FOREST ECONOMICS

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UBCPress · Vancouver · Toronto

Contents

Figures and Tables

FIGURES

TABLES

Foreword

For more than 30 years I have taught forest economics to undergraduate and graduate students and to financially sophisticated investors. The latter know much about economics and are interested in forestry but are trying to connect the two. This new textbook will serve these groups well.

Economics is the study of the optimal allocation of resources to achieve society's aims. It has a prescriptive element: how should actors behave if they wish to achieve certain objectives? It also has a normative element: how will key economic factors such as timber prices, harvest levels, and standing inventories evolve if variously incentivized actors (individuals, businesses, governments) interact while seeking to optimize their own positions? This book covers both elements.

While technically a new edition of Peter H. Pearse's classic text, *Forest Economics* is so thorough, comprehensive, and modern a revision that it is really an entirely new book that draws on the individual strengths and collaborations of two of the field's leading practitioners. Pearse has contributed widely to forest policy and natural resource management in Canada, and his seminal paper "The optimum forestry rotation" in *The Forestry Chronicle* has informed many students about the significance of this problem. Because of the large standing inventory of timber in relation to annual harvest, forestry is perhaps the most capital-intensive activity found in a modern economy. The optimal use of that capital has played a seminal role in forest economics for centuries. This book includes the original Pearse formulation and extends it to cover the various elaborations developed in the literature since then. Daowei Zhang's capable analysis of forest sector markets and policy (as exemplified in his book on North American lumber markets, *The Softwood Lumber War:*

Politics, Economics, and the Long US-Canada Trade Dispute) provides a strong normative dimension. Zhang and Pearse have already published together on the impact of forest tenure arrangements on management outcomes, and this important topic is thoughtfully covered in this book.

Both authors have taught forest economics for many years. This book reflects the collected wisdom of that experience. It also includes material drawn from my own courses, which Zhang assisted in presenting at the University of British Columbia. Those who teach forest economics will find this textbook to be a straightforward guide for a semester-long course – there are 13 chapters in the book, a number that does not seem accidental!

Students of forest economics will benefit from the analysis, which links economic principles with both private and public forestry decision making, including resource allocation over time and space, forest sector markets and market intervention (including international trade), valuing unmarketed ecosystem services, and forest taxation. The book extends the traditional discrete-time analysis to the more modern and analytically rigorous continuous-time formulations. The discussion of policy issues (such as the impact of sustained-yield regulation and environmental protection rules, the effect of governmental incentive programs on silvicultural investment, the consequences of alternative forest tenure arrangements, and the role of forestry in economic development) usefully includes contemporary theoretical analysis that is backed up by existing empirical evidence.

Forests in their totality accommodate a wide variety of uses. For billions of us, they are the backdrop to everyday life. Millions of Aboriginal people call forests home. They help regulate key global biogeochemical cycles. Where human interference is absent, or nearly so, they provide important spiritual, ecological, and cultural values. Wood from forests is also one of the most important sources of raw materials and energy in the world today. Sustainable forestry demands that we respect all of these values, and the study of forest economics provides key insights into how forests can be best used and managed. This book provides the tools to begin that task.

Clark S. Binkley
Cambridge, Massachusetts

Preface

This textbook is a thorough revision and expansion of *Introduction to Forestry Economics* by Peter H. Pearse, published in 1990. It is written for undergraduate forestry students taking courses in forest economics and for graduate students with diverse academic backgrounds who are interested in forest management and policy.

This book reflects the two authors' more than 50 years of combined experience in teaching undergraduate and graduate courses in forest economics in the United States and Canada. It differs from the earlier book in its additional and updated content and its more advanced, empirical presentation of materials. Yet the emphasis is still on basic economic concepts, principles, and constructs used to analyze key features of private and public forestry decision making.

Forestry, as we see it, is the applied science of managing land and trees to advance social objectives, which may relate to the production of industrial timber, recreation, or a variety of other goods and services of value to people. Economics is concerned with choices about how resources are allocated and used to create things of value to people. Having begun careers as foresters and later turned to economics, we have found that the two areas of study converge and complement each other. Forestry involves using land, labour, and capital to produce goods and services from forests, while economics helps in understanding how this can be done in ways that will best meet the needs of people.

Moreover, it is increasingly apparent that we cannot isolate forestry from the economic forces that drive other activities. The growing intensity and variety of demands on forests for recreational, aesthetic, and environmental benefits as well as for timber give rise to complicated

problems that involve choosing among a wide range of human wants and needs – precisely the subject of economics. And as forestry in North America and elsewhere becomes increasingly concerned with husbanding and managing forests rather than simply harvesting them, it competes directly with investment needs for other social purposes. Forestry must therefore be understood in its full economic context, and this context can provide a unifying framework for analyzing forestry problems.

Nevertheless, those of us who have taught undergraduate courses in economics for forestry students are often frustrated by the limited reference materials available. Further, there is no introductory forest economics textbook suitable for a graduate-level course, a complaint often heard from both instructors and graduate students.

Thus we have produced a textbook that will help forestry students understand the economic implications of the work they will do as professional foresters, and will also help graduate students become forest economists. Whatever undergraduate students learn in one course in forest economics will have to last most of them for many years, while graduate students need more advanced materials. In writing this book, therefore, we have made an effort not only to distill the subject down to the fundamentals – the basic economic principles of forestry and how they bear on forest management and policy decisions – but also to cover more advanced theoretical and empirical issues of forest economics.

Most students of forest economics have already taken a course in economic principles, and those who have not should be referred to suitable references. This book therefore begins with and builds on the general principles of economics, and elaborates on the particular concepts relevant to forest management.

Thus the preparation of this book has been in large part a process of winnowing through economic doctrine on the one hand and forestry problems on the other, in order to focus on the basic connections between the two. Preparation of a textbook that meets the needs of both undergraduate and graduate students is a challenge, however, and runs the risk of satisfying neither. We must rely on instructors to guide students with varying capabilities towards suitable applications, practical problems, and further readings, some of which are suggested at the end of each chapter. We also rely on instructors using this book for an undergraduate course to identify which materials should be excluded, and those using it for a graduate course to provide additional materials and examples.

We will be content if undergraduate students completing their forest economics course thoroughly understand a few fundamental concepts of economic theory and their relevance to forestry, such as economic efficiency, markets, opportunity cost, incentives, marginal analysis, valuation over time and valuation of non-market goods, optimal rotation age, management intensity, and the implications of property rights, taxes, and international trade. Much of this book deals with the application of these concepts to problems of forestry, and we will be satisfied if graduate students completing their forest economics course understand and gain additional insights into the forest sector, its markets and relevant government functions, and their special challenges for economic analysis.

