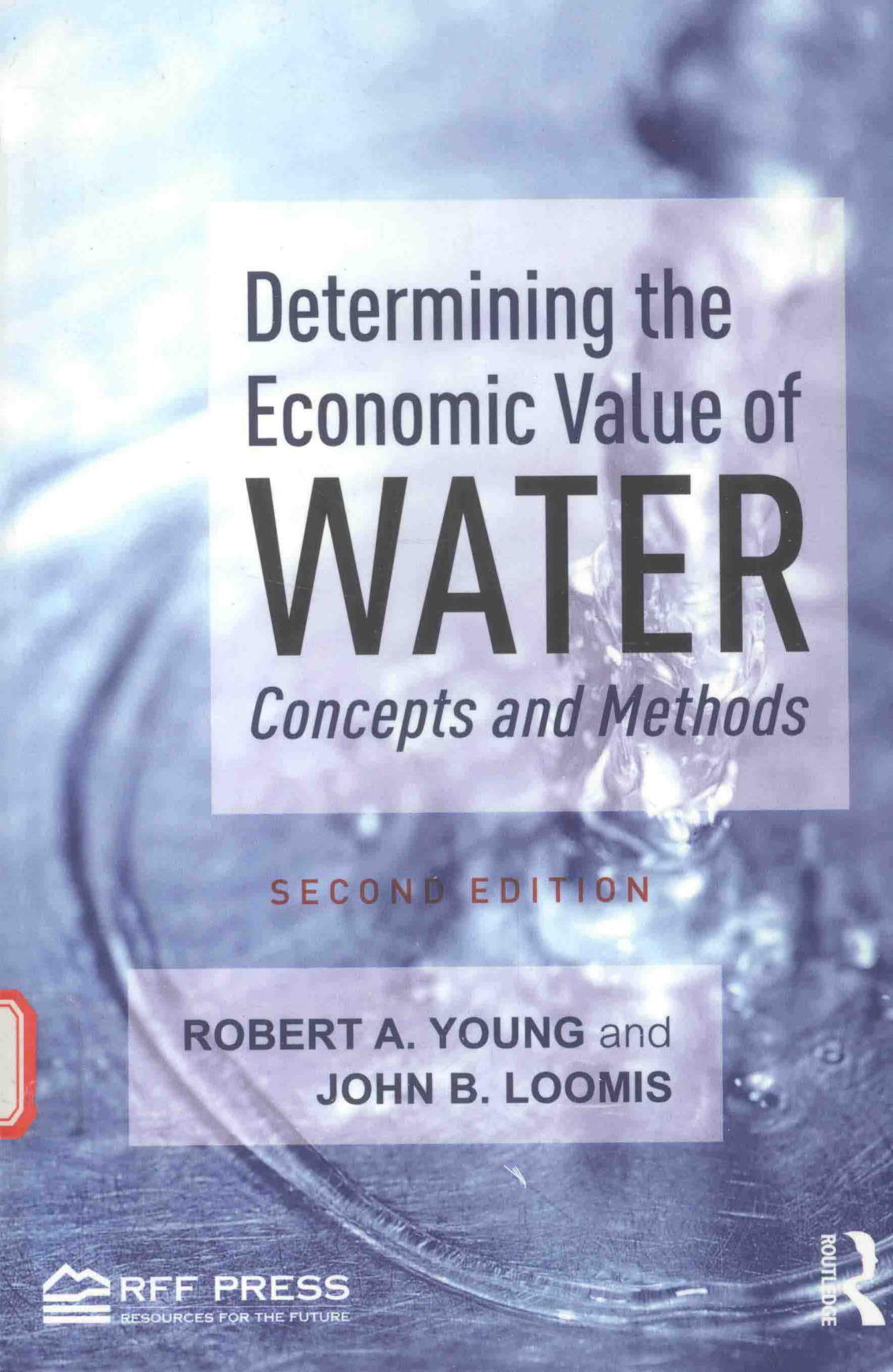
Determining the
Economic Value of
WATER
Concepts and Methods
SECOND EDITION
ROBERT A. YOUNG and
JOHN B. LOOMIS
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ROUTLEDGE

# Determining the Economic Value of Water

## Concepts and Methods

2nd Edition

Robert A. Young and
John B. Loomis

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# Author Biographies

**Robert A. Young** was a faculty member at University of Arizona before joining the faculty at Colorado State University in 1970. He was a faculty member in the Department of Agricultural and Resource Economics for twenty-one years, and then was Professor Emeritus until his death in 2013. He had worked as a water policy consultant for the World Bank and the United Nations. Young's research interests were in water supply and quality, particularly in the case of offstream water uses, in agriculture, municipalities, and industry. Young's research has received awards from the American Agricultural Economics Association, the Western Agricultural Economics Association, the American Water Resources Association, and the Warren A. Hall Medal for Distinguished Contributions to Water Resources.

