Hydrologic Monitoring at Nettle Brook, Mount Mansfield

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Highlights from Water Year 1995

Extremes in weather and climate make for extremes in hydrology. At Nettle Brook, our small stream station on the west flank of Mt. Mansfield, 1995 had one extreme followed by another. Highlights in streamflow for the water year (October 1, 1994 through September 30, 1995) included low fall flow, a major January thaw, a very early snowmelt hardly worthy of the name, a bone-dry June, followed on July 1 by the highest instantaneous flow of record, and a 3-day period of very heavy rain and flooding in August (fig. 1).

Sustained streamflow is dependent on sustained stores of water in the soil and groundwater. In our northern climate, two separate major seasonal events limit recharge to these subsurface storage reservoirs. In summer, recharge is limited by evaporation and transpiration by the forest canopy. These processes, collectively known as evapotranspiration, or ET, return one-third to one-half of annual precipitation to the atmosphere. In winter, recharge is limited by lack of supply to the subsurface; precipitation does not infiltrate, but rather is stored in the snowpack. The counterparts to these low-flow periods are the high-flow periods in later autumn, when ET is greatly reduced, and in spring, when water locked up in the snowpack is released rather quickly and subsequent rains fall on saturated soils while ET is still minimal. Typically, one-half of total annual streamflow occurs in a six-week period during snowmelt.

On Mt. Mansfield, autumn flow usually reaches a peak in November or December. In the fall of 1994, however, rainfall was somewhat below average, thus flow was below average coming into the winter months. Dry conditions continued in the early winter; snowpack development was minimal. An unusually strong January thaw took out much of this snowpack. The temperature in Burlington reached 66 F, an all-time January record. Streamflow at Nettle Brook increased significantly during the thaw, but was kept in check by the meager snowpack and lack of accompanying rainfall.

Warm temperatures arrived in early March, and the snowpack, which had never developed to its usual depth, rapidly succumbed and produced a snowmelt notable for its earliness and low peak discharges; flow was an order of magnitude lower than that in the 1994 snowmelt (fig. 2).

In June, flow is typically still running high from sustained discharge of groundwater recharged during snowmelt, while ET demand has just begun. In 1995, however, continued below average precipitation after snowmelt, coupled with the low groundwater tables due to limited recharge during snowmelt, brought on drought conditions by late spring. At the end of June, flow in Nettle Brook was reminiscent of late September.

The drought showed signs of breaking in July, as the thunderstorm season got rolling. Although summer in Vermont is as wet as any other season, precipitation tends to be concentrated in shorter periods of higher rainfall intensity. When summer precipitation falls on dry soils, most of the water is captured in the unsaturated zone, where it is subsequently lost to ET before it infiltrates far enough to recharge groundwater. However, at high rain intensities, water that does run off -- because it falls directly on stream channels or saturated riparian zones, or is rapidly transmitted through soil cracks or other macropores -- may cause high peak flows of limited duration. In these storms, flow returns to baseflow conditions in a matter of hours. One such thunderstorm took place on July 1. Forty mm of rain -- nearly triple the rainfall for the entire month of June -- fell within 2 hours, causing the highest flow peak of the year.

The real drought-busting storms occurred in early August (fig. 3), when a major flood struck parts of northern Vermont. While most of the areas affected received the heaviest rain on the night of Saturday, August 5, the heaviest rains at Mt. Mansfield fell during the day on Friday and Saturday. In all, 175 mm (7 inches) of rain fell. The cumulative effects of the heavy rainfall caused the highest peak on Saturday afternoon, though less rain fell that day, and caused sustained high flows by Sunday, August 6 (fig. 3).

The low snowpack and subsequent drought were the dominant factors in the overall low annual runoff. Runoff was 43.51 cm in water year 1995 compared to 58.48 cm in water year 1994.

Water-quality sampling

Water quality sampling in 1995 centered around snowmelt and storm events. In conjunction with other projects, stream samples have been collected for analysis of Hg (mercury), NO_3 (nitrate), DOC (dissolved organic carbon), silica (Si), and other major ions. These data are in a preliminary stage of analysis. The major ion data will be used to compute input-output budgets, using the NADP site at Proctor for the input data. Input-output budgets establish boundary conditions helpful to understanding what processes control biogeochemical cycling in the ecosystem.