The book is divided into five parts. Part 1 consists of three chapters. Chapter 1 begins by gathering the threads of economics as they apply to forestry, sketches the scope of the subject, and introduces the issues addressed in the rest of the book. Chapter 2 reviews intermediate microeconomics in the forestry context, and covers important economic concepts and principles, such as economic efficiency, production theory, market failures, and policy failures. Chapter 3 turns to forest investment analysis, which may be seen as an introduction to finance as applied to forestry. This chapter covers the important principles of valuation over time and techniques for assessing forest investments, which are applied to specific problems in subsequent chapters.

Part 2, "The Forest Sector," also has three chapters. Chapter 4 covers market goods in the forest sector, notably timber, and the supply of and demand for these goods. Chapter 5 introduces the variety of non-market goods and services produced through forestry and shows how their values can be assessed. Chapter 6 discusses land allocation among various uses and values.

Part 3 is called "Economics of Forest Management." Chapter 7 deals with the optimal forest rotation age; Chapter 8 considers the regulation of harvests over time; and Chapter 9 presents the temporal dynamics of the forest sector and silvicultural investment.

Part 4, "Economics of Forest Policy," focuses on two of the most important policy issues – property rights and taxation – with a chapter devoted to each. Finally, Part 5 examines some international forestry issues, including trade in forest products and the impact of global forest resources on economic development and the environment.

Forestry involves measurement, but the forestry measurement units used in North America and elsewhere vary considerably. Because

foresters and forest economists should be accustomed to working with numbers, in this book we have deliberately used various, often local measurement units in our examples. Students are encouraged to examine the conversion factors listed before Part 1 and to make their own conversions and comparisons.

In preparing this updated book, we have benefited from advice and suggestions from many colleagues, including David N. Laband, Robert Tufts, Yaoqi Zhang, Shaun Tanger, and Gloria M. Umali-Maceina of Auburn University, Michael G. Jacobson of Pennsylvania State University, Janaki Alavalapati of the Virginia Polytechnic Institute and State University (Virginia Tech), Joseph S. Chang of Louisiana State University, Tamara Cushing of Clemson University, and Gary G. Bull and Anthony Scott of the University of British Columbia. Three anonymous reviewers of an early draft were particularly insightful and helpful, so we sought, and received from UBC Press and the reviewers themselves, permission to identify them and acknowledge their contributions. They are Claire A. Montgomery of Oregon State University, Harry Nelson of the University of British Columbia, and Van A. Lantz of the University of New Brunswick.

We must also record our appreciation of the helpful comments we received from William F. Hyde when we began this project, and our thanks to Clark Binkley for contributing the Foreword to the finished product.

Support from our families and the School of Forestry and Wildlife Sciences of Auburn University made this project manageable. Last but not least, we would like to acknowledge the continuing stimulus of our students over many years, which has honed our appreciation of how economics can help to elucidate the challenges of managing forests.

Daowei Zhang
Peter H. Pearse

CONVERSION FACTORS

Length
1 inch = 2.54 centimetres
1 foot = 12 inches = 0.3048 metres
1 mile = 5,280 feet = 1,609.3 metres
1 chain = 66 feet

Area
1 square foot = 0.0929 square metres
1 acre = 43,560 square feet = 0.4047 hectares
1 acre = 10 square chains

Volume
1 cubic foot = 0.028317 cubic metres
1 cubic metre = 35.313378 cubic feet

Weight
1 pound = 0.4536 kilograms
1 short ton = 907.1848 kilograms = 0.90718 metric tons = 2,000 pounds
1 long ton = 1,016 kilograms = 1.016 metric tons = 2,240 pounds

Selected Forest Products
1 cord (80 cubic feet) = 2.27 cubic metres*
1 board foot (logs) = 0.00453 cubic metres**
1 board foot (hardwood lumber) = 0.00236 cubic metres
1 board foot (softwood lumber in US) = 0.00170 cubic metres***
1 board foot (lumber exports and imports) = 0.00236 cubic metres
1,000 square feet (¼ inch panels) = 0.590 cubic metres
1,000 square feet (⅜ inch panels) = 0.885 cubic metres
1,000 square feet (½ inch panels) = 1.180 cubic metres

* A cord is a stack of wood 8 feet long, 4 feet wide, and 4 feet tall (or 128 cubic feet). On average, a cord contains about 80 cubic feet of wood, but a cord of southern pine timber contains 72 cubic feet of wood. Thus, species and log sizes affect the amount of wood in a cord and its conversion factor to cubic metres.

** A board foot is a piece of wood 1 foot × 1 foot × 1 inch, squared in all three dimensions. Because logs are circular and tapered, the quantity of wood they con-

tain is measured more precisely in cubic metres (or tons). Thus, the conversion factor between board feet and cubic metres varies considerably for different species and log sizes.

*** Softwood lumber produced and consumed in the US is measured in nominal, not actual, terms. For example, in the United States, 2 × 4 softwood lumber (historically 2 inches × 4 inches in cross section) is actually 1.5 inches × 3.5 inches, which is why this conversion factor differs from that used in international trade.

PART 1

Markets, Government, and Forest Investment Analysis

Chapter 1 Forestry's Economic Perspective

Forestry calls on a variety of skills and disciplines of study. Foresters must combine knowledge drawn from biology and other natural sciences, applied sciences, and social sciences such as economics. Each discipline brings a different set of tools and methods to the task of managing forests. This book deals with forestry from an economic perspective.

This chapter begins with the economic perspective of valuing forest resources and presents some context for studying forest economics. Those who decide how forests are managed and used must take careful account of the economic and social environment in which they operate, so we review the basic structure of market economies, introduce ideas about society's fundamental economic goals, and sketch the role of governments and private producers. We also explain the scope and substance of forest economics and illustrate how forest economics can help us understand and enhance social values. Finally, we outline a framework for policy development and decision making and indicate where economic analysis fits in.

FORESTRY FROM AN ECONOMIC VIEWPOINT

Forests are *economic* resources because we can use them to help produce goods and services that people want to consume. This is the definition of economic resources (or "factors of production," as they are called in economics textbooks) – things in limited supply that can be combined with other things to produce products and services that consumers want. Thus, we can make use of a forest, combined with some labour and other inputs, to help produce consumer products such as housing, newspapers, fuel wood, outdoor recreation, and environmental services.

