

Preface

The purpose of this book is twofold. First, I wish to present my approach to and understanding of hydrology. That approach is best designated as "Watershed Hydrology." Second, I hope to provide students of hydrology with a wildland-oriented text with a focus on storage. My understanding is one born of courses in both engineering and ecological hydrology, by practicing field work and research, and through my consulting experience. I have seen engineers who have paid little attention to the natural world around them, and environmentalist protectionists who have paid little attention to the realities of water as a physical entity in the environment. My organization is based on scientifically founded knowledge of the hydrologic environment in its natural state. This posture is essential in order to comprehend the interactions of natural hydrologic events and the impacts of our inadvertent and planned activities on that environment.

Generally this book is about the *ecology* of watershed hydrology. A watershed is a natural unit of land from which the surface, subsurface, and ground water runoff drain to a common outlet. Hydrology is the study of water in the natural environment; the study of the laws, principles, processes, quantity, and quality of water movement and storage. In this book, the emphasis is on wildlands. *Watershed hydrology*, then, is simply the study of the movement and storage of water on and in the context of the natural land unit of the hydrosphere, the watershed.

Why another book on hydrology? Obviously, none of them fill the bill. I have about a dozen on my bookshelf with the word "hydrology" in the title, and another dozen that deal with hydrologic processes in one way or another, without actually saying so in the title. The beginning of an answer lies in either the inappropriateness or unavailability of any text truly suitable for the Forest Hydrology course taught at the SUNY College of Environmental Science and Forestry and, no doubt, elsewhere. Dunne and Leopold's 1978 book, for instance, entitled *Water in Environmental Planning* comes close, but was unavailable for some time and still presents only minimum attention to wildland hydrology. For example, it includes about twenty pages on the important processes involved in evapotranspiration. In one paragraph the importance and magnitude of the processes involved are discussed, and it is properly pointed out that "more than two-thirds of the precipitation falling on the conterminous United States is returned to the atmosphere from plants and water surfaces." Two thirds! Of nearly 800 pages 2.5 percent are devoted to 66 percent of the water balance, and that is more than any of all the other books I have on the shelf, save one. At the other extreme is Colman's monumental literature review, *Vegetation and Watershed Management* which, in addition to being published in 1953 and, therefore, not being quite up to date, omits useful engineering aspects of hydrology. The book is often used for a second course in a wildland hydrology sequence, such as "Practice of Watershed Management," so, presumably, the basics would have been presented in the introductory course. It is an excellent review of the research into the topic, but was published before it was finished owing to the untimely death of the author/compiler. The differences in characteristics and management of stormwater and groundwater are ecologically covered herein.

Other published hydrology books pay little attention to the vast storage potential of the soil, or to the wildland hydrologic processes sometimes referred to as "Forest Influences": most are arranged by processes. The processes, of course, are important and obvious. They are in striking evidence as billowing clouds, falling water, or flowing streams. Perhaps the excessive attention to processes, then, should not surprise us. Even the vast storage capacity of oceans appear to us visually as waves, water in motion; it is difficult to comprehend the volume of water involved, as evidenced by the fact that we think nothing of traversing – or "seeing" – a mile horizontally on the ocean's surface, but cannot comprehend the same distance in depth. And the primary reason we know as little about and do so little to protect or develop ground water is simply that we cannot see it, much less comprehend its complex physical and chemical characteristics and relationships with its surroundings.

By and large, hydrology texts do discuss storage of water. To my knowledge, however, none of the books have storage as a focus. In fact, storage is a topic that has been seriously ignored in the texts and, as a consequence, in some rather basic hydrologic model research. A rare exception is B. J. Knapp's 1979 booklet entitled *Elements of Geographical Hydrology*: in the first figure of the book, the hydrologic cycle is depicted as a series of processes moving from one type of storage reservoir to another. Slight attention to vegetation limits the utility to the wildland manager of this otherwise fine presentation on runoff processes and the hydrograph.

The processes that move water in and out of storage sustain major changes as undisturbed or rural lands undergo transition to urban and suburban uses, profoundly affecting storage. It is here that major floods are generated, that water quality begins to deteriorate, and that other problems such as subsidence begin. It is to a balanced consideration of both process and storage, then, that we must turn our attention. Indeed, it is essential if we are to develop our society without impairing the utility of the water resource on which we depend for domestic and residential use, commerce, industry, power, aquatic resources, and recreation.

Major exceptions to the lack of attention to storage in the available hydrology books are the chapters on snow, soil moisture, and ground water. Even these generally focus on movement through the porous media in which the water is found, not how the storage affects runoff. A major interest, of course, is the outflows from snow, soil, and ground water, the three major storage locations in the terrestrial portion of the hydrologic cycle. They deserve major consideration. However, water is also stored in the atmosphere and biosphere. By considering the "spheres" first as types of storage, each with characteristics influenced by basic principles and water properties, some patterns of substance and presentation emerge. How is the bulk of water in each realm characterized? How does water get into and out of that segment of our environment in light of its characteristics? And what is the perspective on water's characteristics between the several realms of the hydrologic cycle? Out of these questions, an arrangement for studying and presenting watershed hydrology becomes apparent. Thus, the basic organization of this book is by spheres of water.

The chapters are arranged so that each examines the primary characteristics of the parts of the environment, also referred to as "spheres": the energy sphere, the atmosphere, the biosphere, the terrisphere, the hydrosphere, and the cultural sphere, without always using those specific names. In order to do this effectively, it is necessary first to present a brief overview - the terminology and broad relationships - of the hydrologic cycle (Chapter 1). This enables meaningful discussion of the effects of storage and process in one sphere, on storage or processes in another, to take place without having to skip around from one chapter to another.

This organization did not drop on me out of the blue. About twenty years ago, upon changing the title of the course to "Principles of Watershed Management," I reworked my lecture notes. In the process, I asked myself the question likely to be raised by students enrolling in the course: what are the principles? I came up with seven broad paradigms on which I felt I could elaborate and which embrace all of the basic physical (and related biological and chemical) rules of water movement and storage pertaining to the hydrologic cycle. The statements follow (the seventh one is the product of collaboration with my colleague Dr. Arthur R. Eschner):

1. Although it often appears otherwise, there is plenty of water on the Earth: its quality – and temporal and spatial distribution – are often undesirable.
2. The sun is the ultimate source of energy for the movement and storage of water and for its changes of state throughout the hydrologic cycle.
3. In the atmosphere, the movement of water is in response to the general global circulation and to local vapor pressure gradients.
4. In the vegetated zone, movement of water between the atmosphere and the soil plays a diversified role in the storage capacity of and the complex relationships between all three regimes.
5. In the soil, water moves in response to gravity when it is not responding to tension gradients.
6. In the stream, runoff is the integrator of all of the factors that affect its quantity, quality, and regimen, and is one of the factors of the ecology of the watershed itself.
7. Watershed management is the planned manipulation of one or more of the factors of the environment of a natural or disturbed drainage so as to effect a desired change in or maintain a desired condition of the water resource.

The middle five statements are basic principles of how water moves and is stored within each realm or sphere. I have used these as sub-chapter axioms in the book. I also often use these concise sentences as the basis for essays on a final examination, asking the student to elaborate on the statement, to explain what it means, how it is ramified, and what evidence there is to support it. Upon a subsequent re-instatement of the title of the course as "Forest Hydrology," I kept the organization and accompanying basic principles. More recently, and rather obviously, I changed the title again to "Watershed Hydrology" and have used it in short courses as well.