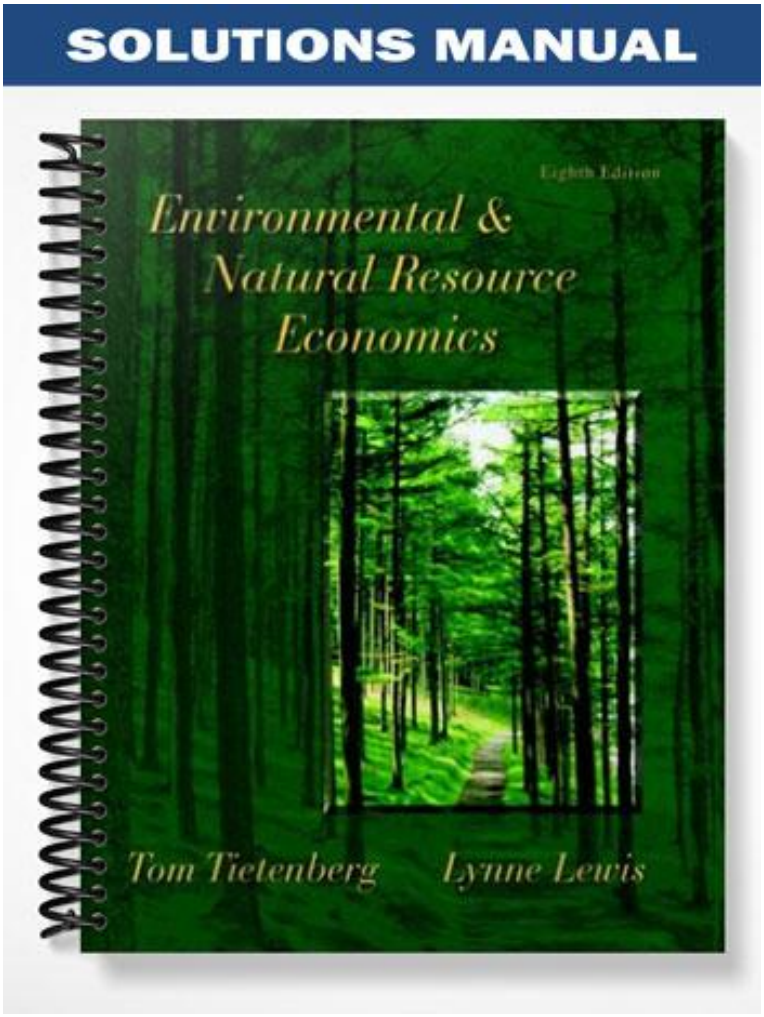
SOLUTIONS MANUAL



Chapter 2
Valuing the Environment: Concepts

Chapter 2 provides an overview of basic microeconomics as it applies to natural resource and environmental economics. The chapter includes much of the basic economics terminology and describes the framework from within which the various topics in the text will be presented. As such, the chapter covers *a lot* of material. Students without much background in economics may find this material abstract and difficult. You may find it beneficial to spend extra time on this chapter, especially when teaching the non-major. Ensuring that your students have a good grasp of the concepts and tools early in the semester will make teaching the other chapters easier and will facilitate the learning process.

■ Teaching Objectives

1. Define the economic approach and distinguish between positive and normative economics.

2. Derive and define a demand curve, and distinguish between individual and market demand, total and marginal benefits, and total willingness to pay and marginal willingness to pay.

3. Define opportunity cost. Distinguish between a contemporaneous opportunity cost and an intertemporal opportunity cost.

4. Derive and define the marginal cost curve. Distinguish between marginal and total cost.

5. Define present value and the discount rate. Illustrate the basic discounting equations.

6. Calculate the present value of net benefits and show how benefit-cost analysis can be used to evaluate specific options.

7. Derive net benefits graphically. Define optimality and economic efficiency.

8. Distinguish between static efficiency and dynamic efficiency. Use the Equimarginal principle to illustrate both efficiency and inefficiency.

9. Define the concept of Pareto optimality.

10. Apply these concepts to real world examples.

■ Objectives for the More Advanced Student and Economics Major

1. Derive net benefits both graphically and mathematically.
2. Derive the optimal allocation graphically and mathematically
3. Distinguish between discrete and continuous discounting formulas.