Figure captions

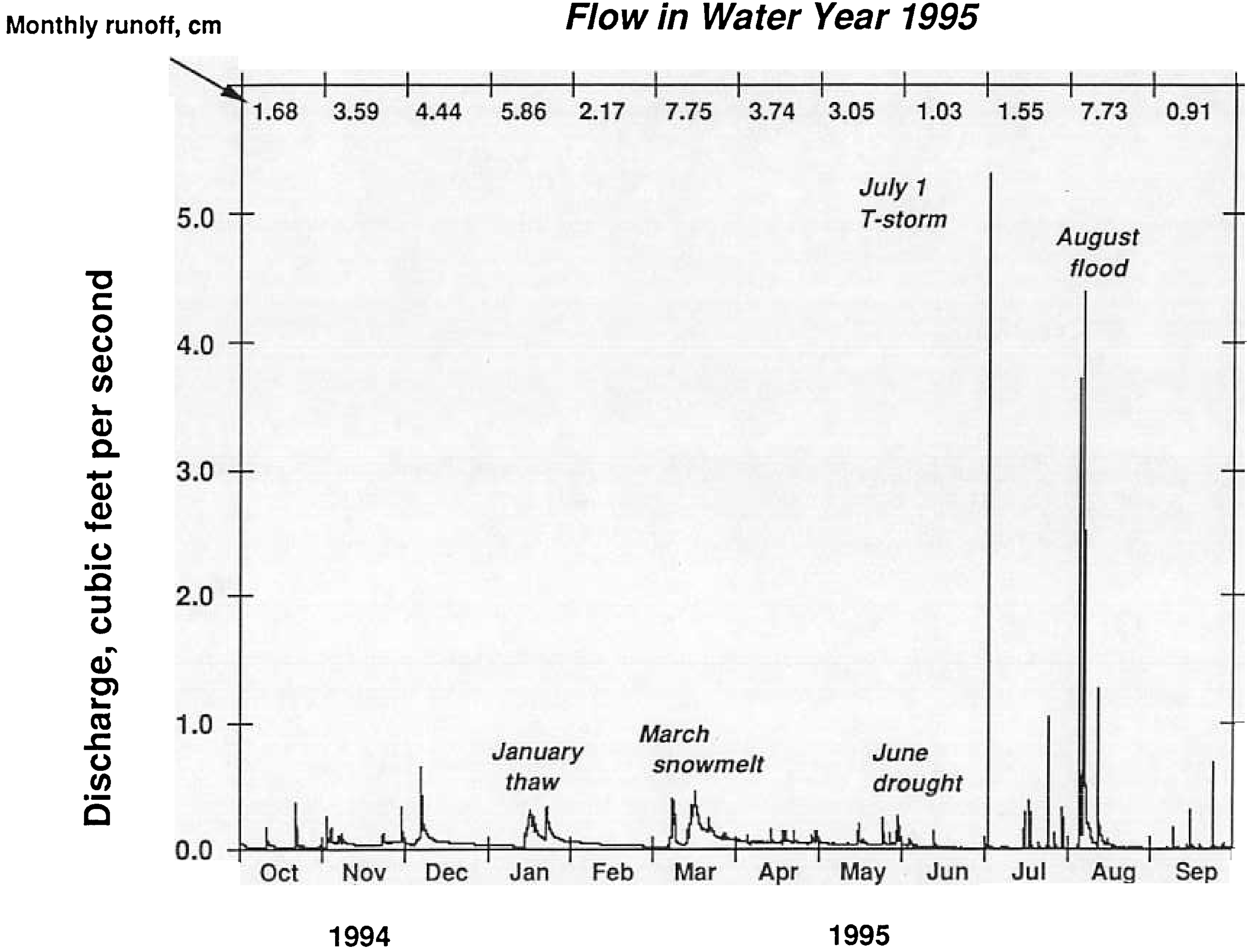
1. Nettle Brook hydrograph for water year 1995. Monthly runoff given across top of plot. Runoff is total flow (L^3) divided by basin area (L^2), giving units of L, which can be directly compared to precipitation amount.

