Merging Perspectives in the Catchment Sciences: the US-Japan Joint Seminar on Catchment Hydrology and Forest Biogeochemistry

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Kevin J. McGuire*
Virginia Water Resources Research Center and Department of Forest Resources and Environmental Conservation, Virginia Tech, Blacksburg, VA, 24061, USA; Tel: +1-540-231-6017, Email: kevin.mcguire@vt.edu

Stephen D. Sebestyen
Northern Research Station, USDA Forest Service, Grand Rapids, MN, 55744, USA; Tel: +1-218-326-7108, Email: ssebestyen@fs.fed.us

Nobuhito Ohte
Department of Forest Science, Graduate School of Agricultural and Life Sciences, University of Tokyo, Tokyo, 113-8657, Japan; Tel: +81-3-5841-5214, Email: nobu@fr.a.u-tokyo.ac.jp

Emily M. Elliott
Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA, 15260, USA; Tel: +1-412-624-8882, Email: eelliott@pitt.edu

Takashi Gomi
Department of International Environmental and Agriculture Science, Tokyo University of Agriculture and Technology, Tokyo, 113-8657, Japan; Tel: +81-42-367-5751, Email: gomit@cc.tuat.ac.jp

Mark B. Green
Center for the Environment, Plymouth State University and Northern Research Station, USDA Forest Service, Plymouth, NH, 03264, USA; Tel: +1-603-535-3095, Email: mbgreen@plymouth.edu

Brian L. McGlynn
Division of Earth and Ocean Sciences, Nicholas School of the Environment, Duke University, Durham, NC, 27708, USA; Tel: +1-919-684-1743, Email: brian.mcglynn@duke.edu

Naoko Tokuchi
Field Science Education and Research Center, Kyoto University, Kyoto, 606-8152, Japan; Tel: +81-75-753-2268 Email: tokuchi@kais.kyoto-u.ac.jp

*Corresponding author: Virginia Water Resources Research Center (MC 0444), Cheatham Hall Suite 210, 310 West Campus Drive, Blacksburg, VA, 24061-1036, USA

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Commentary

Japan has strong research programs in the catchment sciences that overlap with interests in the US catchment sciences community, particularly in experimental and field-based research. Historically, however, there has been limited interaction between these two hydrologic science communities due to differences in language, culture, and research approaches. These differences highlight a potential for scientific discovery through coordinated interactions. In this vein, US-Japan Joint Seminars have been held about once a decade since the early 1970s (Yevjevich and Downs, 1971; Bras *et al.*, 1988; McDonnell *et al.*, 2001). In addition, beginning in 2000, *Hydrological Processes* began hosting annual special issues of the Japanese Society of Hydrology and Water Resources, which furthered the infusion of Japanese research into the English literature (Board of JSHWR, 2000; Tsujimura *et al.*, 2012) and has helped increase participation of Japanese researchers in North American and European scientific conferences. In March of 2013 at the East-West Center in Hawaii (www.eastwestcenter.org), the fourth US-Japan Joint Seminar was held to continue the tradition of fostering interaction, exchanging ideas, and establishing collaborations between the US and Japan in the catchment sciences. This commentary summarizes the goals and outcomes of the meeting and establishes a vision for inter-continental catchment science research in the future.

Research in the catchment sciences has evolved along divergent pathways in Japan and the US, which had been a point of discussion in previous US-Japan Joint Seminars. Questions such as the following have been asked (McDonnell and Tanaka, 2001):

- How does US and Japan catchment hydrology differ?
- What questions motivate research in the US compared to Japan?
- How much overlap is there in approach and content?