■ Outline

I. The Human Environment Relationship

A. The Environment as an Asset

The concept of the environment as an *asset* will likely be a new one to most students. This subsection provides examples of some of the goods and services the environment provides and discusses the treatment of the environment as a closed system, using the first and second laws of thermodynamics. Reminding students that assets have value that can be carried into the future will serve as a preview for the discounting topics that come up later in the chapter. As a preview to upcoming chapters you may also choose to discuss examples of natural resource assets. It is easy to illustrate that privately owned tree lots have both an asset value (while growing) and a use value (when cut). Open access fisheries, however, lose the asset value as there is no way to save fish for the future if you cannot prevent someone else from catching them. This will serve as an introduction and hint of future topics.

B. The Economic Approach

Normative and positive economics are both defined here. Given the controversies that tend to surround environmental issues and debates, examples from current events should be easy to find. Some timely examples of where normative decision-making will be prevalent include dam removal and policies to prevent or mitigate climate change.

II. Normative Criteria for Decision-Making

This section is the meat of the chapter and presents the basics of benefit-cost analysis. Beginning with the definition of a demand curve, students should learn the concepts of total and marginal benefits, total and marginal willingness to pay, total and marginal costs and present value. I have found it useful when teaching the non-major to derive an individual demand curve for a market good first. Students will grasp the concepts of willingness to pay, for example, for the first cup of coffee in the morning and the idea of diminishing returns from drinking additional cups relatively quickly. When they have mastered the basic concepts and vocabulary for a common market good, it will then be easy to illustrate the same for an environmental good that sometimes does not have a market price. Willingness to pay for preservation, for example, is much more abstract and difficult if the students are not familiar with microeconomic principles and concepts. The concept of things having value because humans value them may also be controversial.

A. **Benefit-cost analysis** provides a method for determining whether or not an action should be supported. Most simply, if the benefits exceed the costs, then the action should be supported.

B. **Benefits** can be derived from the demand curve for the good or service.

C. **Total willingness to pay** or **total benefits** is the area under the demand curve from the origin to the allocation of interest.

D. **Costs** are measured by the **marginal cost curve.**

E. All costs should be measured as **opportunity costs.** Opportunity cost is the net benefit foregone when an environmental service is lost to a different use.

F. **Marginal opportunity cost** is the cost of producing the last unit.

G. **Total cost** is the sum of the marginal costs or the area under the marginal opportunity cost curve up to the allocation. This will also be the area under the supply curve in purely competitive markets.

H. **Net benefit** is the excess of benefits over costs or the area under the demand curve that lies above the supply curve. This is also **consumer plus producer surplus.**

I. **Benefit-cost analysis** requires comparing benefits and costs that usually occur at different points in time. The concept of **present value** allows us to incorporate the time value of money and to compare dollars today to dollars in some future period by translating everything back to its current worth.

J. The present value of benefits, $\$B$, received n years from now is $\$B_n/(1 + r)^n$, where r is the discount rate.

K. The present value of a stream of benefits $\{B_0,\ldots,B_n\}$ received over a period of n years is the sum from time $I = 0$ until year n of $\$B_i/(1 + r)^i$.

L. **Discounting** is the process of calculating present value.

III. Finding the Optimal Outcome

A. An allocation is **efficient** or has achieved **static efficiency** if the net benefit from the use of those resources is maximized by that allocation. If at an allocation marginal cost is greater than marginal benefit, then net benefits are less than the maximum possible, and the allocation is **inefficient** (too much has been produced). Likewise, if marginal benefit is greater than marginal cost, net benefits can be increased by increasing the allocation. Thus, an efficient allocation will be achieved when marginal benefit and marginal cost are equal. Inefficient allocations do not maximize net benefit.

B. The **first Equimarginal principle** says that net benefits are maximized when the marginal benefits from the allocation equal the marginal costs.

C. An allocation is **Pareto optimal** if no other feasible allocation could benefit some people without any negative effects on at least one other person.

D. Allocations that do not satisfy C are **suboptimal.**

E. An allocation has achieved **dynamic efficiency** if it maximizes the *present value* of net benefits.

IV. Applying the Concepts

This section presents some examples of actual studies in which benefit-cost analysis has been used. The benefits and costs of U.S. air pollution control policy are discussed as are preservation versus development conflicts. The Box Examples 2.3 and 2.4 in this chapter are useful case studies to discuss in class.

■ Common Student Difficulties

Students will likely jump ahead and want to know the *how to:* how to calculate or measure benefits, etc. This subject is covered in depth in Chapter 3. It is important at this point that your students understand the principles, graphs, and jargon. This chapter contains a lot of potentially brand new material. While examples are always helpful, getting through the underlying theory and making sure it is understood will make the rest of the course easier for you and for your students!

Students with limited backgrounds in economics will also have trouble with the Equimarginal principal and will frequently confuse total and marginal. Simple numerical examples that illustrate the maximization of net benefits means equalizing marginal cost and marginal benefit should help. They may also have difficulty with the concept of optimization and Pareto optimal allocations. This might be a good place to also start talking about the role of government intervention.

