual risk to the environment, this is in effect a subsidy to the licensees as a lower expected penalty would result.

Licensees signal government their operational intent in their development plans and expert assessments as required by regulation, which are reviewed and approved by the government official responsible for monitoring the licensee’s forest practices. Compliance and enforcement activities ensure the real threat of penalties to provide incentive and serve to maximize social welfare by minimizing the social losses experienced in inordinate risk or actual environmental damage.

To provide certainty and consistency in forest management practices and statutory decision-maker decisions, an independent public watchdog in the form of the Forest Practices Board was formed in 1995 to conduct independent audits of determinations made under the Code to assist in correcting mistakes in the tax/subsidy of sanctions on non-complying licensees. The Board has identified many areas of concern in the current process, and serves to confirm or recommend for appeal determinations under their review. The Forest Appeals Commission then can confirm, vary, rescind, or send back for review the determination made by a statutory decision-maker.

The Board’s concerns over how penalties have not reflected the value of the actual environmental damage are likely founded, and could result from a number of factors identified in the investigations using the principal-agent model to observe the dynamics of the relationships between precautionary effort, penalties, enforcement effort and the implications to social welfare overall.

7.0 Conclusions

From the model developed in Section 4, the relationships describe the bounds of costs and benefits in a social welfare point of view on Category 1 and 2 lands, and result in the following conclusions:

1. penalties are necessarily greater than the difference in the cost of diligence relative to any increase in the probability of environmental damage, but less than the
value of profits that would be available to a licensee if they were diligent. In essence, penalties are “capped” so that diligent behaviour is rewarded;

2. the social welfare cost of a firm not being diligent is (much) greater than the negative social welfare impact that incorporates all other costs combined;

3. the social costs experienced when a firm is diligent are lesser than those experience when a firm is not diligent, exceeding them by the amount of the difference in both government enforcement costs and expected environmental and infrastructural damage;

4. the social costs of environmental and infrastructural damage are greater than the increased costs of diligence and enforcement effort relative to the increase in probable environmental damage; and

5. the level of effort for government to expend in ensuring diligence is necessarily more than the value of firm diligence minus the probable environmental damage and infrastructural losses. This describes that government expenditures on enforcement actions are necessarily greater than the cost to firms of diligence less the expected social welfare losses experienced through environmental damage.

The Forest Practices Board concludes in their report that statutory decision-makers need to more seriously consider environmental impacts when setting penalty amounts. They go on to say “the Crown should be compensated for destruction of all types of public resources, even those without traditional market value.” As discussed above, this recommendation would require that penalties could go beyond the participation constraint that limits the penalty to what a company can afford if diligent, and that any “excess” of environmental damage would need to be borne by the government. This makes sense in a way, as if government provides lands that could be damaged to beyond licensee profitability if fined, they should in effect be Category 3 lands and not Category 2 or 1. That risk government must bear in order to insure licensees are not operating where social welfare losses could exceed the gains of managing for timber extraction.
No consistent qualitative, nor any quantitative values for environmental damages were provided in the data from Compliance and Enforcement Branch. To compile this information, it would require personal visits and file reviews from 47 different geographic locations in the province. When summarized in aggregate though, the penalties are not large, and most would not even offset the costs of enforcement in inspecting, investigating, and administering the enforcement action. As shown in the model development though, government does not consider recuperating their costs when applying penalties. Note that the purpose of a compliance assurance system and process is not to recover costs, but to ensure the threat of sanctions is very real.

Penalties could be low due to government ensuring the participation constraint is recognized and binds the application of sanctions – in effect, they share an appropriate part of the risk of development. Penalties could also be low if government can be considered more risk averse and sets stumpage and penalties together, collecting stumpage that reflects the risk they bear relative to the risk to society. The literature supports that compliance is more effective if penalties are moderate in range and that firms are more likely to comply with non-financial cooperative strategies. Other social and psychological values and the moral structure of enforcement systems can effect compliance without penalties as described by Sutinen and Kuperan, 1999.

