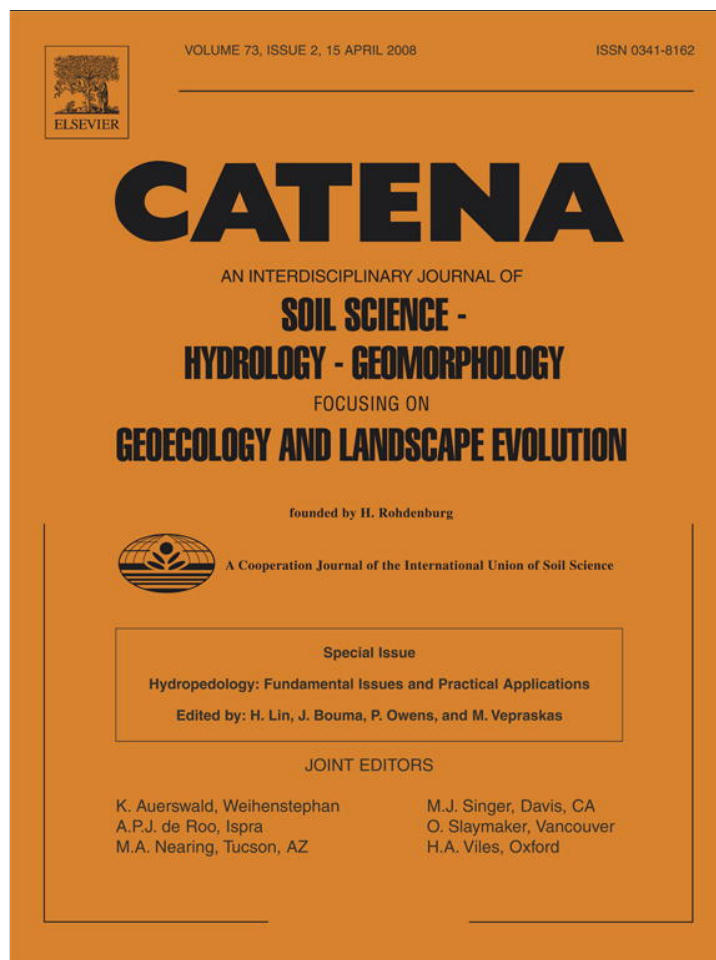


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## Introduction

## Hydropedology: Fundamental issues and practical applications

This special issue of *Catena* publishes selected papers from the Hydropedology Symposium held at the 18th World Congress of Soil Science in July 9–15, 2006 in Philadelphia, PA, USA. This symposium, entitled *Hydropedology: Fundamental Issues and Practical Applications*, recognized growing professional interests and publication activities related to hydropedology. The emerging interdisciplinary field of hydropedology promotes *synergistic integration of pedology with hydrology to enhance the holistic study of soil–water interactions and landscape–soil–hydrology relationships across space and time, aiming to understand pedologic controls on hydrologic processes and properties, and hydrologic impacts on soil formation, variability, and functions* (our working definition of hydropedology). Hydropedology emphasizes *in situ* soils in the landscape where distinct pedogenic features (e.g., structure, horizonation, and heterogeneity), environmental variables (e.g., climate, landforms, and organisms), and anthropogenic impacts (e.g., land use and management) prevail and interact. This Hydropedology Symposium attracted a total of 58 oral and poster papers, from which eight papers were selected for publication after peer-review. The symposium papers were grouped into four categories: *Field Techniques and Methods*; *Soil Structure and Soils Information*; *Landscape and Catchment Studies*; and *Models and Modeling*. The oral session at the symposium included speakers from the US, Australia, Czech Republic, the Netherlands, and UK. The poster session included three poster theaters where authors gave a 5-minute highlight of their posters. Interesting discussions followed, including a well-attended panel discussion with panelists Daniel Hillel, Mirek Kutilek, and Henk Wösten.

This special issue encourages studies that integrate pedological and hydrological expertise, and the quantification of soil morphology, soil structure, and other pedological properties from a hydrological perspective. The eight selected papers address either the fundamental aspects or practical applications of hydropedology.

The first part of this publication includes four papers that are more fundamental, with a broader implication. The first one by Vepraskas and Caldwell is a prime hydropedology example, which goes into depth in terms of both soil morphology and hydrology, and the two themes are intertwined quantitatively through hydrologic modeling and water table monitoring. They show that different hydric soil field indicators (Histosol, Histic Epipedon, Sandy Mucky Mineral, Dark Surface, Umbric

Surface, Depleted Matrix, and Redox Depressions), which are used to identify wetlands in the U.S., can be calibrated to long-term rainfall data (40 years) that allow precise on-site assessments of wetland hydrology in North Carolina. The second paper by McDaniel and others utilizes a hydropedology approach to examine the linkages between very slowly permeable fragipans, perched water tables (PWTs), and catchment-scale hydrological processes in a 1.7-ha catchment dominated by Fragixeralfs (Fragic Luvisols). Through extensive automated monitoring of PWTs, soil water content, and catchment outflow, they demonstrate that subsurface lateral flow on top of the fragipan accounts for redistribution of up to 90% of the precipitation received on site during late winter/early spring and that this lateral flow, combined with relatively high lateral saturated conductivity ( $K_{\text{sat}}$ ) and varying depth to the fragipan (23–158 cm below the soil surface), creates a flashy and highly variable patterns of saturation-excess runoff. The paper by West, Abreu and Bishop evaluates vertical  $K_{\text{sat}}$  distribution with soil depth and hillslope position in the Georgia Piedmont in relation to soil structure, parent material type and composition, C horizon cementation, and depth of soil development. They highlight the major influence of pedogenic structure on vertical  $K_{\text{sat}}$  in these soils, leading to the question of conventionally assumed exponential decline of vertical  $K_{\text{sat}}$  with soil depth (which is widely used in hydrological modeling). The paper by Zhou, Lin and White addresses the impacts of four land uses on surface soil hydraulic properties in four soil series in Pennsylvania. Their results indicate that temporal variation of surface soil hydraulic properties appears to be greater than their spatial variation caused by land use and soil series, suggesting that the temporal dimension would need to be considered in the proper use of the concepts of genoform (for genetically defined soil series) and phenoforms (for soil types resulting from a particular form of management in a given genoform).