It is this usefulness of forests that makes them valuable economic resources. The more value in final goods and services that can be generated from a tract of forest, the more valuable is the forest itself.

Usually there is more than one way in which a forest can be used, and someone must choose from among them. The timber might be harvested and used for making lumber, paper, or fuel wood. It might be kept standing, to support recreational or aesthetic values or environmental services, or it might be saved for industrial use by future generations. Often, a forest can generate two or more kinds of benefits simultaneously or sequentially – such as industrial timber, recreation, livestock forage, wildlife habitat, flood control, and carbon storage – in which case, someone must choose the preferred combination and pattern of uses. In all cases, choices must be made about how a forest will be managed, what goods and services will be produced, how much will be invested in enhancing growth or conservation, and so on.

Economics is the study of such choices, specifically the choices that determine how scarce factors of production are allocated among their alternative possible uses to produce useful goods and services. In other words, it is a science of decision making or the study of how individuals, firms, and societies decide how scarce resources are used.

To illustrate how economics can help individuals make decisions, take the example of college students. Students go to college with one or a few objectives, such as having a good education and getting a good job. On a daily basis, all students have a limited or scarce resource – time. How to allocate time every day is critical to whether students can achieve their goals. Each day, students have several things to do: study, work, engage in sports, relax (for example, by watching TV), and socialize. The economic principle that guides them in allocating their time is that the marginal utility (satisfaction) of allocating the last unit of time to each activity should be equal. In this way, the students get maximum possible utility (satisfaction). Doing this consistently is likely to make them succeed in college. These last few sentences demonstrate the efficiency rule that is developed later.

Forest economics deals more narrowly with choices about how forests are managed and used; how other factors of production, such as labour and capital, are used in forest production, utilization, and conservation; and what and how much forest products are produced and marketed. Forest economics applies the discipline of economics to decision making in forestry and covers the whole forest sector.

Forest economics can be approached from several directions, so it is important to specify at the outset the viewpoint taken in this book and

some general assumptions underlying the discussion that follows. First, the focus of attention here is the forestland, the timber, and other goods and services produced directly from forests – the economics of forest resource management. We also deal briefly, however, with the manufacturing and marketing of secondary forest products, such as lumber, plywood, and paper, because the demand for primary forest products such as timber is driven by the value of these secondary products.

Second, our judgments about economic performance are made from the viewpoint of society rather than that of individual forest owners or producers. The criterion we adopt for assessing the economic advantage of one activity over another is a comparison of the net gain, the surplus of benefits over costs, that accrues to society as a whole, taking into account relevant concerns about the distribution of the benefits and costs. This is important because the economic interests of individual entrepreneurs, landowners, workers, or forest users often diverge from that of society collectively. In this respect, this book differs from texts that take a business management approach and analyze problems from the narrower viewpoint of producers or forest owners.

Third, we shall assume throughout that the broad purpose of forest management and the production of forest products is to generate the maximum net gain, or value to society. This assumption is important because much of the literature on forest management assumes, or at least implies, different objectives, such as production of the maximum possible quantity of wood, maximum profits to producers, or stability of harvest rates. Such different objectives have an important place in forestry traditions and, as we shall see, have profoundly influenced forest policies around the world. It is important to recognize, however, that narrower objectives such as these inevitably conflict, to a greater or lesser extent, with the goal of maximizing the forest's economic contribution to society as a whole.

The value that a forest generates for a society can take a variety of forms. Some of these, such as industrial timber, are ordinarily marketed and their value is reflected in their market prices. Others, such as aesthetic benefits and some forms of recreation, are usually provided free, so there is no market indicator of their value. Moreover, while the market values of products like timber are critical to a private company, many non-market benefits of forests are also important to private landowners as well as the public. For example, for many small private forest landowners in North America and Europe, the non-market recreational values of their lands are the primary motivation for owning the land and timber values are secondary. Indeed, a complex range of market and

non-market values is a common aspect of forestry almost everywhere in the world. In the forested areas of developed countries, in regions such as British Columbia, Oregon, and Washington, the important values for most landowners may be timber and recreation. In developing countries like India and Nepal, the important values may be construction timber and poles, fruit, and fuel wood; the first two are usually sold in markets, while the latter two are often unmarketed and consumed in homes.

The important point is that in assuming the viewpoint of society as a whole, we must take unbiased account of the full range of social benefits, whether they are priced or not. Even for most private landowners, we must account for a range of both priced and unpriced benefits from forests. Much of our attention in this book will therefore focus on the problems of evaluating environmental and other non-market benefits, trade-offs among uses, and multiple use.

Forest values are classified into two main categories in Figure 1.1. One of these is *extractive values,* which involve physically harvesting and removing resources for use outside the forest; these include not only the familiar timber, poles, and fuel wood but also minor products such as mushrooms, fruit, nuts, livestock fodder, and game. The other main category is *non-extractive values,* which are realized without extracting resources from the forest, and are further divided into two subcategories: *ecosystem services,* such a soil and water protection, biodiversity, and climate modulation; and *preservation values,* which refers to the value that people place on preserving forests in their present state. Recreational or cultural uses of forests can have extractive value (such as hunting and fishing), non-extractive value (such as birdwatching and hiking for relaxation and spiritual renewal), or both.

Although not explained in detail in Figure 1.1, it is useful to distinguish three types of preservation values: *existence value, option value,* and *bequest value.* Existence value is the value that people place on preserving forests from human disturbance for the continuing benefit of future generations; this is the value most often associated with protecting environmentally sensitive forests in their natural state as a park or some other secure form of protection. Option value is the value that forest owners or others may gain from preserving a forest in the present to maintain the option of harvesting it in the future. Bequest value is the value that people derive from bequeathing forests in their present form to future generations. The boundaries between these categories are often unclear and inevitably overlap.