There are also opportunities to erode at the amount of any penalty if there is a difference in the perceived likelihood of environmental damage that cannot be quantitatively determined. If a licensee believes environmental damage is less likely than what government perceives, and government cannot prove otherwise, the benefit of the doubt falls to the licensee and the expected requirement for diligence would be lower, effecting a lower penalty.

Penalties are levied to provide economic incentive for an agent or firm to adopt diligent standards of operations, allowing for government to maximize social welfare by making available Category 2 lands for production. From the literature, a consistent social welfare and economic efficiency perspective outlines that penalties are inefficient when the marginal increase in the costs of diligence and enforcement exceed the marginal social benefits of increased enforcement activities or firm
diligence. Thus low penalties may be the result of marginal benefits of higher enforcement effort or diligence not being justified.

Optimal penalties that ensure firm participation are found to be necessarily less than firm profits and yet more than the difference in the cost of being diligent versus not-diligent, all relative to the increased probability of environmental damage. The literature outlines that penalties must compensate the land owner (the Crown in this case) for all externalities and do not consider the participation constraint. I argue that if harvesting is only conducted on Category 1 and 2 lands, then diligence ensures positive social welfare gains with the incentive of penalties that minimize marginal environmental losses. Operations are avoided on Category 3 lands as the social losses resulting from industrial activities do not maximize social welfare.

In reviewing the actual penalties levied under the Code in Section 5, it is striking to see that penalties on average are low enough as to question whether, on average, they consider the level of environmental damage and increased government sanction costs per equation (3.4). An average penalty of $3,626.08 for damage to the environment, with the majority of the penalties being $500, does not consider environmental damage in the penalty as it is negligence-based and considers only costs of diligence relative to increased risk of damage. To consider environmental damage in the penalty would require government to shift all the risk to licensees and apply strict liability. This is not likely practical given that government cannot guarantee no environmental damage if diligent, and therefore must bear some of the economic risk.

Category 1 and 2 lands are the focus of environmental interests, in that trying to redefine the lands that provide ecological value as Category 3 reserves requires government to shift their level of ecological value in reservation utility ($W$). If market prices do not reflect the costs of incurring precautionary effort to reflect the externalities associated with environmental impacts, government would then need to adopt a higher risk to the environment to ensure they allow competitive market access to B.C. timber. It's a fine balance between what industry can afford given their cost structure and world prices for lumber, and what level of environmental damage may be irreparable given the scope, magnitude and level of timber harvesting in the province.
Conversely, if government contemplates a low risk to the environment, this higher level of reserve would reduce harvesting activities by defining a smaller timber harvesting land base (described as the “THLB” in timber supply reviews conducted by the Chief Forester). If the THLB physically shrank from current operational viability, it would require higher market prices in order to provide equivalent economic rents to producers and government (i.e. government revenues would no longer be $4 billion per year unless market prices adjusted to reflect a higher level of precautionary effort).

When government enforcement success is considered in determining optimal penalties, expected penalties will necessarily be higher the lower is the likelihood of successful sanction. If government enforcement success is low, and expected penalties are low, then penalties are not likely providing incentive for compliance and that other non-financial strategies and market-based incentives are likely responsible for the high compliance rates described by the MOF (96% compliance in the 2000 C&E Annual Report).

I speculate that the clearer are the standards for forest practices, that a greater likelihood of successful sanction, a higher expected penalty, more incentive for compliance, and a more clear moral understanding of the performance expectation of licensees on Crown lands will result.
References


Clogg, J., Gage, A. and Haddock, M., *A Results-Based Forest and Range Practices Regime for British Columbia: Submission from West Coast Environmental Law*, June, 2002


Garoupa, N., *Optimal Magnitude and Probability of Fines*, Universitat Pompeu Fabra, April 2, 2000, 10 pages


Page, D. and O’Carroll, A., *Who’s minding our forests?*, © Sierra Legal Defence Fund (SLDF) and ForestWatch, May 2002


Raymond, M., *Enforcement leverage when penalties are restricted: a reconsideration under asymmetric information*, Journal of Public Economics, 73(2) 1 August 1999, pp. 289-295


Appendix A

Context with Principal-Agent Theory

The principal (government) negotiates a social contract with the agent (licensee) that provides incentives for the licensee to participate in the business of forest management, and ensures that the relative costs of low precautionary effort are more costly to the firm than a due diligent level of effort. Incentives, or external costs levied to a non-diligent agent are provided in the form of instructional orders, penalties, licence volume reduction and other types of sanction.

