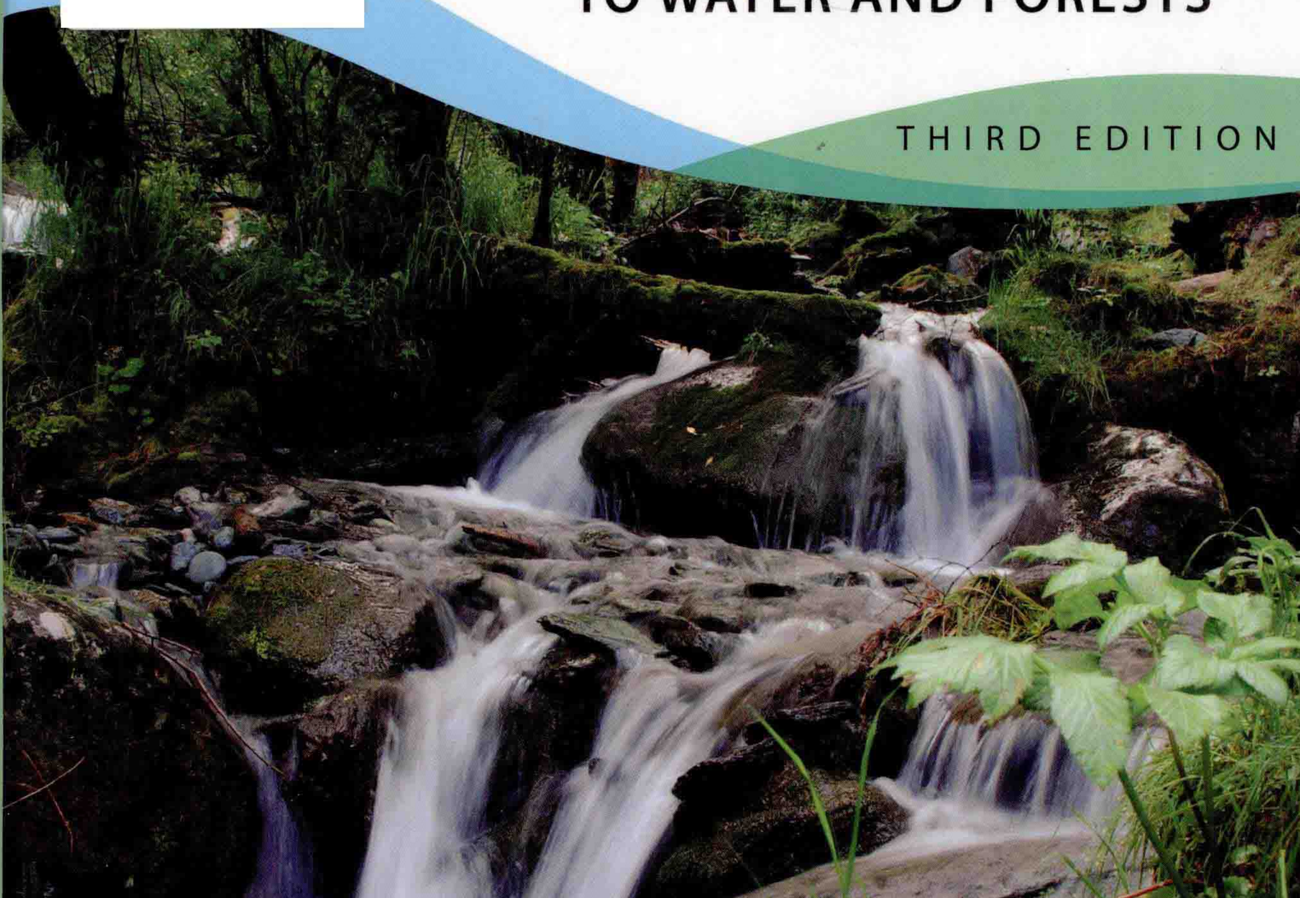
FOREST HYDROLOGY

AN INTRODUCTION TO WATER AND FORESTS



THIRD EDITION

MINGTEH CHANG

CRC Press
Taylor & Francis Group

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A nation that fails to plan intelligently for the development and protection of its precious waters will be condemned to wither because of its shortsightedness. The hard lessons of history are clear, written on the deserted sands and ruins of once proud civilizations.

