Differential Winter Stemflow Generation Under Contrasting Storm Conditions in a Southern New England Broadleaved Deciduous Forest

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EXTENDED ABSTRACT

Despite the importance of stemflow as a hydroecological process, differential winter stemflow generation among and within precipitation types (e.g. snow, rain-to-snow) is poorly understood. The purpose of the present study is to better understand winter stemflow generation under contrasting meteorological conditions in a leafless deciduous forest. It is hypothesized that stemflow volume and production, expressed as a funneling ratio, will differ significantly among and within precipitation event types. Acceptance of this hypothesis would mean that intra-event meteorological conditions have a significant and discernible effect on stemflow production in deciduous forests, differentially affecting soil moisture, groundwater recharge, soil solution chemistry, and nutrient cycling.

The study site was located in a protected forested section of the Tower Hill Botanic Garden (THBG) in the Wachusett Reservoir watershed of central Massachusetts (42° 21' N, 71° 43' W) at an elevation of 160 m above sea level. Long term total annual precipitation is 1210 mm (US Climate Data Center, 1995). Thirty year mean temperature values for the months of December, January, February, and March are -2.9°C, -5.1°C, -4.0°C, and 0.3°C, respectively (US Climate Data Center, 1995). Approximately one-third of the annual precipitation is snow. For the two successive winter seasons (1997-1998 and 1998-1999) in which stemflow production was monitored from seven canopy trees, mean monthly air temperatures were 1.1 °C, -2.3 °C, 0.2 °C, and 3.1 °C for the months of December, January, February, and March, respectively. The significantly higher air temperatures and pronounced air temperature oscillations around the freezing point during precipitation events resulted in the increased frequency of mixed precipitation (e.g. snow-to-rain, rain-to-snow, snow-to-freezing rain). Mixed precipitation accounted for 35% of the precipitation between December 1998 and March 1999. Only 26% of the precipitation events were snow.

Stemflow volume was found to differ significantly among different and same-type precipitation events. A rain event that occurred on 8 Dec 1998 and snow-to-rain event on 18 Jan 1999 were of similar duration, magnitude, and intensity, yet produced stemflow volumes that differed by a factor of 4. For two snow-to-rain events, stemflow volumes differed by a factor 11. Stemflow production even varies widely within a discrete precipitation event as a function of meteorological conditions. Stemflow volumes have been observed to differ greatly among different and same-type precipitation events. Contrasting meteorological conditions can explain differential stemflow production among precipitation events. In general, stemflow quantities were observed to (1) increase with storm duration; (2) decrease with storm intensity; (3) decrease with lower air temperatures; (4) increase with an increase of incident solar radiation; and (5) increase when windy conditions were synchronized with rainfall.

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The magnitude of a precipitation event did not appear to have a detectable influence on stemflow generated during winter precipitation events. Future studies attempting to model winter stemflow inputs in deciduous forests must recognize that the volume of stemflow produced varies greatly as a function of meteorological conditions. Such models should be physically based to avoid discrepancies involved with modeling stemflow quantity solely as a function of precipitation type.

Keywords: stemflow, winter, meteorological conditions, funneling ratio, deciduous forest