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Monitoring and simulating vernal pool hydrology in the Canadian Shield forest to understand their ecological functions

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Vernal pools are hydrologically-isolated wetlands commonly found in temperate forests of eastern Canada and the northeastern United States. They contribute to forest biodiversity by providing breeding habitats for amphibians during their spring and early summer period of hydrological activity. However, because vernal pools are typically of small extent and their hydrology has been little studied, these wetlands are extremely difficult to protect. The aim of this study was to identify the sources of water inflow and outflow that regulate the hydrology of forest vernal pools in the Canadian Shield bedrock of southern Quebec to better understand the drivers of their hydroperiod. The 16 selected vernal pools were located in bedrock depressions partly filled with silt and fine sand sediments, and organic deposits. They were instrumented to monitor groundwater and surface water levels and precipitation (April to November 2016 and 2017). Detailed topographic surveys were conducted to describe pool bathymetry, sediment stratigraphy was determined using in situ observations, and vegetation was characterized. The studied wetlands have areas varying from 35 to 740 m2 and their maximum monitored water depths varied between 0.17 and 1.77 m. The spring and early summer (April to July) of the two studied years were highly contrasted with 238 mm in 2016 and 432 mm in 2017. Due to these contrasting conditions, the median spring hydroperiod (activity period for breeding amphibians) was much shorter in 2016 (55 days, starting in early April) than in 2017 (127 days starting in end of March). During the summer periods, the vernal pools became hydraulically active temporarily after rain events exceeding 35 mm. All the wetlands were active in November and remained wet (frozen) throughout the winter season. A simple daily water budget model showed that the pools are probably fed by surface runoff starting at snowmelt and receive groundwater inflow when the water table is high (April to June, and October-November). This groundwater inflow was confirmed by the presence of Radon-222 (a groundwater flow tracer) in all the wetlands in May and November 2017. The vernal pools lose water to the bedrock aquifer during the dry season (July to September), except at times when important rain events increase groundwater levels above a threshold and the pools reactivate temporarily. This aquifer-vernal pool connexion implies that external factors modifying groundwater levels (pumping, building roads, drainage, or tree harvest) can also impact the hydroperiod. This has strong implications for vernal pool conservation which should clearly extend beyond their (relatively small) surface watershed limits.