It is important that we have a composite, national view of water problems and needs if we are to attack them intelligently and comprehensively.

Lyndon B. Johnson
XXXVI President of the United States (1963–1969)
"Letter to the President of the Senate and to the Speaker of the House: Transmitting an Assessment of the Nation's Water Resources," November 18, 1968

Conversions of Basic Units Used in the Book

Length	1 meter (m) = 10^6 micrometers (μm) = 10^3 millimeters (mm) = 10^2 centimeters (cm) = 10^{-3} kilometers (km) = 39.37 inches (in.) = 3.28 feet (ft) = 6.215 (10^{-4}) miles (mi)
Area	1 hectare (ha) = 10^4 m^2 = 10^{-2} km^2 = 2.47 acres (ac) = 3.86(10^{-3}) mi^2
Volume	1 m^3 = 10^6 cm^3 = 10^3 liters (L) = 35.3 ft^3 = 264.2 gallons (gal) = 40.857(10^{-3}) ft^3 s-day^{-1} = 8.11(10^{-4}) ac-ft = 10^{-4} ha-m
Mass	1 kilogram (kg) = 10^3 grams (g) = 10^6 milligrams (mg) = 2.204 pounds (lb)
Velocity	1 m $second^{-1}$ = 3.28 ft s^{-1} = 3.6 km $hour^{-1}$ = 2.2374 mi h^{-1} = 1.944 knots
Discharge	1 m^3 s^{-1} = 35.3 ft^3 s^{-1} = 2.26(10^7) gal day^{-1} = 15.8(10^3) gal min^{-1}
Density	1 kg m^{-3} = 10^{-3} g cm^{-3} = 10^3 mg L^{-1} = 6.245(10^{-2}) lb ft^{-3}
Force	1 newton (N) = 1 kg-m s^{-2} = 10^5 g-cm s^{-2} (dynes) = 0.225 lb
Work	1 N-m = (1 kg-m s^{-2})(m) = 1 kg-m^2 s^{-2} = 10^7 dyne-cm (or erg) = 1 joule (J)
Power	1 watt (W) = 10^{-3} kW = [(kg-m s^{-2})(m)]/s = 1 J s^{-1} = 1.3406(10^{-3}) horsepower (hp) = 0.7373 ft-lb s^{-1} = 3.413 Btu h^{-1}
Energy	1 calorie (cal) = 4.186 J = 3.968(10^{-3}) British thermal units (Btu) = 3.088 ft-lb
Energy flux	1 cal cm^{-2} $minute^{-1}$ = 1 langley min^{-1} = 697.80 W m^{-2} = 3.6864 Btu ft^{-2} min^{-1}
Pressure	1 millibar (mb) = 10^{-3} bar = 9.872(10^{-4}) atmosphere = 0.75 mm Hg = 0.0145 lb $in.^{-2}$ = 10.20 kg m^{-2} = 1.019 cm of water = 100 pascal (Pa) = 0.1 kPa = 10^3dynes cm^{-2} = 100 N m^{-2}
Dynamic viscosity	1 poise = 100 centipoise = 1 dyne-s cm^{-2} = 0.1 N-s m^{-2}
Shear stress	1 N m^{-2} = 1 Pa
Soil erosion	1 metric ton ha^{-1} $year^{-1}$ = 0.445 ton ac^{-1} yr^{-1}
Rainfall factor	$R = EI_{30}/100$, which is in: [(m-metric ton/ha-cm)(cm)](cm/h) = m-metric ton-cm/ha-h = 0.5764 ft-ton-in./ac-h
Thermal conductivity	1 cal/[s cm^2 °C cm^{-1}] = 1 cal s^{-1} cm^{-1} °C^{-1} = 418.4 W m^{-1} K^{-1} = 418.4 J cal s^{-1} m^{-1} °C^{-1} = 241.747 Btu cal h^{-1} ft^{-1} °F^{-1} = 1506.24 kJ cal h^{-1} m^{-1} K^{-1}
Electrical conductivity	1 siemen m^{-1} (S m^{-1}) = 10 mmho cm^{-1} = 10^4 μmho cm^{-1}

Preface

This third edition of *Forest Hydrology: An Introduction to Water and Forests* arrives 11 years after the 2002 publication of the first edition. During the past 11-year period, global warming was more apparent, weather-related natural disaster more severe, water shortage more critical, and concern on the forest–water relation more widespread than any of its preceding decades. It becomes necessary to publish a new edition for the text of *Forest Hydrology* to (1) update resources and environmental data, (2) add new research findings and technology, (3) address the concerns and issues regarding forests and climate change, (4) incorporate comments and suggestions, and (5) improve comprehensiveness. The book was 12 chapters and 3 appendices in the original edition, expanded to 14 chapters and 4 appendices in the second edition, and is now 16 chapters and 4 appendices in the third edition. There are also 14 new tables, 24 new figures, and many new sections that have been added to the current edition.