**John B. Loomis** joined the faculty at Colorado State University in 1993, after being an Associate Professor at University of California-Davis. Previously he worked as an economist for two agencies in the U.S. Department of Interior. Loomis' primary research interests are in non market valuation of water resources such as recreation, instream flow, endangered species, and public lands. Loomis' research has received several awards including from the Agricultural and Applied Economics Association. He was elected Vice-President of the Association of Environmental and Resource Economists, and was selected as a Fellow of that Association in 2013. He was also selected as a Distinguished Scholar of the Western Agricultural Economics Association in 2006. He was selected as a Fellow of the Agricultural and Applied Economics Association in 2014.

# Preface to the Second Edition

The second edition to this book began when Bob Young asked me to join him in updating and revising his encyclopedic first edition of this book. It was with some trepidation that I agreed, as Bob Young was one of the most experienced (forty plus years) and knowledgeable water economists in the world. Our first step involved a revised outline for the book that is reflected in this second edition. As the book progressed, Bob's comments on my revisions of several chapters reinforced my view that he was an insightful water resource economist. Bob Young was also a true scholar in the broad sense of the word: well-read and reflective and he set this scholarly standard in everything he did including this book. It is with much sadness that I must report that several months before the book was completed he suddenly passed away. Bob's wife (Lynn) and I were determined that this second edition would be finished, and finished in a way that would make him proud to have his name on it. We hope we have achieved that very high standard.

Part I of the book on the Concepts and Theory was updated and refined to reflect advances in the way economists think about water resources in the twenty-first century. The biggest change the reader will see is in Chapter 4 on what was valuation of water as environmental public goods. Since this is my specialty, and part of the reason Bob asked me to join him in this revision, this chapter was reorganized around the now widely accepted and used ecosystem goods and services framework. In addition this is an area where great advances have been made in the last decade. In particular, techniques for nonmarket valuation of public goods have been significantly refined and broadened to value several aspects of water-related ecosystem goods and services that were not previously valued.

Part III of the book, on Application of Valuation Methods, has been updated with recent evidence of and more extensive discussion of water markets for agriculture (Chapter 5) and municipal uses (Chapter 7). Chapter 5 now has more and updated references and discussion on the use of optimization models and computable general equilibrium models for valuation of water in agriculture. Chapter 6, on industrial uses of water, has been expanded to include discussions of water in energy production with an emphasis on biofuels and hydraulic fracking for oil and gas production. The chapter on empirical methods for valuing ecosystem services has been updated and expanded to discuss the advances that have been made in choice experiments and

other nonmarket valuation techniques. An extensive literature review on the benefits of reducing nonpoint source pollution is now provided.

Overall, I feel that this second edition reflects Bob Young's and my joint vision for what an updated second edition of this book would look like. We hope graduate students and our colleagues continue to find it a useful book and a handy reference on accepted techniques for valuing all the many uses of water resources.

John B. Loomis

# Preface to the First Edition

Water economists are called upon to answer some difficult questions:

- What types of goods and services are produced by water? Why are prices for water seldom observed on normal commodity markets?
- What do economists mean by "value" or "benefits" in relation to water resources? Is the economic benefit of an increment of water the same at all times and places and for all purposes? Why are estimates of water-related policy benefits important?
- What nonmarket valuation methods can be used to estimate economic benefits of water-related policies? Which methods are most appropriate for producer goods and which for consumer goods uses of water?
- How are the various methods applied in practice? What are their advantages, limitations, and appropriate roles?

