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# Preface

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The *Handbook on the Economics of Natural Resources* includes 18 chapters written by leading scholars in the field. We asked the authors to contribute chapters that would define the state of the art and to sketch the likely development of the field in the coming years. We envisage this *Handbook* as being a 'go to' resource for graduate students, instructors, and for scholars investigating new areas of research in natural resource economics. It will provide them with the means to consider what has been accomplished to date, and productive paths for future scholarship.

The volume has been organized around four themes in natural resource economics: nonrenewable resources, modeling of biological resources, conservation of biological resources, and water resources. These are reflective of the canon, but at the same time are forward looking toward what we and the authors see as some of the key areas of future development in the field. Below we briefly introduce how each chapter contributes to this mission.

## 1 NONRENEWABLE RESOURCES

The modern analysis of the optimal depletion of nonrenewable resources begins with Gray (1916) and Hotelling (1931). In Chapter 1, John Hartwick provides an overview of the theoretical literature focusing on Gray's analysis of an extractive firm, Hotelling's analysis of an extractive industry, as well as subsequent theoretical developments of the Hotelling model, including durable nonrenewable resources and stocks of heterogeneous qualities.

The theoretical literature following Hotelling has generally assumed that each resource is available to every user at the same cost per unit, resulting in the unrealistic prediction that simultaneous extraction of different grades of a resource will never occur. In Chapter 2, Gérard Gaudet and Stephen Salant exposit a generalized model with multiple demands that allows for the analysis of users differing in their location, regulatory environment, or resource needs.

In Chapter 3, John Livernois and Henry Thille survey the empirical literature that appraises the theoretical implications of the theory of non-renewable resources with respect to the dynamic behavior of scarcity rents

and resource prices, and find that the evidence is mixed. They also consider the empirical evidence on alternative measures of the implications of nonrenewable resource scarcity for sustainability and conclude that all have imperfections but market price is probably the best.

The design of tax systems for nonrenewable natural resources is important both because tax revenues are a major source of government revenue in many countries and because the existence of scarcity rents implies the possibility of obtaining these revenues without causing distortions in resource extraction paths. These issues are discussed in two complementary chapters.

In Chapter 4, Gérard Gaudet and Pierre Lasserre compare the effects of specific and *ad valorem* severance taxes (also known as royalties), a profit tax and a lump-sum tax on extraction decisions over time and the initial reserves to be developed. They also consider the effect of the inclusion of a depletion allowance in a corporate income tax on the relative investment in resource and non-resource industries.

In Chapter 5, Robin Boadway and Michael Keen compare the effects of royalties to rent taxes, which are taxes on pure profits (revenues less all imputed costs). Several variants of rent taxes are considered and are concluded to be preferable to royalties when the untaxed equilibrium is efficient. They also consider the optimal combination of rent taxes and royalties when market failures exist.

Some empirical studies have indicated the existence of a ‘resource curse’, with natural resource wealth having a negative effect on economic growth. In Chapter 6, Richard Auty argues that the resource curse is part of a broader rent curse that arises from political contests to capture windfall revenues. Therefore the rent curse is not confined to resource-poor economies and is not deterministic but instead can be remedied by policy reform.

## 2 MODELING OF BIOLOGICAL RESOURCES

In Chapter 7, Eli Fenichel, Sathya Gopalakrishnan and Onon Bayasgalan illustrate bioeconomics as an application of capital theory to biological resources. While bioeconomic modeling has an important tradition in fishery economics, the authors make clear that it has a crucial role to play across a wide range of ecosystem resources and services. They offer directions for future research, and both a call and approaches for increasing the realism of bioeconomic models.

The forest harvesting problem is probably the earliest example of a natural resource economics problem dating to Faustmann’s 1849 solution. In Chapter 8, Gregory Amacher surveys the last several decades of

contributions to this problem with a focus on risk, uncertainty, dynamics, and spatial aspects. He also asks whether new and important contributions are forthcoming on this well-studied problem. He concludes that yes, there is still much interesting work to be done.

