Preface

Ecological surprises are not that uncommon – they often emerge when we overlook the subtle signs of cascading causes and effects from seemingly inconsequential perturbations in our surroundings. Take an example of a corn chip that you might dip into your salsa sauce. Who would guess that the corn chip can be linked to shrimp mortality in the Gulf of Mexico and global warming? The surprising interconnections can be traced back to a cornfield along the Mississippi River, where a farmer growing a crop destined for corn chip production may routinely add more fertilizer than is required by the corn plants. From that simple initial action, at least two unintended consequences may follow. First off, the addition of excess nitrogen fertilizer to the soil is likely to stimulate increased microbial production of the greenhouse gas N_2O that contributes to increased warming potential of the atmosphere. A second major outcome occurs when the excess fertilizer is transported by drainage waters into the nearby river system and is ultimately delivered downstream to coastal waters in the Gulf of Mexico. There, the farmer's fertilizer contributes to a process of nutrient enrichment and eutrophication that transforms the Gulf waters into a massive "dead zone" where dissolved oxygen levels are too low to sustain shellfish and other marine organisms.

The anoxic Gulf coast waters are a symbol of the adverse environmental externalities that often accompany human activities. Many of the current and emerging issues regarding water quality, food production, deforestation, climate change, atmospheric pollution, and human health are linked inextricably to humans and their influence on the cycles of nutrients and contaminants in the biosphere. As we confront the challenges of sustaining environmental quality in the twenty-first century, our progress will depend in part on our ability to understand the intricate and diverse interactions of global chemical cycles with living systems. It is those cycles, processes, and feedbacks that are the focus of this textbook on the subject of biogeochemistry.

Biogeochemistry is an interdisciplinary science that integrates the study of biological, ecological, geochemical, and hydrologic patterns and processes in an effort to understand how biologically active elements and compounds interact with living organisms. The goal of this book is to provide a learning tool that will allow readers to gain biogeochemical insights and critical thinking skills that can be applied to careers in watershed science, ecosystems analysis, ecology, global change science, and environmental science.

This textbook presents a comprehensive process-oriented approach to biogeochemistry that is intended to appeal to readers who want to go beyond a general exposure to topics in biogeochemistry, and instead are seeking a holistic understanding of the interplay of biotic and environmental drivers in the cycling of elements in forested watersheds. The book is organized around a core set of **ecosystem** processes and attributes that collectively help to generate the whole-system structure and function of a terrestrial ecosystem. In the first nine chapters, a conceptual framework is developed based on distinct soil, microbial, plant, atmospheric, hydrologic, and geochemical processes that are integrated in the element cycling behavior of watershed ecosystems. With that conceptual foundation in place, readers then proceed to the final three chapters where they are challenged to think critically about integrated element cycling patterns; biogeochemical models; the impacts of disturbance, stress, and management on watershed biogeochemistry; and linkages among patterns and processes in watersheds experiencing environmental changes.

The organization and content of this biogeochemistry text are intended to provide an engaging and fresh alternative to existing references on this topic. Many of the well-known books on biogeochemistry focus on nutrient cycling patterns in specific local long-term watershed study sites such as Hubbard Brook Experimental Forest in New Hampshire (Likens et al. 1977, 2013; Bormann and Likens 1996) and the Walker Branch Watershed in Tennessee (Johnson and Van Hook 1989). The current alternative to those books is the widely-adopted *Biogeochemistry: An Analysis of Global Change* by Schlesinger and Bernhardt (2013) that offers a global-scale overview of major element cycles in terrestrial, freshwater, marine, atmospheric, and wetland sectors of the earth. There are thus several more narrowly focused case studies at one end of the spectrum, compared with a global-scale overview of biogeochemistry at the opposite end of the spectrum.

In comparison with those existing instructional resources, this biogeochemistry textbook is distinctive in two key respects: (a) it provides a unified emphasis on forested watershed ecosystems that is more process-oriented, detailed, and pedagogical than the single watershed case studies; and (b) unlike the broader, global scope of the reference by Schlesinger and Bernhardt, this book specifically delivers a coherent synthesis of biogeochemistry at the watershed ecosystem scale – the most common landscape unit for current research and resource management. Using this text as an introduction to biogeochemistry, students will achieve a level of subject mastery and disciplinary perspective that will permit them to see and to interpret the individual components, interactions, and synergies that are represented in the dynamic element cycling patterns of watershed ecosystems. In many respects, this book is intended to serve as an operational manual that examines how forested watersheds work with respect to fundamental parts, processes, interrelationships, whole-system behavior, and responses to changing conditions.

The text that follows provides an introduction to the biogeochemistry of terrestrial watershed ecosystems, with a major emphasis on forested systems. The subject treatment emphasizes concepts, principles, and patterns, and includes selected examples from the literature. The intent of the illustrations and tables is to provide visual examples of biogeochemical observations, rather than a comprehensive comparison of data from different ecosystems. A number of the examples of data are based on research by the author and his colleagues, because those research results provide simple illustrations for points that are emphasized by the author in his graduate class. To complement those specific regional examples, the author requires students in his class to read and to discuss a broad range of other research studies from the primary literature.

It is hoped that this book will provide readers with a clear and meaningful introductory framework for understanding biogeochemical principles and processes that apply to pristine or human-dominated watershed ecosystems. The goal of this textbook is to present the fundamental biogeochemical patterns and processes common to forested watershed ecosystems and to examine how biogeochemistry varies in response to changing environmental conditions in the landscape.

Note: Words printed in **bold print** within the text are defined in the glossary at the end of this book.

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