Water management, historically always important, is an increasingly timely subject. In its varied forms, the water resource supplies important benefits to humankind, ranging from commodity-type benefits in agriculture, industry, and households to environmental values, including biodiversity and recreation. However, significant water management problems can be found throughout the world, and in many areas they are rapidly becoming worse. Growing populations and incomes increase demands for water for agricultural, industrial, and residential uses from limited surface and ground water supplies. These same forces of economic and population growth add to the pollution discharged to the world's waterways, and to the encroachment of human activities upon lowlands vulnerable to flooding or upon important natural ecosystems. Increased prosperity carries with it amplified demand for improved water quality, for more access to recreational and amenity uses, and for the preservation of biodiversity and natural ecosystems.

The price signals which reflect scarcities of goods and services and which are successfully used to guide investments and resource allocation in the private sector are usually absent or distorted for water, complicating public sector decisionmaking related to the resource. A premise of this work is that, although market prices will play an increasing role in water allocation, the market's function will continue to be

limited; consequently, applied economic valuation procedures can play an important role in guiding public policies related to water. To address the many public policy issues arising when markets are absent or imperfect, economic researchers and practitioners have adapted the neoclassical economic model to public policy decisions, developing the evaluative procedure termed cost–benefit analysis. A major portion of that effort has been devoted to formulating, perfecting, and applying nonmarket methods for measuring benefits, forgone benefits, and costs of proposed public policies and programs relating to the natural environment. These efforts have often been directed to evaluation of changes in water resource supplies and quality. Tools have been developed and refined which are conceptually consistent with market prices and which permit increasing confidence in bringing economic efficiency considerations to bear on public decisions relating to water (and other environmental resources).

This book is broadly about putting a monetary value on goods and services provided by water. More formally, it is intended to introduce the reader to the application of welfare economics principles to the measurement of economic benefits in the context of assessing water-related policies (intersectoral water allocation and reallocation, investments or policies to augment water supplies or qualities, pricing, or other water planning decisions). A major aim is to provide professional economists (both field practitioners and advanced students) with a consistent conceptual foundation for comparing the economic values of water across alternative uses and with costs of investments. It will show readers the concepts and techniques for applying alternative empirical approaches to measuring the economic benefits of water-related policies or investments, illustrate how to understand the strengths and weaknesses of these alternative approaches, and provide guidance to the more technical literature.

For several reasons, the emphasis here inclines toward offstream and private good issues, valuing water in agricultural crop irrigation, industrial, and municipal uses. First, my professional research has mainly focused on such issues. Second, although there is considerable diverse literature on valuation of water in offstream private good cases, there is no single volume that attempts to integrate this literature with the much more fully developed literature on valuation of environmental goods and services. Moreover, nonmarket methods for valuing water in the production sectors have not received the comprehensive attention devoted in recent decades to environmental issues. Agriculture accounts for the largest consumptive use of water in the United States and worldwide, and industries are also important water users. Accordingly, this volume gives special emphasis to valuing water as a producers' good; it critiques a number of methods frequently employed, and proposes improved approaches. Thus, it attempts to fill the gap in the existing literature regarding application of nonmarket valuation techniques to commodity uses of water in agriculture, industry, and municipalities in a framework consistent with that already well-developed for public environmental goods and services.

The book is organized as follows: Part I sets the stage. Chapter 1 identifies the physical, economic, and social attributes of water and describes a number of standard water policy issues for which economic analysis is frequently needed. Chapter 2 briefly reviews the basic conceptual and analytic issues underlying the neoclassical

approach to the economic valuation of water. Chapter 3 introduces applied methods of nonmarket valuation, reviews the procedures appropriate to measuring water values in producer uses of water, and describes their advantages and limitations. Chapter 4 covers issues of applied benefit measurement for consumer uses of water, primarily public good benefits (such as obtained from water-based recreation, preservation values, and water quality enhancement).

Part II describes and evaluates applications of the various methods to specific water use categories. Chapters 5, 6, and 7 discuss the applications of these methods to offstream or withdrawal uses in agriculture, industry (including hydropower), and municipalities, respectively. Methods and applications of measuring the value of water as public environmental goods are addressed in Chapter 9, which reviews methods for addressing such issues as instream flow valuation, and environmental preservation.

The scope is mainly limited to the estimation of direct benefits (and benefits forgone) of water-related policies. A number of broader treatments of the principles of cost–benefit analysis—including the validity of secondary benefits, the rate of discount, the planning horizon, decision criteria, and the general issues of setting up and performing a cost–benefit analysis—are available (e.g. Fuguitt and Wilcox 1999; Boardman et al. 2011, etc.).