The concept of discounting might also be problematic for some students. Examples they can relate to (all students will likely have a high rate of time preference for money) will illustrate present value and the role of the discount rate. Asking them if they would like $100 today or $100 on the day they graduate should nicely illustrate the time value of money. If they are skeptical, this type of question should help prove to them that most people have positive rates of time preference (prefer benefits sooner and costs later).

■ Suggested Classroom Exercises

An in-class example or problem set related to discounting will not only let the students learn with a hands-on example, but will likely ease their minds about the difficulty of the concept and of the course. I have also found that many students will not have used or seen spreadsheets before. Having the students learn how to use a program such as Excel now will facilitate the teaching (and their homework time) in later chapters. If you have a teaching assistant, have him or her hold a review session in the computer lab on how to use a spreadsheet. If your classroom is a lab, you could use a little bit of class time for this purpose if time permits.

The spreadsheet problem set below is a hypothetical example of two proposed uses for a coastal area. Obviously, you can think of many different scenarios and sets of numbers. You can tell the students, for example, that a coral reef area will either be protected or mined. A set of costs and benefits is given for a 10-year period. As you can see in the answers, I have set this problem up so that the net present value changes from positive to negative with a change in the discount rate. This is a nice illustration of the effect of the discount rate. The example is also set up so that a different project would be pursued at a different rate. Additionally, the answers can be calculated using a continuous discount rate if you are teaching your students both discrete and continuous discounting. A discussion on the choice of the discount rate could be started here or saved for a later chapter.

There are many different ways to illustrate these concepts. This is just one example.

Problem Set 1. Discount rates

Project 1. Gringoland Marine Park

	Years										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Costs (thousands of $)											
Construction	1250										
Recurring costs		130	130	130	130	130	130	130	130	130	130
Foregone recreation	20	20	20	20	20	20	20	20	20	20	20
Benefits											
Increased tourist revenue	300	300	300	300	300	300	300	300	300	300	300
Net											
NPV @ 5%											
NPV @ 10%											

Project 2. Gringoland Coral Mining

Costs (thousands of $)											
Extraction costs	3000										
Costs of coastal erosion	200	200	200	200	200	200	200	200	200	200	200
Benefits											
Revenues from limestone	4500										
Net											
NPV @ 5%											
NPV @ 10%											

Answers:

Project 1. Gringoland Marine Park

	Years										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Costs (thousands of $)											
Construction	1250										
Recurring costs		130	130	130	130	130	130	130	130	130	130
Foregone recreation	20	20	20	20	20	20	20	20	20	20	20
Benefits											
Increased tourist revenue	300	300	300	300	300	300	300	300	300	300	300
Net	–970	150	150	150	150	150	150	150	150	150	150
NPV @ 5 188.26	–970	142.86	136.05	129.58	123.41	117.53	111.93	106.6	101.53	96.691	92.087
NPV @ 10 –48.31	–970	136.36	123.97	112.7	102.45	93.138	84.671	76.974	69.976	63.615	57.831
Continuous *r*											
NPV @ 5 181.14	–970	142.68	135.73	129.11	122.81	116.82	111.12	105.7	100.55	95.644	90.98
NPV @ 10 –68.44	–970	135.73	122.81	111.12	100.55	90.98	82.322	74.488	67.399	60.985	55.182

Continued

Project 2. Gringoland Coral Mining

	Years										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Costs (thousands of $)											
Extraction costs	3000										
Costs of coastal erosion	200	200	200	200	200	200	200	200	200	200	200
Benefits											
Revenues from limestone	4500										
Net	1300	–200	–200	–200	–200	–200	–200	–200	–200	–200	–200
NPV @ 5 –244.35	1300	–190.5	–181.4	–172.8	–164.5	–156.7	–149.2	–142.1	–135.4	–128.9	–122.8
NPV @ 10 71.09	1300	–181.8	–165.3	–150.3	–136.6	–124.2	–112.9	–102.6	–93.3	–84.82	–77.11
Continuous *r*											
NPV @ 5 –234.86	1300	–190.2	–181	–172.1	–163.7	–155.8	–148.2	–140.9	–134.1	–127.5	–121.3
NPV @ 10 97.92	1300	–181	–163.7	–148.2	–134.1	–121.3	–109.8	–99.32	–89.87	–81.31	–73.58

■ Discussion Question

Should humans place an economic value on the environment? Using debate Box 2.1, discuss the issues related to the monetization of nonmarket values. Can you think of a local example where this is relevant? Is this example controversial?