Scholars and others use terms like "ecosystem services" and "preservation values" in various ways. The most broadly encompassing definition

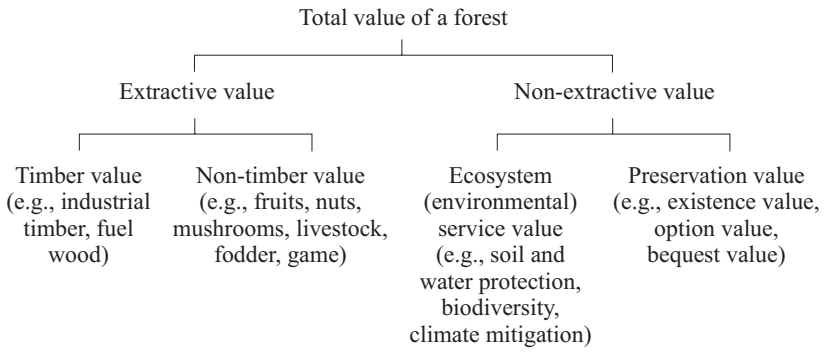

Figure 1.1 A forest's economic value.

of ecosystem services is that of the United Nations 2004 Millennium Ecosystem Assessment, which embraces all benefits that humans receive from managed and natural ecosystems – that is, all the values listed in Figure 1.1. For our purposes, however, it is useful to distinguish these values to draw attention to the different challenges they present for measurement and for making trade-offs among them in forest management decision making.

As a final observation on the values derived from forests, it is worth noting that some biologists and philosophers argue that forests have intrinsic value independent of their instrumental value or usefulness to human beings, and so an economic valuation is too anthropocentric to capture their full value. Human values are undoubtedly influenced by ethical and moral norms, however, especially as these apply to nature, and whether there are values beyond this – or a practical method of measuring them – is unclear. In any event, this book focuses on the economic value of forests, defined broadly to include all their identifiable priced and unpriced values, to guide forest management decisions.

BASIC ECONOMIC QUESTIONS

An economy consists of production, consumption, investment, and other activities linked by a huge number and variety of transactions taking place continuously. The bewildering detail and complexity of an economy can, however, be visualized in terms of a few straightforward processes.

On the one hand, the society being served by the economy has certain wants. People *want* goods like food, houses, and television sets, and services like medical care and recreation. Their welfare or standard of living is measured by the extent to which these wants are met: the more

people's wants are satisfied, the better off they are and, since no society has ever been known to be fully satisfied, welfare is always a matter of degree. It is important to note that people's wants extend beyond strictly private desires to collective or public concerns about economic security, equity, and freedom.

On the other hand, any society has a limited capacity to produce the goods and services that will satisfy these wants. The wherewithal to produce these consists of natural resources (or natural capital); human-made capital such as machines, roads, and other infrastructure; labour; and technical knowledge. All of these change over time, but at any point in time they are finite.

The function of the economic process is to determine how these limited resources are used to satisfy some of the unlimited human wants. Thus, economics is the study of how scarce resources are allocated among competing uses.

Every society must deal with three fundamental economic questions. Given its limited endowment of productive resources and the unlimited wants that they must serve, a society must somehow make decisions about:

- *which goods and services,* of the almost infinite variety that it is technically possible to produce with these resources, will actually get produced, and in what quantities
- *which* of the variety of technically possible *ways of producing* each good and service will be adopted in each case
- *how* the goods and services produced will be *distributed* among members of the society.

These basic questions are answered in every economy, but in different ways. Primitive, subsistence societies rely heavily on custom and tradition to make decisions about what to produce, and how. Socialist systems rely primarily on central planning and governmental direction. The capitalist system depends on market forces generated by the independent actions of individual producers, consumers, and owners of productive resources. A mixed capitalist system utilizes market forces as well as government intervention. Nowadays, pure socialist and pure capitalist economies are rare. Rather, most countries have adopted mixed capitalist and socialist systems, which depend on varying degrees of government participation and intervention in markets.

Any study of the economics of forestry must take careful account of the character of the economic system within which forestry is being

practised because this governs the issues that need attention. A socialist or subsistence economy raises quite different problems from a capitalist one. In this book, we assume the context of a mixed capitalistic economy, except where we note otherwise.

In a typical form of "mixed capitalism," most production is organized and carried out by private entrepreneurs responding to market incentives. Governments play an important role in regulating economic activity, however – providing a variety of services, manipulating prices and incentives, redistributing income and wealth, and managing the general level of economic activity.

The basic theory developed to explain how mixed capitalist economies operate is thoroughly dealt with in numerous elementary textbooks. This book is intended to build on, rather than duplicate, this general economic theory. Accordingly, the basic principles of economics are reviewed only briefly in the following chapters. Our emphasis is on the particular role that forests play in the economic system and on the economic choices faced by forest managers.

MIXED CAPITALISM AND THE ROLE OF GOVERNMENT

In a market economy, entrepreneurs take responsibility for producing things. They occupy the interface between suppliers of productive resources and purchasers of final goods and services. Entrepreneurs purchase the resources they need in order to produce the goods and services desired by consumers, and the prices they pay for these resources determine the incomes of those who provide the resources. The first of the three basic economic questions referred to earlier – what should be produced – is therefore determined in the first instance by consumer demand, hence the concept of "consumer sovereignty." The second question – about how the output will be produced – is determined by constant competition among individual producers to find the most cost-effective means of production in order to enhance their profits. And the third – concerning the allocation of the fruits of production – is resolved by the distribution of income, which in turn is governed by the market values of the labour, capital, and other productive resources that private suppliers make available to producers.

In the mixed capitalist system typical of most countries in the world today, however, governments intervene in these processes and change the pattern of production in important ways. They provide not only the traditional *public goods* (such as roads, lighthouses, and national defence) that private producers do not normally produce at all but also an increasing variety of goods and services that private producers produce

inadequately. Such things as health care, education, and the arts fall into this category of *merit goods,* which have a social value exceeding their value to individual consumers. Some governments even produce industrial timber, a seemingly pure private good. More importantly, governments indirectly influence private production and consumption by means of taxes, subsidies, and regulations. Governmental regulation of activities ranging from marketing to safety procedures for workers affects industrial structure, output, and prices. All these forms of intervention that alter the way in which productive resources are allocated and used comprise the *allocative* role of government.

Governments also substantially affect the distribution of wealth and income. Taxes, government spending programs, transfers, and borrowings of various kinds all redistribute income within and among socioeconomic groups, regions, and generations. Sometimes these redistributional effects are deliberate and obvious, as when pensions are paid to the elderly, but often they are subtle and indirect, requiring complex analysis to trace their full impact. This is the *distributive* role of government.

Finally, modern governments accept responsibility for maintaining a stable level of economic activity. This calls for fiscal policies (spending and revenue-collecting programs) and monetary policies (manipulation of interest rates, exchange rates, and the supply of money) to offset trends towards inflation or unemployment. Related to these stabilization activities are policies for promoting economic growth and regional development. These comprise the *stabilization* role of government.

