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JONES, J. B., AND P. J. MULHOLLAND [EDS.]. 1999. **Streams and ground waters.** Academic Press. xix + 425 p. $79.95. ISBN 0-12-389845-5.

European limnologists Ohrigin and Schwoerbel first described the hyporheic biotope four decades ago, but apart from the long-held understanding of the crucial influences of stream–substratum exchange on spawning and egg incubation of fishes, the ecological importance of water and materials exchange between channels and alluvial aquifers along the longitudinal corridor of streams and rivers remained largely undocumented until the 1980s, when a number of key papers demonstrated conclusively that water and organisms can penetrate deeply into the bed and banks of rivers and streams. By the late 1990s, biophysical fluxes and transformations mediated by exchange of surface and ground waters had become a dominant theme of lotic limnology; it was clear that hyporheic zones vary from small to enormous (depending upon the size of the stream, the nature of the bed sediments, and the extent of the associated alluvial aquifers) and that hyporheic food webs and processes are fundamental attributes of stream–river ecosystems (Gibert et al. 1994; Boulton et al. 1998; Stanford and Gonser 1998).

This new book builds upon this firm foundation. Its 17 chapters provide comprehensive overviews of the hydrogeology, biogeochemistry, and community ecology of ground and surface water interactions. All of the chapters offer valuable insights, but several stand out notably. Harvey and Wagner's thorough analysis of hyporheic hydrology is highlighted with original data. They provide a reasoned view of the spatial and temporal domains of water flux in relation to channel features of streams, and they succinctly describe limits on the use of tracers to demonstrate interstitial flow paths. Packman and Bencala elaborate the difficulty of tracer use by noting that local channel–stream bed exchange involves turbulent interaction between stream and pore water flows, interactive pumping induced by pressure variation over bedforms, and turnover due to bedform motion. Superimposed on these enormously complicated, but localized (<10 m stream length), processes are regional processes driving longer flow paths that encompass reach, segment, catchment, and in some cases, even transcatchment scales. Groundwater flow models, such as MODFLOW, assume nonturbulent flow and do not allow for zones of preferential flow that act as injectors and drains in large alluvial aquifers. Three-dimensional flux modeling is in its infancy, even though lateral, vertical, and longitudinal pathways clearly are basic elements of virtually every stream corridor. In sum, no model yet developed comes even close to describing the heterogeneities that occur in natural streams.

In the geochemical realm, Duff and Triska provide an excellent examination of nitrogen flux and transformations along redox gradients in the stream corridor. Evidence is also presented showing that geochemical domains regulate phosphorus dynamics (Hendricks and White) and the accumulation of N and P within subsurface pathways (Kaplan and Newbold). The latter is driven by the metabolism of organic matter entrained from the stream and its riparian zone and is responsible for patches of elevated plant productivity in exfiltration zones.

The last group of papers deals with the ecology of stream–riparian landscapes, which is largely determined by spatial and temporal biophysical variation of exfiltration. Boulton nicely summarizes the amazing diversity among hypogean macrofauna of streams and rivers. This chapter, along with insightful ones by Findley and Sobczak (microbiota) and Hackencamp and Palmer (meiofauna), show that interstitial food webs and organic matter cycling involve a wide array of species, body sizes, and functional guilds, as well as complex interactions with the hydrogeomorphic setting. Great discoveries that will further revolutionize river ecological science seem very likely in this research arena.

In the final chapter, Stanley and Jones conclude that although an understanding of hydrology and nutrient geochemistry of stream–groundwater exchange is now relatively robust, the same cannot be said of food web ecology and taxonomy. They also note that riparian ecology seems disconnected from hyporheic ecology in practice and that more detailed documentation and modeling of complex interstitial flow paths and biogeochemical processes in them will be required to clearly articulate three-dimensional riparian–riverine linkages in alluvial systems.

The only real drawback of the book is that it focuses mainly on small streams. Fields of piezometers can be installed by hand in the channels and banks of small streams. This makes it possible to use chemical tracers effectively to follow in- and exfiltration of stream water and groundwater; but I worry that readers might wrongly conclude that hyporheic studies of large rivers do not exist or that experiments and observations in small streams necessarily apply to large rivers with expansive flood plains and aquifer subsystems. A notable exception is the very interesting chapter by Pringle and Triska, which deals with catchment-level controls on materials flux in relation to ground- and surface water interactions (I also liked their use of this information to underscore how human activities tend to sever hyporheic and groundwater pathways). The book also is biased toward North American sites and studies. A final quibble is that most of the authors did not respond to the editors' charge to provide testable hypotheses based on their reviews.

Despite these minor problems, this is an important and useful book that all lotic limnologists must study carefully. It contains key information on hydrology, geochemistry, and organismal ecology in the context of surface and subsurface interactions. Together with the other syntheses noted above, it offers a robust understanding of surface–subsurface exchange processes in streams.

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