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Editorial

Watershed Ecology and Its Applications

Zhifeng Yang

State Key Laboratory of Water Environment Simulation, School of Environment, Beijing Normal University, Beijing 100875, China

Global climate change and intense human activities greatly alter natural eco-hydrological processes in multi-scale watersheds, resulting in a series of threats to human society and ecosystems that include the increase of extreme climatic events, water quality degradation, and decreases in biodiversity and ecosystem stability. Many theories and approaches on ecological restoration for different types of water environments (e.g., rivers, lakes, marshes, and estuaries) have been proposed in the existing research. However, hydrological connections, mass and energy transports are usually considerable among the different types of water environments in a watershed, and restoration measures for one component typically affect other components in the same watershed. In addition, the interactions that occur among social activities, economic activities, and natural eco-hydrological processes are complex. Therefore, it is essential to explore sustainable watershed management from a systems perspective.

Watershed ecology treats natural hydrological units (i.e., watersheds) as systems and analyzes the interacting biotic and abiotic components in a watershed. By exploring knowledge on system structures and interactions among the human and natural processes in a watershed, it offers useful tools for managers to assess the effects of environmental changes on ecosystem health and to create strategies for ecological restoration from a systems perspective. Motivated by the critical significance of watershed ecology in directing sustainable management, this special issue of *Engineering* was proposed in order to establish a forum for the discussion of recent progress in watershed ecology. Seven papers exploring new theories and approaches are collected in this special issue and contribute to the discussion on the following two hot topics:

(1) **Environmental changes and eco-hydrological response**. Environmental data are essential for revealing environmental changes and their effects. In this issue, Lega et al. conduct a data analysis of their abundant collected data in order to assess the effects of environmental changes on the risks of natural hazards (e.g., rock falls and debris flows) in a mountain region. They demonstrate that appropriate policies can be planned, based on environmental data collection and elaboration. In addition to data, modeling approaches are important. Although various models have been developed for eco-hydrological simulation, environmental changes increase the uncertainty in modeling processes and thereby increase the difficulty of model calibration. Fan et al. develop a multivariate risk-assessment framework to evaluate the occurrence of extreme eco-hydrological events, and quantify parameter uncertainties via a Markov Chain Monte Carlo algorithm. They demonstrate that the obtained confidence intervals can bracket the observations well, especially for flood duration. Shivhare et al. use the Soil and Water Assessment Tool (SWAT) for hydrological modeling and compare the calibration performances of three common techniques. They find that the technique of sequential uncertainty fitting requires the least amount of data and performs best in their case.

(2) **Ecological restoration and sustainable water management**. Artificial measures can assist in ecological restoration. In this issue, Brown et al. report on their design for a floating island consisting of biological and physical–chemical treatment modules for the removal of phosphorus from surface waters. The removal efficiency of this treatment system is demonstrated to be satisfying (i.e., about 40%–50%) in their case study. In addition to artificial measures, appropriate management strategies are important in pursuing sustainability. Asaeda et al. suggest hydrogen peroxide as a quantitative indicator of environmental stresses on plants, and demonstrate its usefulness through laboratory and field experiments. Since hydrogen peroxide is relatively stable and can be conveniently quantified, this study offers a useful approach for vegetation management. Human activities are especially intense in urban areas, and threaten urban ecosystems. Yin et al. report on their new method for the regulation of environmental flows (e-flows) in channelized urban rivers, considering multiple ecological demands and economic cost. Their method offers an efficient and economical tool for directing the construction and management of e-flow supply projects in urban areas. As the conflict between human and ecosystem water demands becomes increasingly serious, sustainable water management is crucial for both humans and ecosystems. Wang et al. propose an eco-friendly operation strategy for multi-reservoir systems in order

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to coordinate human and ecosystem water demands. They demonstrate that this strategy is effective in maintaining the key ecological functions of rivers while mediating the negative effects of e-flow provisions on human benefits. Thus, with the publication of this special issue, we hope to further the discussion on new progress in watershed ecology, with a focus on assessing environmental changes and creating strategies for environmental restoration.