By intervening in various ways, governments attempt to correct some of the weaknesses and inadequacies of the market system. Expressed in another way, government intervention in the form of *allocative, distributive,* and *stabilization* measures reflects efforts to improve the performance of the economy in terms of achieving the economic objectives that a society sets for itself through the political process.

In studying the economics of forest management, we find ourselves continually confronted with government policies aimed at influencing the way forest resources are developed, managed, and used. The primary objective of some of these policies is to improve efficiency by affecting the rate and pattern of resource use. Other policies are motivated by distributional or equity considerations, or a desire to manipulate community and regional growth. Whatever their primary purpose, all forms of intervention inevitably have implications for all three of the fundamental forms of economic impact, namely, the allocation of resources, the distribution of income and wealth, and economic stability and growth.

ECONOMIC OBJECTIVES: EFFICIENCY AND EQUITY

The allocative, distributive, and stabilization roles of government imply two fundamental economic objectives of society: *efficiency* and *equity.* These objectives provide us with criteria for assessing economic performance.

In any society, there is a presumption, more or less qualified, that the primary objective of economic activity is to satisfy consumer demands to the greatest extent possible. The extent to which these demands are met with the available resources is a measure of the *efficiency* of the economic system.

At the macroeconomic level, if resources were employed in one sector of the economy when they could generate greater value in another, it would be possible through some reallocation to increase the value of total output and hence the efficiency of the total system. In that case, the gross domestic product (GDP), the total value of all goods and services produced in an economy in a year, which is often used as a first approximation of an economy's performance, would be increased. Similarly, at the microeconomic level, an inefficiency exists if a producer fails to employ an available technology that would enable him to produce more with the same amount of inputs.

Thus, *economic efficiency* refers to the allocation of resources that generates maximum value from the resources used. The level of economic efficiency is reflected in the relationship between inputs and outputs: the greater the output relative to input, the greater the efficiency. In economic analysis, efficiency is expressed as the ratio of benefits (outputs) to costs (inputs), both measured in the common denominator of dollar values. Of course, a thorough economic analysis from the viewpoint of society as a whole must account for unpriced benefits and costs as well as those that are more readily observed and measured in market prices.

Efficiency in economic activity is therefore a logical social objective. Unless there are offsetting considerations, the use of any resource in a way that generates less value than it is potentially capable of generating through some other uses is simply a waste, lowering the value that society derives from its resources.

How forests can best be used in light of the variety of demands on them is one of the central questions of economic efficiency in forestry. A second question concerns the intensity of forestry – that is, how much labour and capital can be advantageously devoted to utilizing and managing forests to increase production. There is also an important temporal dimension to economic efficiency in forestry, referring to the pattern of

investment and utilization of the resource over time. Because forests take so long to grow and can be harvested over such a broad span of time, this temporal dimension of efficiency is especially important in forestry.

Market economies give producers incentives to operate efficiently and thereby compete successfully. On the other hand, various distortions and *market failures,* or failures of prices and the need for corrective policies to reflect society's real preferences, give scope for governments to improve efficiency through their allocative, stabilization, and growth-stimulating activities.

Equity refers to fairness in the distribution of income and wealth, and therefore the fruits of production, among the population. As noted above, the distribution of income is determined, in the first instance, by payments for the factors of production. It can be altered to a preferred pattern, however, through taxes, subsidies, transfers, and other types of distributive intervention by governments.

Like efficiency, equity invites a comparison of possible alternatives to determine which, of all the possible distributions of income and wealth, best serve society's preferences. Also like efficiency, equity has more than one dimension. *Interpersonal equity* refers to the distribution of income among individuals at any time. Equity among people living in different geographical regions is referred to as *interregional equity.* And *intergenerational equity* refers to the distribution of income among people living at different times. All these dimensions of equity are relevant to forest policy. In forestry, questions of equity often relate to the needs of poorer people or poorer regions, or to conserving forest resources for future generations.

Both efficiency and equity are difficult to measure. Efficiency is usually measured in dollar terms: the value of outputs relative to the cost of inputs, both of which are often reflected in market prices. Market prices are sometimes misleading, however: some benefits are not traded in markets, some costs exceed the amount of compensation paid, and other distortions and market failures make it necessary to supplement market price information with estimates of social values in order to assess efficiency. Equity, which rests on subjective judgments about fairness in the distribution of income and wealth, defies empirical measurement except through political processes and ethical judgments. For example, a policy that makes disadvantaged people worse off is often considered inequitable, but that might not be so if it serves some other social objective, such as a desired regional redistribution of income or benefits to future generations, all of which are difficult to measure and compare.

It is important to note that the objectives of efficiency and equity often come into conflict, and it becomes necessary to sacrifice one for the other. For example, measures that could expand output (increase efficiency) might create unwanted changes in the distribution of income (decrease equity), and vice versa. This illustrates the trade-off between improvement in equity and aggregate production, and the choices that must be made. The relative priority of objectives and the appropriate compromises among them are not matters that can be solved by economic analysis. Political and electoral processes must be depended upon to prescribe the appropriate mixture of allocative, distributive, and stabilization efforts on the part of governments and to reconcile divergent opinions about equity and efficiency. Economic analysis can provide guidance in making these decisions, however.

This book places heavy emphasis on the efficiency of resource allocation, especially the economic efficiency of forest resource development and use. This is not to suggest that concerns about equity and stability are unimportant in forestry; on the contrary, we shall see that some of the most profound issues in forest management, issues that have motivated significant forms of governmental activity, have to do with distribution among groups and regions and economic stability over time. We emphasize the efficiency of resource allocation, however, for two reasons. One is that it provides a necessary starting point for examining the benefits and costs of governmental policies and programs that change the distribution of income, promote economic growth, or affect market outcomes in other ways. The second reason is that from the viewpoint of an economic analyst, much of the uniqueness of forestry, as distinct from other forms of economic activity, centres on problems of efficiency.

FORESTS AS ECONOMIC RESOURCES

In economics, the general term "resources" refers not only to land and natural resources but also to capital, labour, and human skills that are valuable in producing goods and services. The essential characteristic of an economic resource is that it is "scarce," in the sense that there is not enough of it available to satisfy all demands for it. It is this scarcity, or limitation of supply, that raises problems of choice about how resources are to be allocated. It also makes them valuable, even though their value in some uses is not reflected in market prices.