Varian (1997) provides a basic model for the principal to maximize social welfare through due diligence in

$$\max_{x, e, s} x(e_D) - s(x(e_D))$$

such that $s(x)$ is minimized (in the classic model of incentives, $s(x)$ is a payment function for the agent to maximize by incurring effort for the principal. In the context of this thesis however, $s(x)$ is a penalty function to be minimized. Given that lower penalties infer that lower levels of environmental damage or risk are occurring, firms are in compliance, there is a perception of good forest practices, and administrative sanction costs are minimized, it is in government’s and licensee’s best interest to keep penalties low.

To provide incentive for agents to adopt precautionary effort, the level of penalty function given the output resulting from non-diligent activity, $x(e_N)$, considers a penalty that takes away the difference in profit resulting from non-compliance, or $x(e_D) - x(e_N) = \rho$, where the penalty ($\rho$) is levied to a maximum leaving the agent as the residual claimant on the remaining surplus over and above any sanction amount.

The participation constraint listed above provides that a licensee will receive at least business incentive to operate. In the case of non-diligence, as described, penalties must

---

28 as listed in the Administrative Remedies Regulation under the Forest Practices Code of BC Act, 1997
be greater than the gains where \( \rho > x(e_N) \) such that the incentive constraint binds operational activities. Operational incentives require that government adequately describe the expectation of due diligence effort required of the agent, and ensure that the level of penalty adequately compensates the Crown for damages (or undue risk).

**Hidden Action – Monopoly Solution**

Government (the monopolist) sets up an incentive program for multiple agents with unobservable actions. In setting up the model, there are several assumptions that need introduction.

**Assumptions**

- there are a finite number of output levels \((x_1, x_2, \ldots, x_n)\)
- an agent (licensee) can choose only one of two actions, \(e_N\) or \(e_D\), which influence the probability of occurrence of various outputs, i.e.
  - \(\pi_N\) is the probability output \(x_i\) is observed if agent chooses action \(e_N\)
  - \(\pi_D\) is the probability output \(x_i\) is observed if agent chooses action \(e_D\)
- \(s_i = s(x_i)\) is the penalty to the agent if \(x_i\) is observed, where the penalty will equal zero (0) in the case of due diligence.
- the agent is risk-averse, seeks to maximize their von Neumann-Morgenstern utility function (linear in probabilities, with the mathematical expectation of a real function on a set of outcomes) of the penalty \(u(s_i)\), and the cost of the action \(c_N\) enters into the utility function. Hence the agent will choose action ‘\(e_D\)’ if
  \[
  \sum_{i=1}^{n} u(s_i)\pi_{iD} - c_D \geq \sum_{i=1}^{n} u(s_i)\pi_{iN} - c_N
  \]
  incentive constraint (4.1)

  and will choose action ‘\(e_N\)’ otherwise, and that
  \[
  \sum_{i=1}^{n} u(s_i)\pi_{iD} - c_D \geq \bar{u}.
  \]
  participation constraint (4.2)

If an agent’s action is perfectly observable, penalties would be based on action \(s(e_N)\) rather than on output \(s(x(e_N))\). The principal would then be able to determine the expected profit for each possible action by the agent, then would levy the appropriate penalty that would minimize social welfare losses if environmental damage occurs.
Unfortunately, government cannot perfectly observe a licensee’s precautionary effort, such that road construction and maintenance, inventory and assessments, valuation, timber harvesting, transportation, regeneration and deactivation all occur without government involvement. Agent action is not perfectly observable, meaning the principal provides incentives in the way of inspections and penalties based on the agent’s output and risk category.