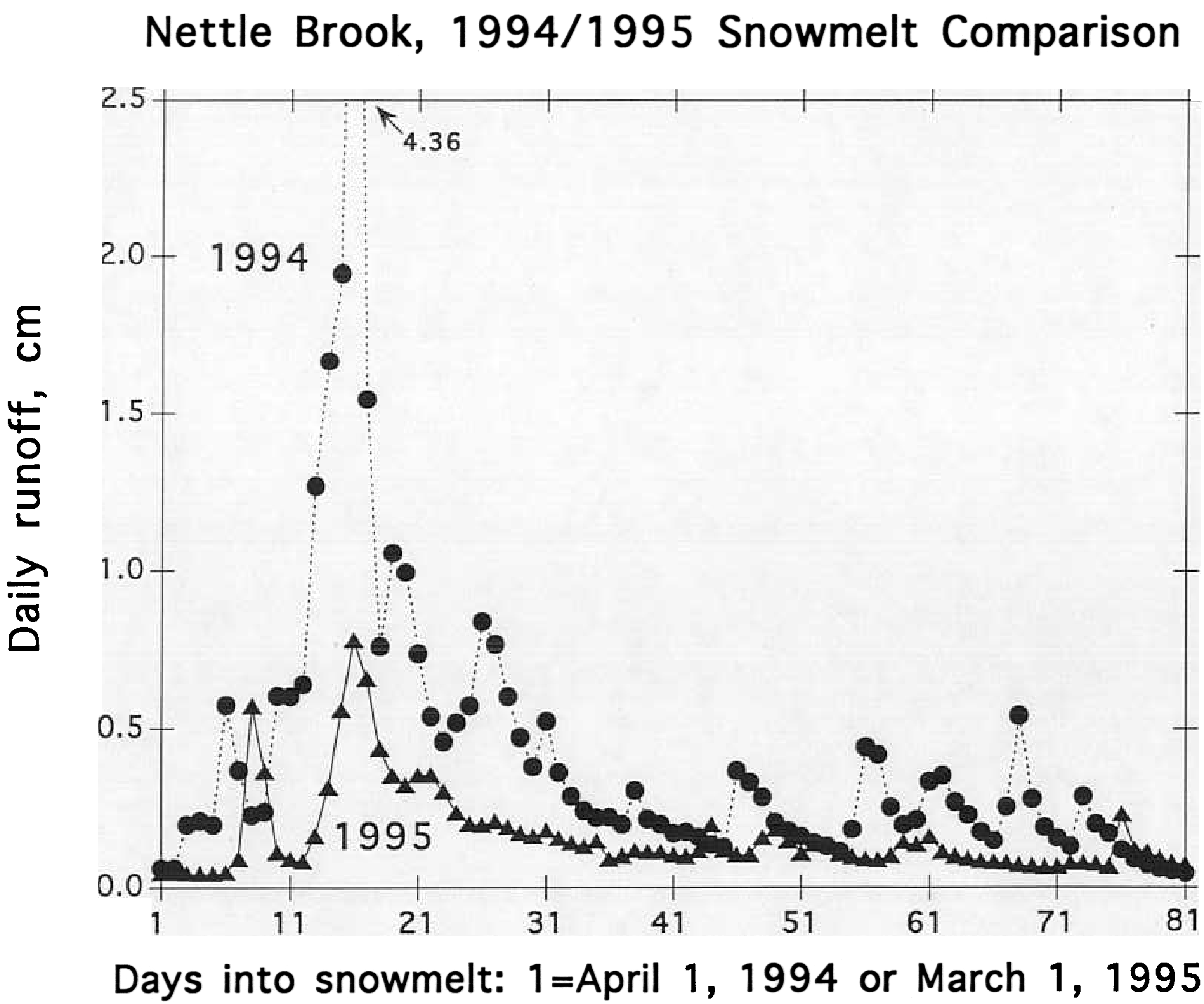
2. Comparison of daily runoff during and after snowmelt in 1994 and 1995. Note 1995 snowmelt began one month earlier, had much smaller peak flows, and was followed by a drought.

3. Rainfall and discharge for the August, 1995 flood

Nettle Brook:

Flow in Water Year 1995





Nettle Brook, 1994/1995 Snowmelt Comparison
Daily runoff, cm
2.5
2.0
1.5
1.0
0.5
0.0
4.36
1994
1995
1
11
21
31
41
51
61
71
81
Days into snowmelt: 1=April 1, 1994 or March 1, 1995

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