Not all forests are economic resources in this sense. Some are so inaccessible, so remote, or of such poor quality that they are not demanded for any economic purpose, even though they might provide environmental benefits. Having no economic value or alternative uses, such

forests do not present the usual problems of choice and allocation among competing uses that are associated with economic resources. Most forests, however, are capable of yielding one or more products or services, and so they constitute part of an economy's total endowment of productive resources. It is this economically valuable part of the total physical stock of forest that we are concerned with in forest economics.

An economy's total endowment of productive resources is commonly divided into four broad categories: *land, labour, capital,* and *entrepreneurship.* Each of these has distinctive economic characteristics, and each generates economic returns of a different kind, namely, *rent, wages, interest,* and *profit,* respectively.

Forest resources fall into two of these categories. The basic resource is the forest *land,* which has the same economic characteristics as agricultural and other land. In any location, it is fixed in supply; it varies in productive quality; and it generates a residual value, or rent, that varies accordingly. The *forest* itself, consisting of trees on the land, falls into the category of capital. It can be built up over time through investment in silviculture and pest control, or it can be depleted through harvesting; it derives its value mainly from the final goods and services that can be produced from it; and it generates returns measured as interest. Standing timber is capital in this economic sense regardless of whether it is a gift of nature or a product of a long period of costly management.

Forestland and timber are economic resources because they are valuable in producing other final goods and services. The demand for land and timber stems from the consumer demand for these final products, and in this sense is a "derived" demand.

Forestland and the capital embodied in timber are part of a society's total endowment of productive resources that can be used in a variety of ways to produce useful goods and services. As with other resources, the extent to which they contribute to social welfare is governed by the efficiency with which they are allocated and used.

Traditionally, forest economics has been concerned with the management of forests for production of wood for industrial manufacture into building materials, pulp and paper, and so on. Forests also yield other goods and services, however, and are often managed to produce fuel wood, livestock, fish and wildlife, recreation, and water supplies. Such benefits are often produced in combination with industrial timber production. Some of these values, especially recreational and environmental benefits, are becoming increasingly important. These increasing and overlapping demands on forest resources complicate the problem of allocating them among alternative uses and combinations of uses.

Moreover, as some forest values are often not priced, they are difficult to evaluate in terms comparable with timber values, but these values are real whether or not they are priced; the absence of price indicators only complicates the problem of economic analysis. Later chapters address these issues in detail.

WHY FOREST ECONOMICS?

Economics deals with all kinds of productive resources, while forest economics focuses specifically on those used in forestry. The latter includes, obviously, the land and forest growth that constitute the forest itself, but it must also consider the labour, capital, and other inputs to forest operations and forest products production. Much of forest economics is concerned with how much of these other resources can be efficiently combined with forestland and timber in producing forest products and services.

This is the subject matter of microeconomics – the half of economic science that deals with how prices and incomes are determined, how producers find the most efficient scale and form of production, how consumers behave, and so on. Forest economics builds on this basic theory as it applies to forests and land. Forest economics is therefore in large part a study in applied microeconomics.

Like other special fields of applied economics, forest economics draws on the particular threads of economic theory that are relevant to the unique or especially important problems of the field. For forest economics, the theory of production, especially the theory of capital and rent, is fundamental. And, as a relatively narrow area of applied economics, it draws on broader applied fields such as the long-established specializations in land and agricultural economics and the newer branch of natural resource and environmental economics.

The special characteristics of forest resources that justify considering forest economics as a special field of study can be summarized as follows:

- Forests can produce a wide variety of goods and services and combinations of them, some of which are not priced in markets. This gives rise to special problems relating to the allocation of resources among uses.
- With the exception of some tropical and temperate species, forests typically take a long time to grow, often involving investment periods of decades. This gives rise to special problems in investment analysis, harvesting schedules, risks in carrying forest crops over long periods,

and market uncertainty. It also means that forests can be altered only slowly in response to changed economic and natural conditions.

- Forestry usually involves very high capital and carrying costs relative to production because the slow rate of forest growth means that large forest inventories must be carried to sustain a modest harvest. As a result, the costs of forest production are often dominated by the burden of carrying land and capital over time.
- Forests valued for industrial timber are both productive capital and product. This fact distinguishes forests from other forms of capital and gives rise to special analytical problems in selecting the best age to harvest and in designing taxes and regulations.
- Governments often wield a heavy hand in forest management and utilization. Partly because forest production is a long process, partly because forests produce many goods and services that are not sold in markets, and partly because timber harvesting and intensive forest management often have adverse side effects, governments in various countries have usually had more involvement in forestry than other sectors of the economy, through public ownership, timber-harvesting and forest practices regulations, taxation, and subsidies.

These features are not unique to forestry, but forestry illustrates them to a unique degree. They are also issues that underlie most of the analytical problems addressed in this book.

The economic choices in forest management are constrained by the biological capacity of the resource. Those limits, and the scope for manipulating them, are the subject of the natural science of forestry, or silviculture. Silviculture is a specialized field of biology, just as forest economics is a specialized field of applied economics. Whereas silviculture is concerned with all the things that can be done to manipulate the structure and growth of forests, forest economics deals with decisions and choices within that range of possibilities, focusing attention on their social rather than biological implications.

Forest economics is concerned not only with silviculture but with all aspects of forest management and forest products markets – protection, consumption, development, harvesting, and utilization of the full range of goods and services associated with forests. The natural science of forestry identifies the limits of natural systems and the range of choices available to forest managers; this range provides the framework of natural constraints within which economic analysis can help in identifying the social implications of alternative courses of action.

ECONOMIC DECISION MAKING

Forest resource management ranges from the design and implementation of high policy to the execution of everyday field tasks. Broad policy objectives are determined by governments and corporate boards of directors; how particular forests are to be used is usually the decision of their private or public owners; for detailed matters, it is often foresters, superintendents, or foremen employed by the owners who make the decisions.

Whatever the level, the process of decision making can be viewed as involving at least the following steps: (1) identification of goals or objectives, (2) identification of the alternative possible means of pursuing those objectives, (3) evaluation of the alternatives, (4) choice of the preferred alternative, and (5) implementation of the decision. In practice, decision making seldom follows the orderly sequence implied by this list of steps. The objectives of the parties involved are often unclear or conflicting, their motives may range from self-interest to altruism, and their time perspective may range from the immediate to the distant future. The processes of investigation and evaluation often bring out new information that causes those involved to change positions and shift alliances. As a result of this ongoing process, decision making often appears confused and disorderly, especially in matters of public policy. Nevertheless, it is helpful to the understanding of decision making to identify these separate components of the process.