According to Varian, the optimal incentive scheme will involve risk-sharing between the principal and the agent, wherein if the principal were not to impose any penalties for environmental damage, there would be no incentive for licensees to incur precautionary effort. In context, this would mean the principal would fully insure the agent from any risk of loss due to their activities. Clearly government applies penalties, however it will be discussed later in the thesis how strategies are not efficient at providing incentive to comply with regulatory standards.

With the credible threat of penalty, licensees run the risk of compensating the principal for any environmental damage caused by their operational activities. The principal would prefer to impose low penalties, however there are times when government cannot tell if any resultant environmental damage is due to low effort or just plain bad luck. Government then conducts investigations to collect as much information toward determining the level of diligence the agent. If penalties were levied based on the strict liability of any damage being the responsibility of the licensee, those times where bad luck or uncertainty would impose too much risk on the agent and fines would need to be lower to compensate.

So what would be the optimal penalty be, given the risk of loss of social welfare resulting from environmental damage, that would adequately compensate the Crown while ensuring licensees have incentive to participate and adopt precautionary effort?

**Optimal Incentive Scheme**

Government is welfare maximizing, where the principal’s problem can be expressed as
\[ W_D = \max_{\tau_D} \sum_{i=1}^{n} (x_i + s_i) \tau_D \] subject to constraints (4.1) and (4.2)

which is a linear function with curvilinear constraints. In order to solve for the optimal incentive scheme, it will be easier to set the model as a curvilinear objective function by defining \( f \) as the inverse utility function \( s_i = f(u_i) \) with linear incentive and participation constraints. This function expresses the relationship that defines how much of a penalty the principal will levy to provide utility \( u_i \) to the agent, a decreasing concave function.

The magnitude of the penalty is a function of the agent’s utility as penalty must ensure participation (by providing for at least the agent’s reservation utility, \( \bar{u} \)) and affects the profitability of the agent in requiring precautionary effort (\( e_D \), a dis-utility given it is greater than \( e_N \)). The above model can be written as

\[ W_D = \max_{\tau_D} \sum_{i=1}^{n} (x_i + f(u_i)) \tau_D \] (5)

subject to

\[ \sum_{i=1}^{n} u(s_i) \tau_D - c_D \geq \bar{u} \] (5.1)

and

\[ \sum_{i=1}^{n} u(s_i) \tau_D - c_D \geq \sum_{i=1}^{n} u(s_i) \tau_D - c_N \] (5.2)

The problem then can be analyzed as two states of the world where \( n = 2 \) (where state 1 is the undesired state of non-diligence (environmental damage occurs) and state 2 is the desired or diligent precautionary effort state. The agent has one of two utility levels, \( u_1(u(x_1)) \) and \( u_2(u(x_2)) \). In probabilities, by definition the likelihood of state 2 occurring when a licensee is diligent is greater than when not being diligent, or \( \pi_{2D} > \pi_{2N} \). Conversely, the probability of state 1 occurring is more likely under non-diligence than under diligence or \( \pi_{1N} > \pi_{1D} \). Most importantly for later, the result is that efficiency ratios can be derived as \( \pi_{1N}/\pi_{1D} > 1 \) and \( \pi_{2N}/\pi_{2D} < 1 \).

Expanding equation (5.2) above and setting them equal as the point where the agent is indifferent between choosing action ‘\( e_D \)’ or ‘\( e_N \),

\[ u_1 \tau_{1D} + u_2 \tau_{2D} - c_D = u_1 \tau_{1N} + u_2 \tau_{2N} - c_N \]

and solving for \( u_2 \).
\[ u_2 = u_1 + \left[ \frac{c_D - c_N}{\pi_{2D} - \pi_{2N}} \right] \]  

(5.2.1)

means that the penalty that would provide incentive to a licensee to adopt precautionary effort to ensure state 2 would be more likely to occur would be

\[ \bar{\rho} = \left[ \frac{c_D - c_N}{\pi_{2D} - \pi_{2N}} \right] \]

(5.2.2)

as a function of the difference in expected cost of being diligent and not being diligent, relative to the difference in probability of no environmental damage occurring between being diligent and not being diligent.