The second part of this special issue consists of four papers dealing with hydropedology applications. The paper by Severson, Lindbo and Vepraskas examines quantitatively how redoximorphic features are related to the depth to seasonal saturation (frequency and duration) in a coarse-loamy catena in the lower coastal plain in North Carolina. Through a year-long monitoring of water table, redox, rainfall, and temperature, their results suggest that  $\leq 2$  chroma redox depletions do not mean the same thing in all soils, and thus may have varying implications to

wastewater treatment and water quality. The paper by Owens, Wilding, Miller and Griffin proves the use of zero valent iron rods (polished nails) as a simple, non-intrusive, and inexpensive field technique to quantitatively estimate the ranges of O<sub>2</sub> status in seasonally-saturated soils. By comparing to piezometer, soil moisture, alpha–alpha dipyrindyl, oxygen concentration, and redox potential measurements, surface coating colors on the iron rods are shown to reflect the ranges of O<sub>2</sub> in three soil toposequences. The third paper by Mooney and Morris attempts to quantify preferential flow in four intact structured soil blocks using image analysis with dye tracers and X-ray Computed Tomography. This is the only paper in this special issue that was done in the laboratory; however, the findings from this study are relevant to the field understanding of preferential flow at the pore and pedon scales. For example, this study has identified four key factors as the causes of preferential flow, i.e., water potential, pore morphology, convergence points caused by stones or funnel convergence, and the surface topography of the soil blocks. Finally, Wösten and his colleagues present an interesting application of hydropedological modeling in understanding the interrelationships between peat and water in tropical peatlands in Indonesia. They demonstrate that the combination of hydrology and pedology is essential for wise use of valuable but threatened tropical peatland ecosystems and that hydropedological modeling can identify areas with good restoration potential based on predicted flooding, subsidence, and fire risk.

To help the readers understand better the concept of hydropedology, we would like to note here that the term of “hydropedology” is different from the generic term of “soil hydrology” or “vadose zone hydrology.” While overlaps exist between these closely related disciplines, there are clear distinctions between them: 1) Hydropedology emphasizes *in situ* soils in the context of the landscape, where intact pedogenic features (such as structure, horizonation, and morphology) and soil–landscape relationships are essential, thus requiring attention to catena, soil mapping, soil morphology, and soil geomorphology; 2) Hydropedology is not just about hydrology; equally important is hydrologic feedback to pedogenesis, soil variability, and soil functions; and 3) Hydropedology deals with variably-saturated zone (both shallow root zone and deep vadose zone) in the surface and near-surface environments, including unsaturated soils and saprolites, fluctuating interface between ground water and the soil zone, wetlands, and even subaqueous soils. It is helpful to note here that merits exist in differentiating “pedology” from the general term of “soil science,” as “ped” is a unique term in soil science and “pedology” captures that uniqueness well. The natural soil “architecture” (influenced by the five interacting soil-forming factors, plus human activities, and governed by interrelationships between inorganic–organic constituents and physical, chemical, and biological processes) is the foundation of the most critical natural resource that we call soil. A crushed sample of soil is as akin to a natural soil profile as a bulk of ground beef is to a living cow. Hence, pedology has been regarded by many as the only sub-discipline of soil science that has its own unique theory, while the other sub-disciplines of soil science are commonly considered as applied mathematics, physics, chemistry, or biology to the study of soils.

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The papers collected in this special issue reflect a window of opportunity that illustrates how synergistic integration of pedology and hydrology could advance our understanding of fundamental scientific issues (e.g., quantification of soil “architecture” and its functional manifestations across scales) as well as real-world implications (e.g., integrated watershed management and ecosystem sustainability). We hope that this special issue can help enhance the visibility of hydropedology in international scientific communities and further stimulate creative and synergistic efforts. Finally, we would like to mention that we are delighted to see a growing community of hydropedology around the world, which has resulted in the formation of the Hydropedology Working Group within the International Union of Soil Sciences during the 18th World Congress of Soil Science.

Guest Editors

Henry Lin

*Department of Crop and Soil Sciences,  
The Pennsylvania State Univ., University Park, PA, USA*

Corresponding author.

*E-mail address: [hul3@psu.edu](mailto:hul3@psu.edu).*

Johan Bouma

*Environmental Sciences Group, Wageningen University and  
Research Center, The Netherlands*

Phillip Owens

*Department of Agronomy, Purdue Univ.,  
West Lafayette, IN, USA*

Michael Vepraskas

*Department of Soil Science, North Carolina State Univ.,  
Box 7619, Raleigh, NC 27695-7619, USA*