Identifying Goals or Objectives

To make appropriate decisions, the decision maker needs a clear purpose to serve as a frame of reference for judging the desirability of one course of action compared with another. Thus, forest managers facing a decision about how to plan a harvesting program, or how much provision should be made for wildlife, or where to direct silvicultural effort must assess their alternatives in light of the objectives they are striving to achieve. There are two fundamental economic objectives: the efficiency and equity objectives discussed earlier. The relative importance of these must also be considered in decision making. Other social objectives, such as public safety, cultural awareness, and social harmony, although not normally economic objectives, have economic implications as well.

Several points about objectives deserve mention. First, objectives, even at the same level of decision making, vary depending upon who is responsible for defining them. A government, for example, is likely to have different and broader objectives for the management of public

forests than a corporation does in managing its private forestland. A major objective guiding the forest operations of industrial corporations is the corporations' responsibility to shareholders to generate profits, and corporate decisions are consequently aimed largely at increasing profits. They may also be influenced by other goals, however, such as corporate growth, security of markets or resource supplies, protection of dependent manufacturing activities, or social responsibility, and firms may be prepared to compromise their current profits to advance these other goals. Similarly, small private landowners may be guided by a desire not only for profit but also for financial security, amenity, or other values that they derive from their forests. The management of public forests in democratic countries reflects the perceived wishes of the populace, which nowadays typically puts considerable emphasis on the non-market and environmental benefits of forests, on distributional considerations, and on regional development. In short, those who make the decisions about how forests are to be managed have varying frames of reference, and hence differing objectives that lead to differing decisions.

Second, the objectives of decision makers depend on the hierarchical structure of the organizations within which they work. As one moves down through the organizational structure of a government or corporation, the relevant objectives of decision makers become more narrowly defined. For example, at the highest policy-making level in a government, the goal might be to promote regional economic stability. Towards this end, the government's forest management agency might adopt a sustainable yield objective in regulating timber harvests in each region. That objective would provide regional administrators with production objectives, the official in charge of silviculture with reforestation objectives, and the foreman of the planting crew with daily planting targets. This illustrates that at each subsidiary level of decision making the objective is different and narrower, but derives from and is consistent with the next higher objective and ultimately with the general goal of advancing regional economic stability.

Third, it is important to distinguish ends from means in this context, because they are often confused. Sustained yield (examined in Chapter 8) is an example. Sustained yield is a principle that has become so enshrined in the forestry administration of some jurisdictions that it has become institutionalized as an end in itself. It is, however, merely a formula for meeting a higher purpose, such as regional industrial stability, and unless it is clearly seen as a means to such an end, its limitations for that purpose and the implications of alternatives to it cannot be properly assessed.

There are many examples of such confusion between goals and means. Concepts such as conservation and sustainable development have garnered enormous popularity as goals for natural resources management, but on closer examination both imply means to higher goals, primarily intergenerational equity. The latter (sustainable development) is defined by the World Commission on Environment and Development (or the Brundtland Commission) as "development that meets the needs of present without compromising the ability of future generations to meet their own needs."

Fourth, forest managers are often expected to pursue several objectives simultaneously. As has been suggested, a corporation might be concerned with such things as security of raw material supply or avoidance of risk as well as profit maximization, and a government may seek to provide stable regional employment or environmental benefits as well as revenues from a public forest. These various objectives are rarely perfectly complementary, and to pursue them simultaneously requires compromises among them. Economic analysis can assist in identifying and evaluating possible trade-offs, but the ultimate choice usually requires some weighting of the competing values, which are often not easily quantifiable.

Similarly, the objectives of individuals or governments vary in the short term and long term, and short-term objectives may conflict with long-term goals, again calling for trade-offs and compromise. To return to an earlier example, college students can readily attest to multiple objectives in a dynamic or inter-temporal fashion. Either by conscious choices or by default, all students have broadly defined, long-term goals. Their intermediate goals in college may be to get a good education, to find a job, to find a life partner, and to enjoy sports and a social life. In each semester or term, they may want to have good grades in various classes and learn certain skills. In everyday life, they must balance several immediate goals (or demands), such as attending classes, reading class materials, playing some sports, partying, and relaxing.

Fifth, although orderly decision making calls for explicit objectives, the objectives that forest managers are expected to pursue are sometimes vague. This is a difficulty faced most frequently in government forest agencies, where guidance about the broad purposes to be served in managing public forests is often ambiguous or even conflicting in the legislation, regulations, and administrative arrangements that articulate public policy. In such circumstances, managers are forced to infer or guess their intended objectives, and this can lead to inconsistencies and inefficiencies.

Finally, it is worth emphasizing that specification of objectives is not usually the responsibility of an economist. The special expertise of the economist is not in prescribing corporate or governmental goals but, as discussed below, in analyzing and evaluating the means of achieving them. There is, however, a normative aspect of economics in which economists incorporate their value or normative judgment about what the economy *ought to be* like or what particular policy actions *ought to be recommended* to achieve a desirable goal. In this sense, economists, along with other decision makers, can prescribe what these goals are and the ways to achieve them.

Identifying Alternative Means

Most corporate or public goals can be pursued in a variety of ways. At the level of high economic policy, a goal such as increased regional employment might be served by promoting industrial development, for example, which can be done in various ways through adjustments of taxes, subsidies, infrastructural improvements, or direct governmental enterprise. Forestry may be only one of several alternative means. Or, at the level of forest management planning, a goal of increasing yields might be accomplished by such varied means as improved protection, reforestation, spacing and fertilization of stands, or more complete utilization of harvested trees. Thus, once the decision maker's objectives are identified, the next step is to identify the range of alternative strategies that can feasibly be adopted to achieve most of those objectives.

This step involves assessing the technical alternatives and the inputs required to achieve a particular level of output, which in economic jargon is referred to as determining the production function. Sometimes it is also important to assess the risk or uncertainty associated with the alternative strategies.

Identification of the feasible means of pursuing an objective, and of their technical production functions, is typically the responsibility of engineers, foresters, and other technical experts. For large ventures, this task sometimes becomes highly formalized in feasibility studies that involve economists and financial analysts, while at the operational field level it typically depends on continuing subjective assessments by working supervisors.

Evaluation of the Alternatives

The next step is to evaluate the technical alternatives in order to provide guidance for choosing among them. It is at this stage that economic analysis is brought to bear on the decision-making process. It involves

assessing the extent to which the goals of the decision maker would be advanced by particular actions, and their costs.