As a hypothetical example, say a sanction is applied against a licensee under Section 45(1) of the Code. The maximum fine for not complying with the section is $50,000. In the investigation, the statutory decision-maker is made aware that the licensee did conduct the necessary terrain stability assessment and operational plans to minimize environmental damage, but failed to follow through on properly implementing the plan (a $20,000 maximum penalty). No environmental damage occurred, but there was a resultant estimated 95% \( (\pi_{2N}) \) risk of a landslide occurring (where \( \pi_{2N} = 0.05 \)). If the licensee had followed through and constructed the road consistent with the plan, there may have been less than a 7% probability \( (\pi_{2D} = 0.93) \) of a landslide occurring and the licensee would have spent $7,000 more on road construction. In this overly-simplistic example, a district manager would consider \( \left( \frac{22,000 - 15,000}{0.93 - 0.05} \right) \), or $7,954 as the appropriate penalty. As we will see later in this thesis, there is latitude in the application of the full amount of that penalty, and given the maximum penalty there are issues with determining the appropriate penalty when \( \pi_{2D} - \pi_{2N} \) is small.

In Varian, figure x below describes the relationship of participation and incentive constraints in the model. With respect to the Code, the participation constraint ensures that firms will have profit incentive to conduct operational forest management activities, the incentive constraint ensures that a firm will adopt a precautionary
approach to managing public forests, and that the penalty amount ensures licensees get
the same or less level of utility (profit) if they are not diligent.

\[ W_D = W_N + \left[ \frac{c_D - c_N}{\pi_N - \pi_D} \right] \]

When a firm is not diligent, they increase their utility at social welfare expense
It's not the cost savings that matter, but the relative gains made at environmental expense.
Big gains at marginal increase in environmental risk require big penalties to provide incentive to comply... is there a proportionality rule?

based on Varian, 1995

Figure 5 Graph of principal’s problem with agent’s indifference curves

Also of note in the figure, as the diligent state is higher effort, in the \( N \)-indifference curve \( u_2 > u_1 \) to ensure the indifference between \( u_2 \) and \( u_1 \). On the \( D \)-indifference curve, the diligent state is still higher effort but the penalty ensures that \( u_2 = u_1 \). In a perfectly competitive market, where the reservation utility \( \to 0 \) such that there will be no incentive for firms to enter the market and the equilibrium will occur where the participation and incentive constraints are equivalent and the maximum penalty will equal that represented by equation (5.2.2).
The statutory decision maker, under the Code, conducts a determination based on the evidence confirming reasonable and responsible precautionary effort. When \( u_2 > u_1 \) the incentive constraint lies above the \( 45^\circ \) line and government must risk-share to provide incentive for the licensee to incur precautionary effort.

As a result of this interpretation,
\[
\begin{align*}
  c_D > c_N & \text{ when } u_2 > u_1 & \text{ penalty} & > 0 \\
  c_D = c_N & \text{ when } u_2 = u_1 & \text{ penalty} & = 0 \\
  c_D < c_N & \text{ when } u_2 < u_1 & \text{ no penalty or incentive required}
\end{align*}
\]

**Optimal Solution**

To determine the optimal incentive scheme algebraically, set up the Lagrangian as
\[
L = \sum_{i=1}^{2}(x_i + s_i)\pi_{id} - \lambda \left[ c_D - \bar{u} - \sum_{i=1}^{2}u_i(s_i)\pi_{id} \right] - \mu \left[ c_D - c_N - \sum_{i=1}^{2}u(s_i)(\pi_{id} - \pi_{in}) \right]
\]
\[
\frac{\partial L}{\partial s_i} = -\pi_{id} + \lambda u_i'(s_i)\pi_{id} + \mu(u(s_i))(\pi_{id} - \pi_{in}) = 0
\]
\[
-1 + \lambda u_i'(s_i) + \mu u_i(s_i) = 0
\]
\[
\frac{1}{u'(s_1)} = \lambda + \mu \left[ 1 - \frac{\pi_{in}}{\pi_{id}} \right]
\]
\[
\frac{1}{u'(s_2)} = \lambda + \mu \left[ 1 - \frac{\pi_{2n}}{\pi_{2D}} \right]
\]

as \( \pi_{in}/\pi_{id} > 1 \) and \( \pi_{2n}/\pi_{2D} < 1 \) as defined above, \( \frac{1}{u'(s_2)} > \frac{1}{u'(s_1)} \) implies that \( s_1 > s_2 \) and that the change in an agent’s utility under state 1 when environmental damage occurs is greater than under state 2 when it hasn’t. This is consistent with the principal recognizing that in state 2, because of unobservable action, any non-compliance could be a result of bad luck rather than lack of precautionary effort.