The control of harmful biological agents such as agricultural pests and disease-causing bacteria is important to human well-being. Pesticides and antibiotics are important to successful control of harmful agents but their effectiveness can become reduced due to the development of resistance. In Chapter 9, Ramanan Laxminarayan and Markus Herrmann survey the literature on the optimal use and regulation of 'bioeffectiveness' and point out parallels to similar problems in the management of natural resources treated in this volume.

### 3 CONSERVATION OF BIOLOGICAL RESOURCES

Economists have long recommended the establishment of well-defined property rights to fishing in order to limit the dissipation of resource rents and reduction of fish stocks below optimal levels. The main way such rights have been operationalized in developed countries has been in the form of 'catch-shares', which allocate shares of the total allowable catch to agents. In Chapter 10, Daniel Holland surveys and examines the structure of such systems which can vary across a wide range of characteristics and contexts.

Forests produce benefits and ecosystem services in a manner that is inherently spatially dependent. In Chapter 11, Heidi Albers and Elizabeth Robinson examine how economists have addressed spatial aspects of forest conservation. They consider how economic methods of analyzing forest conservation have incorporated space and offer suggestions about key areas for future work.

In Chapter 12, Edward Barbier proceeds from the view that ecosystems should be viewed as economic assets that can produce beneficial service flows over time, typically when they are left in a relatively undisturbed state. These beneficial flows must be balanced against the cost of development or conversion benefits foregone. He reviews the unique challenges that quantifying and valuing ecosystem services and balancing them against competing uses poses to the economic analysis of ecosystems as resources.

A key biological resource problem is the conservation of space to protect species and their habitats. In Chapter 13, Stephen Newbold and Juha Siikamäki review the reserve site selection problem which seeks to determine the optimal design of networks of nature reserves. In reviewing

this problem and conservation prioritization more generally, they point to areas where the economic approach based on benefit and cost measurement and optimization has the strong potential to further conservation science.

## 4 WATER RESOURCES

In Chapter 14, Quentin Grafton and Sarah Wheeler provide an overview of water economics and its application to the key global challenges of water scarcity, poor water quality, and conflict and misallocation across competing uses. Topics discussed include the characteristics of water, valuation, water supply and demand, and the specific characteristics of water markets. They note that a key method for improving water allocation is market prices that signal water's value.

The economic principles for implementing efficient pricing of water are discussed in Chapter 15 by Ronald Griffin. He explains that efficiency requires marginal cost pricing based on non-accounting opportunity costs, complemented by budget-balancing flat fees, and notes that instead actual pricing is generally based on average costs with departures from economic principles also including block pricing and the absence of time-of-year pricing.

Inefficiency in the pricing of water rights is addressed in Chapter 16 by Eric Edwards and Gary Libecap. They provide evidence on the continuing price disparities among various water applications and examine the role of historical property institutions in explaining limited water trading and the lack of the appearance of the law of one price. They also explore the efficiency losses of limited trades and the options for adjusting existing rights arrangements.

In Chapter 17, Yusuke Kuwayama and Sheila Olmstead provide an overview of the literature on water quality. The topics considered include the quantification of the demand for water quality, the effectiveness and efficiency of water quality interventions and regulation, the choice of policy instruments, integrated hydro-economic modeling, and the links between water quality and energy development.

At the global level, water management is complicated because many countries share their sources of water. In Chapter 18, Edward Barbier and Anik Bhaduri examine how transaction costs, asymmetric country and information characteristics, and problems of free-riding and moral hazard affect cooperation over negotiating, implementing, and enforcing transboundary water agreements, and suggest that issue linkage may facilitate reaching agreement.

We conceive of the field of natural resource economics broadly and asked the contributors to think broadly as well. They most certainly have accomplished that goal. We hope that our intended audience agrees that the contributors have done an exceptional job in crafting contributions that individually and collectively provide both a firm footing in the state of the art and a path for future contributions. As is made clear by these chapters, natural resource economics is more than capital theory applied to non-human produced products, although it is at least that. It is an essential ingredient in understanding how to best use and conserve those resources that form the foundation for human well-being. It is crucial to providing solutions to many of the problems that our growing populations face.