The relationship between the value of the outputs and the cost of the inputs associated with a particular activity provides a measure of the potential net gain it can generate. Economic efficiency calls for maximizing the surplus of benefits over the cost of resources utilized, so the greater the value of output relative to the cost of inputs, the more efficient the activity is. Chapter 3 describes how alternative courses of action can be assessed according to the efficiency criterion.

The task of identifying the relative advantage of alternative courses of action is often complicated by incomplete information, distorted or unpriced costs and benefits, and uncertainty about future circumstances and outcomes. Notwithstanding these difficulties (which are examined in subsequent chapters), economic evaluations offer a means of ranking alternative courses of action according to consistent criteria for the guidance of decision makers in selecting among the alternative strategies available to them.

Economic decisions are never made with complete certainty, of course. Information about the resources and markets, and about the range of possible actions and their outcomes, is always more or less uncertain. Most decision makers are averse to risk, and so the degree of uncertainty surrounding alternative courses of action has significant influence on their choice. Attitudes towards risk taking vary considerably, however.

The degree of uncertainty is therefore an important influence on decision making, and a later chapter considers how it can be taken into account in economic analysis. It is particularly important in forestry because knowledge about the biological character of forests and their potential responses to treatments is usually limited. In addition, the long planning periods involved in forest production exacerbate the difficulty of predicting the long-term benefits and costs of actions taken today. Thus, the risks of losses from fire and other causes also contribute to the uncertainty in forestry decision making.

Traditionally, economists have approached their subject in two ways. *Positive economics* is concerned with describing and explaining economic behaviour, without judgments about its desirability; in contrast, *normative economics* assesses behaviour in terms of given criteria or objectives, and is therefore more concerned with how economies *should* be organized and regulated. This forest economics book does not follow either of these schools exclusively. We try to avoid prescribing the objectives that decision makers should adopt, or the best distribution of income; rather, our emphasis is on using economic analysis to assist

those who make decisions about managing forests in identifying the most beneficial courses of action in light of their objectives.

Choice, Implementation, and Evaluation

The economist's role in evaluating alternative courses of action is to provide guidance in decision making; it is not to make the final choice. Decision makers may, for a variety of reasons, reject the activity that appears most advantageous on purely economic grounds because of considerations of corporate strategy, political sensitivities, or other concerns not accounted for in the analysis. Nevertheless, economic analysis will help decision makers better understand the economic implications of their choices.

Once a decision maker has chosen a preferred course of action, the final step of initiating and implementing the action is taken. Sometimes an additional step is added, that of review and assessment of the action taken, drawing attention to the dynamic and continuous character of decision making and the need for evaluation.

The process of decision making sketched here is a central concern of management science. The growing literature in this field of study presents a variety of decision models and models of strategic behaviour to help understand the relationships among decision makers, the problems of multiple and conflicting objectives, means of minimizing and coping with uncertainty, and so on.

The following chapter reviews the forces that guide decision making in the context of a market economy, introduces the reasons that most countries today regulate and modify the activities of businesses, individuals, and markets, leading to what we have identified as mixed capitalist economies, and explains why government interventions in markets may fail to achieve their purpose. Subsequent chapters examine the special problems encountered in forest management and how economic analysis can contribute to their solution.

REVIEW QUESTIONS

1 Explain why economics is concerned only with the allocation of "scarce" resources. In what sense are forest resources "scarce"? Where are they not scarce?

2 Compare how management decisions are made for (a) a privately owned forest in a capitalist economy, (b) a government-owned forest in a planned socialist economy, and (c) a tribal forest in a primitive subsistence economy.

3 What are private goods? What are public goods? What are merit goods?

4 Explain how innovations in mechanized forestry can affect (a) economic efficiency in timber production, and (b) the distribution of income.

5 Describe the importance of objectives in evaluating forest management decisions.

6 If the fundamental objectives of society are either economic efficiency or equity, how would you classify the following? (In other words, which would follow the criteria of the equity objective, and which would follow the criteria of the efficiency objective?)

   a) A forestry firm's immediate profits
   b) A forestry firm's long-term profits
   c) Employment in a forested region
   d) Selective employment of indigenous populations
   e) Recreation in a forest park
   f) Long-term security of timber supply for a pulp mill
   g) Long-term preservation of biodiversity on public forestland.

7 Compare the approaches of a silviculturalist and an economist in considering how best to manage a forest. What are the main concerns of each likely to be? Can their approaches be reconciled?

FURTHER READING

Clawson, Marion. 1975. *Forests for Whom and for What?* Baltimore: The Johns Hopkins University Press, for Resources for the Future. Chapters 3 and 7.

Duerr, William A. 1988. *Forestry Economics as Problem Solving.* Blacksburg, VA: Author. Part 1.

Gregory, G. Robinson. 1987. *Resource Economics for Foresters.* New York: John Wiley and Sons. Chapter 1.

Klemperer, W. David. 2003. *Forest Economics and Finance.* New York: McGraw-Hill. Chapter 1.

Quade, Edward S. 1989. *Analysis for Public Decisions.* 3rd ed. New York: North-Holland. Chapters 4-7.

Samuelson, Paul A., and William D. Nordhaus. 2004. *Economics.* 17th ed. New York: McGraw-Hill/Irwin. Chapters 1-3 and 32.

20 19 18 17 16 15 14 13 12 11 5 4 3 2 1

Printed in Canada on FSC-certified ancient-forest-free paper
(100% post-consumer recycled) that is processed chlorine- and acid-free.

Library and Archives Canada Cataloguing in Publication

Zhang, Daowei
Forest economics / Daowei Zhang and Peter H. Pearse.

Revision and expansion of: Introduction to forestry economics.
Includes bibliographical references and index.
Also issued in electronic format.
ISBN 978-0-7748-2152-0

1. Forests and forestry – Economic aspects. I. Pearse, Peter H. II. Title.

SD393.Z53 2011 338.1'749 C2011-903547-2

e-book ISBNs: 978-0-7748-2154-4 (pdf); 978-0-7748-2155-1 (epub)

Canada

UBC Press gratefully acknowledges the financial support for our publishing program of the Government of Canada (through the Canada Book Fund), the Canada Council for the Arts, and the British Columbia Arts Council.

Printed and bound in Canada by Friesens
Set in Syntax and Cambria by Artegraphica Design Co. Ltd.
Text design: Irma Rodriguez
Copy editor: Frank Chow

UBC Press
The University of British Columbia
2029 West Mall
Vancouver, BC V6T 1Z2
www.ubcpress.ca