The analysis should be, for the most part, accessible to those with training in microeconomic theory, mathematics, and statistics at the upper-division, undergraduate level. The text should also be helpful to water engineers, environmentalists, planners, policymakers, and other noneconomists who make use of water valuations or who interact with economists on water policy and planning activities. It should be a useful adjunct to more general textbooks in academic courses in natural resource and environmental economics and in water planning and management. To the reader and potential user of the materials presented here: *caveat emptor.* First, no single magic number represents the economic benefits of water used for any given sector. Just as the market prices for goods and services are typically specific as to *place, form,* and *time,* nonmarket valuations (often called accounting prices) for water also vary according to these dimensions. They further vary with the situation, the underlying factors, and the policy proposal being evaluated. Given the relative lack of transportability of both the public and private attributes of water, values for water can be expected to vary even more widely than do prices for more conventional goods and services.

Second, noneconomists and those economists who are new to the field should be aware that accurate economic valuation of the impacts of water-related polices is seldom quick, easy, or simple. Developing appropriate and reliable estimates of the value of water requires substantial skills, time, and research resources. To adequately perform the assignment calls for command of many if not most of the technical skills of the applied economist. Rigorous estimation of economic benefits of water policies and projects must begin with a close understanding of microeconomic theory. Successful shadow pricing of water in any particular use will further demand proficiency in one or more forms of quantitative economic modeling. Competence

with advanced statistical and econometric techniques is a necessity for developing sound contingent valuation, travel cost, and hedonic price estimates. Probably the quantitatively least demanding of the commonly used methods of valuing water and other nonmarket environmental goods are simple benefit transfer techniques, but advanced approaches here too call for considerable statistical skills. For valuing water as a producers' good, an essential foundation is familiarity with production theory, business accounting, and spreadsheets. Moreover, mathematical optimization and computable general equilibrium modeling are increasingly used for addressing this type of problem. Finally, careful collection of accurate and representative primary data or selection of adequate secondary data is an often underemphasized requirement. Only a handful of economists have the training, native abilities, resources, and time to become proficient in more than a few of the many types of issues that arise in shadow-pricing. Specialization, as elsewhere in the economy, is here a necessity.

This volume arose from numerous assignments and collaborations during my work on water economics over the past four decades. I became interested in water valuation as applied to arid-area water policies in the mid-1960s working with William Martin and the late Maurice Kelso at the University of Arizona. Subsequently, as a visiting scholar at Resources for the Future, I was fortunate to collaborate with Charles Howe in several research efforts, an association that has continued intermittently since we moved to different state universities in Colorado. Applied economic valuation of water became a major research focus of mine at Colorado State University where, with Lee Gray and others, a two-year effort for the National Water Commission developed a conceptually consistent framework for estimating the economic value of water in alternative uses and applied it to various regions across the United States (Young and Gray 1972). Research and consulting assignments with the U.S. Agency for International Development, the World Bank, and the Asian Development Bank provided an international dimension to the research agenda. Particular thanks are extended to Lee Gray for his valuable contributions to the conceptualizations and implementations of specific valuation techniques and, more recently, for his administrative support. For over two decades I taught a graduate course in water resource economics at Colorado State University which emphasized water valuation techniques, and supervised graduate students' research in water economics. Numerous students, both in the classroom and in applied research, posed valuable questions and challenges to the concepts and methods discussed here. Several years ago, in a consulting capacity, I prepared a technical report on water valuation for the World Bank (Young 1996). More recently, the Government of Switzerland provided a grant to the World Bank that enabled me to update and expand that work toward completion of this monograph.

Robert A. Young

# Acknowledgements


## Second Edition

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## First Edition

Particular acknowledgments are due to Ariel Dinar of the World Bank for encouragement and support of this effort and for discussions and advice on the subject and content of the work. Several anonymous reviewers provided useful and insightful suggestions for improvements on earlier drafts. Susanne Scheierling deserves special mention; while on leave from the Asian Development Bank, she read and commented on the entire draft manuscript and was very helpful in improving both the content and the presentation. I am grateful to all of those mentioned above for help in refining and clarifying the ideas presented here.

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