Historically, much of the catchment research in the US has been motivated by explaining the patterns and processes that give rise to the generation of streamflow, effects of environmental disturbance on stream chemistry, or has centered on engineering applications to hydrology (McDonnell and Tanaka, 2001). In the US, these themes largely evolved from acid rain research in the 1980s and 1990s (Church, 1997), ground water characterization and contamination remediation, and rainfall-runoff modeling (Bras *et al.*, 1988). In comparison, Japanese catchment research has historically focused on vadose zone hydrology and process-based runoff production mechanisms (Bras *et al.*, 1988; McDonnell and Tanaka, 2001). These themes have developed in response to other environmental issues specific to Japan, such as forest loss and flooding (Tsujimura and Yamashiki, 2010), slope stability, and erosion (Sidle and Onda, 2004). These different research perspectives are also driven by differences in climate and geologic histories between the two countries. For example, Japan experiences monsoonal climatic regimes and much of the country is vulnerable to seismic activity. As pointed out by McDonnell et al. (2001), another primary difference between the Japan and the US catchment science communities is that interdisciplinary approaches are less common in Japan relative to the US, yet their monitoring technologies are sophisticated and novel. Japanese catchment research is often highly detailed and descriptive compared to US research, which is often aimed at integration, synthesis, and theoretical development. These two complementary research approaches and the diversity of natural environments are reasons why US-Japan Joint Seminars have been so successful and broadly applicable to developing improved understanding of catchment processes.

In the 13 years since the last seminar, much has changed in the catchment sciences. Linkages between biogeochemistry and hydrology developed in the 1990s and formed the focus of the previous US-Japan Joint Seminar (McDonnell *et al.*, 2001). However, today new measurement and analytical techniques (e.g., cavity-ring down spectroscopy, *in situ* optical sensors for high frequency measurements, microbial methods for isotopic analyses, and wireless sensor networks) and research networks (e.g., Critical Zone Observatories [criticalzone.org], Japanese LTER [www.jalter.org]) that were not available a decade ago have ushered in a new era for the catchment sciences. This provided us with an opportunity to revisit the theme of linking hydrological and biogeochemical processes in catchments (McDonnell *et al.*, 2001). The 2013 US-Japan Joint Seminar expanded on this theme to examine how the coupling of hydrology and biogeochemistry provides a lens for viewing forested catchment responses to climatic and environmental change.

The meeting brought together 18 US and 24 Japanese scientists including postdocs and students. The focus of the meeting was a synthesis of the effects that climatic forcing, natural disturbance, and forest management have on the timing, duration, and magnitude of hydrological and biogeochemical responses in catchments. Individual sessions during the meeting were devoted to discussions of insights gained from process studies of streamflow generation and biogeochemistry, merging concepts of hydrologic connectivity and biogeochemical processing, and developing a greater understanding of catchment vulnerability and resilience in the face of change. During the meeting there was recognition of several important research themes, which included: 1) the significance of bedrock contributions to streamflow generation, 2) the influence of landscape evolution on contemporary hydrological processes, 3) explicit linkage between the soil-plant-atmosphere continuum and lateral redistribution of water, gas flux, and nutrients imposed by hillslope/landscape features, 4) the consequences of microbial processes on catchment-scale biogeochemical patterns, 5) the convolution of hydrological and biological controls on nutrient response after disturbance, 6) the critical role of water travel time in understanding biogeochemical responses, and 7) the technological advances and transfers from other disciplines (e.g., geophysics) needed to further develop catchment science.

The workshop discussions coalesced into a vision for catchment science research that is integrative beyond typical catchment science perspectives and inclusive of aspects such as mass fluxes between bedrock and catchment soils, geochemical and geomorphic evolution of landscapes, and microbial communities and function. Likewise, there is a need to make observations across scales ranging from mineral surfaces, molecules, and microbes to physiographic regions to the land-atmosphere boundary layer. This vision is not unlike recent calls from other earth science fields that have reached similar conclusions (e.g., Brantley *et al.*, 2007); however, our perspective remains centered on catchments and how fluxes, storages, and the distribution of water influence a broad set of biogeochemical systems. In coming decades and centuries, these broader perspectives in catchment science will allow us to assess how resilient catchment processes are to changes in environmental drivers such as extreme events, climatic regimes, and disturbance in order to effectively manage and maintain clean water and resilient ecosystems. This seminar has already catalyzed exchange and merging of perspectives between catchment scientists in the US and Japan and improved the appreciation of differing expertise and community strengths that each have to offer. Continued exchange between groups within the catchment science community (not just the US and Japan) will provide opportunities to stimulate and engage the next

generation of scientists to address these integrated research themes and make fundamental advances in the catchment sciences.

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