In reviewing \( \frac{\partial L}{\partial s_2} \), \( \frac{1}{u'(s_2)} = \lambda + \mu \left[ 1 - \frac{\pi_{2n}}{\pi_{2D}} \right] \) is positive, so any increase in \( s_2 \) will increase the principal’s utility as no environmental damage occurs. This can be considered as mitigating inappropriate risk, but is necessarily constrained by the

87
participation constraint of the model protecting the agent from the principal collecting an economically inefficient amount of penalty. This means there must be a functional maximum penalty to provide certainty for firms operating on public lands ensuring government shares some of the risk.

Is a carrot or a stick more efficient?

By the envelope theorem, the derivative of the principal’s optimized value function ‘with respect to’ (wrt) the parameter in question is just equal to the derivative of the Lagrangian function wrt the same parameter. In examining the resultant derivatives when looking at how the principal’s utility changes wrt the agent’s costs of precautionary effort

$$\frac{\partial L}{\partial c_N} = \mu$$

is necessarily > 0,

otherwise the incentive constraint would be unnecessary and the principal would fully insure as $$u_1 \geq u_2$$, and $$\pi_{D_D} > \pi_{S_N}$$ and $$c_D > c_N$$ by definition. Therefore any increase in precautionary costs when a licensee is non-diligent will directly increase social welfare by a factor of $$\mu$$. Conversely, any increase in an agent’s costs over an above due diligence, as shown by

$$\frac{\partial L}{\partial c_D} = -(\lambda + \mu)$$

which is < 0 given the negative sign,

would have a negative effect on social welfare, meaning it would be economically inefficient and inappropriate to penalize a licensee beyond compensation of welfare losses. Or, if a licensee is diligent and incurs a penalty for operational activities, it is a welfare loss as risk that should have been allocated to government has been off-loaded to the licensee. It was proposed during the Code consultation process (Hoberg, 2002) that a deterrent penalty component be considered on top of compensation and remediation costs to the Crown. By this model, anything greater than the maximum would be greater than the expectation of diligent behaviour set by the principal by the participation constraint and would therefore be economically inefficient.

Appropriate penalty
As introduced above in equation (5.2.2), the optimal penalty to motivate a licensee to incur precautionary costs can be considered to be

\[ \rho = \left[ \frac{c_D - c_N}{\pi_{2D} - \pi_{2N}} \right] \]  

(5.2.2)

In the example provided there is a marked difference between \( \pi_{2D} \) and \( \pi_{2N} \). If the difference in \( \pi_{2D} \) and \( \pi_{2N} \) was much less, say 0.05, there would have to be a $140,000 expected penalty to economically motivate a licensee to incur precautionary costs and mitigate the risk of causing environmental damage. The maximum penalty of $50,000 therefore sets an expectation that any difference less than 14% between \( \pi_{2D} \) and \( \pi_{2N} \) would make it untenable to apply a penalty. Of note, it would also likely be very difficult, in terrain stability issues at least, to differentiate between that level of probability.

In fact, this model could be used in trying to determine the appropriate maximum penalty to apply given the expected difference between precautionary and non-diligent operating costs, relative to the expected differential between the probability of state 2 occurring whether a licensee is diligent or not. C&E officers and statutory decision-makers could use this to inform choices in applying sanctions where inspection could evaluate whether the lack of diligence caused an increase in likelihood of greater than 14% on a $7,000 difference in precautionary effort. If it didn’t, the uncertainty in causal factors is likely too high to successfully apply a sanction that will stand up to an appeal.