As stated previously, this book is based on lecture material in "forest hydrology," offered to undergraduate and postgraduate students in the Arthur Temple College of Forestry and Agriculture at Stephen F. Austin State University, Texas. As is the case in many forestry programs in the United States, forest hydrology (or watershed management) is the only required course in water sciences in the curriculum. Because students are new to the subject, it is necessary to cover some basic topics in water and water resources before discussing topics in forest hydrology.

Although a few texts on forest hydrology are available for college students, they cover very little or none of the background on water resources. On the other hand, books dealing with water resources do not cover topics on forest–water relations. This book intends to fill that gap and provides an introduction to forest hydrology by bringing water resources and forest–water relations into a single volume and broadly discusses issues that are common to both. It focuses on concepts, processes, and general principles; hydrologic analyses are not emphasized here.

Subjects in the 16 chapters are arranged in two general groups with one linkage in between. The first six chapters (Chapters 1 through 6) deal with the introduction and basic background in water and water resources, while the last nine chapters (Chapters 8 through 16) address the impact and study of forests on water (Chapters 8 through 14), watershed management planning (Chapter 15), and forest hydrology research (Chapter 16). Between these two groups is a chapter (Chapter 7) that describes forests and forest characteristics important to water circulation, sediment movement, stream habitat, and climate change. It serves as an entrance to the study of forest impacts on water resource—as a bridge connecting water and forests.

The impacts of forests on water are separately discussed in terms of precipitation, vaporization, streamflow quantity, streamflow quality, stream sediment, stream habitat, and flood in Chapters 8 through 14. Topics in streamflow quantity and quality jointly discussed in a single chapter in the second edition are now separately discussed, as suggested by Dr. Y. Jun Xu of Louisiana State University at Baton Rouge, LA, United States, in two individual chapters. This is partly due to water quality as an important issue in forest hydrology and partly due to the size of the streamflow chapter in its previous version.

The creation of Chapter 15, Watershed management planning and implementation, is in response to the comments of Dr. D. E. Leaman of Leaman Geophysics in Australia and others. It outlines the transfer of the science of forest hydrology into practices at the watershed scale—the applications of forest hydrology in watershed management. A chapter dealing with watershed management in a forest hydrology text makes the book "more appealing to both forest hydrology and forest watershed management classes," as commented by Dr. Richard Schultz of Iowa State University at Ames, Iowa.

Research is fundamental in all sciences. A chapter designated for research in forest hydrology provides a foundation for students who might need to conduct investigations and resolve watershed problems in carriers. Accordingly, Chapter 16 is designed to deal with research issues, objectives, principles, and methodology in forest hydrology, along with a step-by-step numerical example on watershed calibration and assessment of treatment effects. Such information is basic in watershed research and helpful to those who might pursue graduate studies.

Most books incorporate hydrologic measurements in the main text. This book presents measurements in four appendices. They include precipitation, streamflow, stream sediments, and forest interception; topics on each type of measurement cover general background, available instruments, and sampling procedures. Since there are relevant models presented in the text, the appendices do not cover the measurement of evapotranspiration. Also, hydrologic modeling is beyond the scope of this book.

The use of mathematical expressions is inevitable in subjects such as hydrology and other earth sciences. This book uses mathematical equations in forms for which knowledge of college algebra and trigonometry are sufficient for understanding. Readers with less mathematical background can skip the difficult equations without hindering their comprehension. In such cases, professors may wish to place more emphasis on the forest impacts, as discussed in the latter part of each chapter, and discuss only the basic hydrologic processes important to the understanding of the impact. The book can be used as a text for students in agriculture, forestry, and land resources management, and as a reference for foresters, rangers, geographers, watershed managers, biologists, agriculturists, environmentalists, policy makers, engineers, and others who may need such background in their professions.

Mingteh Chang

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Author

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