

NATURAL RESOURCE ECONOMICS

*Analysis, Theory, and
Applications*

JON M. CONRAD
DANIEL RONDEAU

สำนักหอสมุด มหาวิทยาลัยเชียงใหม่



616622078

012553888

102668333

Natural Resource Economics

Mathematical analysis is key to the modeling and management of natural resources. By presenting required mathematical methods, classic dynamic models for nonrenewable and renewable resources, and by exploring several contemporary problems, this text provides a foundation for advanced research. Topics include seminal models in fishery, forestry and nonrenewable resource management, as well as an extensive collection of contemporary applications that include the optimal transition from fossil fuels to clean energy, the optimal timing of interventions to save endangered species, pest control, and the optimal management of antibiotic resistance. Deterministic and stochastic models in both discrete and continuous time are covered. The book encourages students to pursue a deeper understanding of the analytics of resource problems and to deploy numerical methods when analytical results prove intractable. The combination of analysis, theory and applications will launch the next generation of resource economists, while serving as a useful reference for established researchers.

Contents

<i>List of Figures</i>	page viii
<i>List of Tables</i>	x
<i>Preface</i>	xi
1 Overview of Fundamental Concepts	1
1.1 Natural Resources Are Capital Assets	1
1.2 Classification of Natural Resources	1
1.3 The Building Blocks of Dynamic Resource Models	3
1.4 Exercises	14
2 Difference and Differential Equations	17
2.1 Introduction	17
2.2 The Classification of Dynamic Equations	18
2.3 First-Order Linear Autonomous Difference Equations	20
2.4 First-Order Nonlinear Autonomous Difference Equations	26
2.5 First-Order Linear Autonomous Differential Equations	30
2.6 First-Order Nonlinear Autonomous Differential Equations	32
2.7 Two First-Order Linear Autonomous Difference Equations	34
2.8 Nonlinear Systems of First-Order Difference Equations	49
2.9 Linear Systems of Two Differential Equations	51
2.10 Nonlinear Systems of First-Order Differential Equations	63
2.11 Bifurcations	66
3 Dynamic Optimization	70
3.1 Introduction: Static versus Dynamic Models	70
3.2 Lagrangian for a Static Allocation Problem	71
3.3 Dynamic Allocation with a Lagrangian	73
3.4 The Current-Value Hamiltonian and Maximum Principle	79
3.5 Deterministic, Discrete-Time, Dynamic Programming	81
3.6 A Most Rapid Approach Problem	83
3.7 Continuous-Time Allocation Problems	86
3.8 Continuous-Time Dynamic Programming	90
3.9 The Capital Accumulation Problem	95
3.10 Discrete-Time Stochastic Dynamic Programming	97
3.11 Continuous-Time Stochastic Calculus and Dynamic Programming	100
3.12 Optimality Conditions: A Summary	103
3.13 Exercises	105

4	Resource Economics with <i>Mathematica</i>	110
4.1	Introduction	110
4.2	Getting Started	111
4.3	Basic Syntax and Special Characters	114
4.4	Creating and Manipulating Lists, Vectors, and Matrices	120
4.5	Defining Functions and Applying Them	122
4.6	Manipulating and Solving Equations	124
4.7	Graphics	129
4.8	Elements of Dynamics	133
4.9	Application: Phase Diagram of the Open-Access Fishery	137
4.10	Application: A Nonlinear Optimization Solver	144
4.11	Application: Functional Iteration of Bellman Equations	149
4.12	Finding Help	157
5	Nonrenewable Resources	158
5.1	Introduction and Overview	158
5.2	Maximizing Utility from Optimal Extraction	159
5.3	The Optimal Date of Exhaustion of a Mine	161
5.4	Optimal Extraction with Reserve-Dependent Costs	164
5.5	Optimal Extraction in Discrete Time	168
5.6	Hotelling, Innovations, and Surprise Discoveries	170
5.7	Optimal Extraction from Multiple Reserves	174
5.8	Multiple Reserves and Spatially Distributed Users	176
5.9	Extraction with CRRA Utility and Stochastic Reserves	179
5.10	Opening and Closing a Mine	181
5.11	A Two-Period Model of Risky Exploration	186
5.12	Global and Locational Externalities	188
5.13	Polluting Resources with a Clean Substitute	190
5.14	Exercises	195
6	Bioeconomic Models of Fisheries	198
6.1	Introduction and Overview	198
6.2	Bioeconomics of Pure Open Access	199
6.3	Regulated Open Access	207
6.4	Limited-Access Fishery: A Game Theoretic Approach	210
6.5	Optimal Management in Continuous Time	214
6.6	Sole Ownership and the Likelihood of Extinction	223
6.7	Optimal Constant Escapement	226
6.8	A Continuous-Time Stochastic Fishery	228
6.9	The Dynamic Fishery as a Stochastic Differential Game	230
6.10	Regime Shift with the Possibility of Extinction	233
6.11	Management Policies	237
6.12	Exercises	246
7	Optimal Stopping Rules	249
7.1	Introduction and Overview	249

7.2	When Should You Open that Bottle of Wine?	249
7.3	Time and the Risk of Species Extinction	251
7.4	Harvesting a Forest Stand	252
7.5	Waiting to Invest in an Irreversible Project	262
7.6	Acting to Save a Stochastic Endangered Species	265
7.7	Exercises	269
8	The Control of Pests and Invasive Species	273
8.1	Introduction and Overview	273
8.2	Two-Period, Single Control, Deterministic Model	275
8.3	Multiple Periods and Controls, Single Threshold	275
8.4	A Three-Period Stochastic Model	277
8.5	Threshold for the Last Pesticide Application	283
8.6	A Stochastic Model of Invasive Species	284
9	Economics of Antibiotics Efficacy	290
9.1	Introduction	290
9.2	Epidemiology	290
9.3	The Demand for Antibiotics	293
9.4	Antibiotics in an Open-Access Regime	294
9.5	The Optimal Use of Antibiotics	300
10	Wildlife, Agriculture, and Labor	308
10.1	Introduction	308
10.2	Primary Model Building Blocks	309
10.3	Dynamics	313
10.4	Analysis	314
10.5	Exercises	324
11	Open Access and Optimal Inventory	325
11.1	Introduction and Overview	325
11.2	Coupling the Hotelling and Open-Access Models	325
	<i>References</i>	338
	<i>Index</i>	345