

Delphis F. Levia, Darryl Carlyle-Moses, and Tadashi Tanaka (eds) *Forest Hydrology and Biogeochemistry: Synthesis of Past Research and Future Directions*.

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This edited volume is an ambitious compilation of research on forest hydrology and biogeochemistry. The book is divided into six major sections (number of chapters): I Introduction (1); II Sampling and Novel Approaches (7); III Forest Hydrology and Biogeochemistry by Ecoregion and Forest Type (8); IV Hydrologic and Biogeochemical Fluxes from the Canopy to the Phreatic Surface (9); V Hydrologic and Biogeochemical Fluxes in Forest Ecosystems: Effects of Time, Stressors, and Humans (10); and VI Knowledge Gaps and Research Opportunities (1). The 36 chapters have a total of 75 authors that represent a broad spectrum of scientists including well-established investigators. There are also other authors who are earlier in their careers, but who are making substantial contributions to their respective disciplines. The geographical representation of the authors is outstanding, including individuals from Asia, Australia, Europe, North America, and South America. As would be expected due to the predominance of hydrological and biogeochemical research in Europe and North America, there is greater coverage of findings from these latter two continents. However, some chapters provide important new information from other areas such as the lowland tropics and mangroves. Hopefully this book will serve as a catalyst for investigators to broaden and intensify research efforts in less studied regions such as central Asia, Africa, and South America. There is considerable attention in the book at the watershed spatial scale, but there are also various treatments that look at a broad range of

spatial scales ranging from hillslopes to entire landscapes.

The book begins with a useful review that places the current volume in a historical perspective. There have been substantially different origins in the development of the study of biogeochemistry and hydrology and only recently have these areas of investigation merged. Some of this integration coincided with the IBP (International Biological Program) (1964–1974) that clearly showed the importance of multidisciplinary science in addressing important ecosystem science questions and the development of new approaches including the implementation of small watershed research. This integration has produced a cadre of investigators who have actively embraced and engaged in interdisciplinary research in biogeochemistry and hydrology.

As is often the case for edited volumes with multiple chapters and authors, the coverage and level of detail among the chapters are highly variable. Some chapters begin with an overall review of the subject area and in some cases a summary of the basic science. Other chapters are more oriented to recent research findings. The chapters vary in the coverage of research sites with some having a narrow focus on an individual site or a small group of sites while others provide a broad overview including a synthesis across sites. Each chapter stands alone with its own separate list of references. In only a few cases are the chapters cross-referenced.

Dominant themes throughout the book include understanding the influence of spatial and temporal variability and patterns on hydrologic and biogeochemical patterns. This continues to be a major challenge in the field due to the high level of heterogeneity often manifested both within and among watersheds. Over the past 30 years there have been major research efforts that have been accomplished as a result of concerns about the impacts of ‘acid

rain'. The understanding of acidic deposition has been especially important to the advancement of biogeochemistry, but the importance of hydrology including the influence of flow paths has been more clearly established. Currently, more attention is being directed to the effects of 'climate change' providing a major challenge to the research community to provide information of what is currently known, as well as what needs to be known, about climatic effects on the hydrology and biogeochemistry of forests. The global and regional needs associated with the evaluation of climate change effects serve as a major impetus to integrate across spatial scales. It is important to identify what major components and processes need additional attention if we are to be able to understand and potentially predict the impacts of climate change and other major anthropogenic factors such as the shift of a higher proportion of human populations into cities. Providing new information, including predictions of how various scenarios affect forest hydrology and biogeochemistry, will be important not only to scientists, but also to policy-makers.

The availability of satellite imagery and other techniques (e.g. LiDAR) for collecting spatial data, including the development of digital terrain models (DTMs), has greatly expanded the evaluation of spatial patterns. The high level of belowground heterogeneity within the solum at many locations serves as a major obstacle in interpretation and integration. Relating this belowground variation to the spatial topographic patterns, which are more easily measured at the surface of the forest floor, is a major challenge. Evaluating temporal patterns and scales are also clearly identified as a critical need in understanding climatic driven effects. These temporal patterns range from long-term landscape changes (e.g. land use, geomorphic alterations, biotic changes) to short-term events (e.g. hurricanes, droughts, ice storms) all of which affect hydrological and biogeochemical

relationships. These scale issues, both spatial and temporal, are addressed in many of the chapters.

Interesting linkages are discussed on those factors, including temporal changes, that affect the connectivity and the resident times of various water pools. Various models involving both chemical (e.g. EMMA) and hydrological (e.g. TOPMODEL) approaches are discussed. The use of combined techniques is certainly needed but requires substantial funding and a multidisciplinary approach. Also, the comparisons of results using various approaches such as EMMA, hydro-metric analyses, stable isotopes, mass balances, etc. need more attention.

There have been recent technical developments, especially related to hydrology, including remote sensing, sensor networks, cyberinfrastructure and modeling, but such techniques are not as well developed for biogeochemistry. There is a need to evaluate a broad range of chemical species and their interactions with physical, chemical and biological components. Further attention needs to be addressed on analytical chemical issues including the characterization of dissolved organic matter (DOM) and the various fractions including the relative amounts and forms for dissolved organic carbon (DOC), nitrogen (DON), and sulfur (DOS). There is a paucity of information on linking these components to biological processes. It is anticipated that the development of novel sensors, their deployment and ability to integrate their measurements will continue to expand for biotic, chemical, and physical measurements.

This book does an especially good job of addressing some major biogeochemical issues and physical aspects of hydrology and biogeochemistry that will be influenced by climate change. Some of the chapters address directly the role of vegetation in affecting hydrology and biogeochemistry, but there is much less emphasis on belowground microbiological processes. There have been major advancements in the evaluation of water flowpaths starting with

the water entering the forest canopy and being directed and biogeochemically altered as throughfall, stemflow, forest floor water, soil water, groundwater, and surface water. How the water is moved and stored and biogeochemically transformed has been a dominant theme of forest hydrobiogeochemistry and more recently there has been greater attention given to the biological role as captured within the field of ecohydrology. It is shown, moreover, that the dynamics of groundwater needs more attention since this pool and associated fluxes play a major role in watershed biogeochemistry, but have not been studied at the same level of detail as soil and surface waters. Clearly one of the major challenges is maintaining and expanding those research sites that provide long-term records of hydrology and biogeochemistry. In addition to the sites themselves, the continuation and development of various networks such as GTN-H, LTER, ILTER, FluxNet, NEON and many others need to be fully supported.

The final chapter summarizes some of the major findings of the book in a limited way and does not completely address the priorities for

going forward with respect to forest hydrology and biogeochemistry. There is certainly sufficient and detailed information in the book that should be helpful in setting such future priorities, but possibly this will need to be done within the various disciplines that contribute to the understanding of the hydrology and biogeochemistry of forest ecosystems.

This book will be a valuable resource for investigators in the field of hydrology and biogeochemistry of forested ecosystems. The book provides a compilation of a large body of topics with an extensive coverage of the literature. Currently some integration of the various areas of forest hydrology and biogeochemistry is included within research that focuses on the 'critical zone' that can be defined as the Earth's outer layer from the vegetation canopy to the soil and groundwater that sustains the biota including human life. Most readers will likely focus on those specific chapters that most clearly match their individual research interests. Various chapters will also serve as useful sources of information and topics for discussion in graduate-level courses that address hydrological and/or biogeochemical topics.

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