

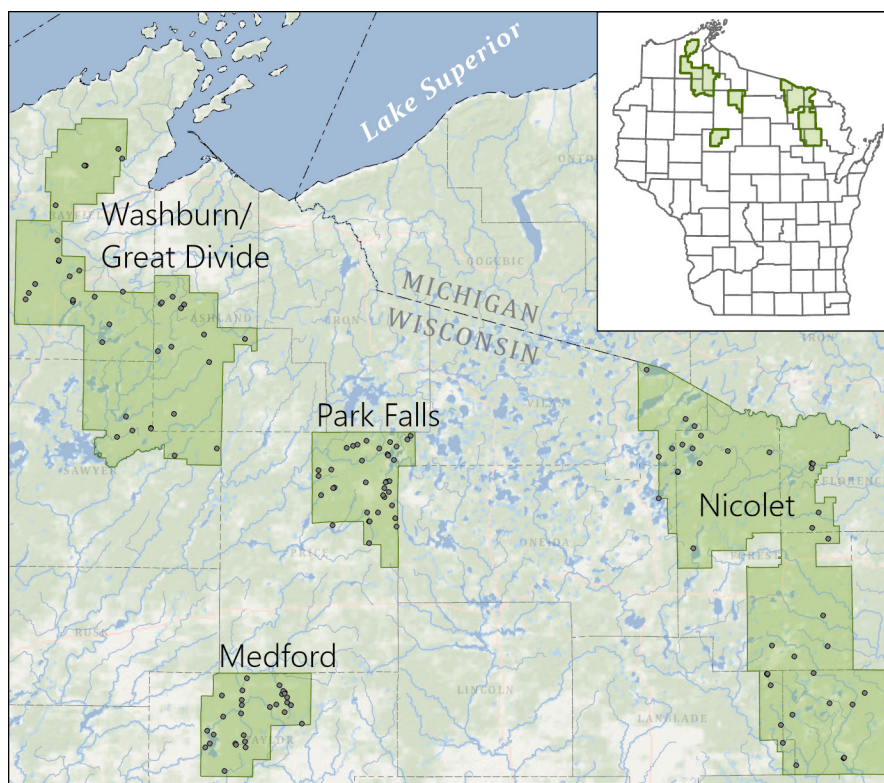
Water Quality in the Chequamegon-Nicolet National Forest

Data Series 003 • 2024 • Susan K. Swanson, G.E. Graham, Pete M. Chase

Introduction

The Chequamegon-Nicolet National Forest (CNNF) in northern Wisconsin contains numerous groundwater-dependent water resources that may be vulnerable to potential effects of land development, mining, and climate change. To improve the understanding of forest hydrology and help the U.S. Forest Service (USFS) protect and manage these resources, researchers from the Wisconsin Geological and Natural History Survey (WGNHS) and the U.S. Geological Survey (USGS), cooperatively with the USFS, inventoried surface water and groundwater resources in the four units of the CNNF (Park Falls, Medford, Nicolet, Washburn/Great Divide) (fig. 1). They developed tools to improve the understanding of aquifer characteristics and groundwater flow and characterized water chemistry in the Forest (Bradbury and others, 2018a; Bradbury and others, 2018b; Fehling and others, 2018a; Fehling and others, 2018b).

Water quality can change over time due to both natural and anthropogenic influences. A necessity for assessing potential future changes to the water resource is an understanding of baseline conditions for water chemistry. To begin to evaluate how and where changes are occurring across the Forest, nearly 140 lakes, streams, wetlands, spring ponds, and wells that were sampled in 2011–2016 as part of the forest-wide inventories, were resampled in 2021–2022. Samples were analyzed for ion chemistry and basic nutrients (nitrate and phosphorus).



ESRI basemap; hydrography, political, and federal boundaries from the U.S. Geological Survey National Atlas, 2016; Wisconsin Transverse Mercator projection, 1991 Adjustment to the North American Datum of 1093 (NAD 83/91) EPSG 3071

Figure 1. The four units of the CNNF in northern Wisconsin. Grey dots represent water sampling locations.

Setting

Throughout the national forest, mostly non-carbonate unlithified glacial deposits overlie crystalline bedrock or sandstone, and forest lands are largely undeveloped. Glacial sands and gravels form the primary aquifer. The crystalline bedrock, which transmits water through fractures, and the sandstone, which is thought to have very low porosity, are only capable of supplying water to low-capacity wells.

Sampling sites

Some lakes, streams, and wetlands are dominated by precipitation and runoff and receive little or no groundwater, others are a mix of groundwater inflow and surface water runoff, and some have a considerable groundwater component. Springs, spring ponds, and well water reflect groundwater quality (fig. 2).

Surface water sampling sites were selected from accessible lakes, streams, wetlands, and spring ponds within the Forest. Most of the wells selected for groundwater sampling are located at USFS campgrounds and picnic areas. Based on available records, wells range from about 40 to more than 300 feet deep and are open to the glacial aquifer; 10 of the wells are screened in crystalline bedrock.

Results

Concentrations of most ions in surface waters and groundwater are relatively low, although groundwater typically contains a higher concentration of dissolved ions than surface water-dominated lakes, streams, and wetlands (fig. 3). Relative concentrations of constituent ions are similar among the four units of the national forest. With the exception of chloride, there is very little difference in ion concentrations in groundwater between 2011–2016 and 2021–2022. Ion concentrations in surface water-dominated lakes, streams, and wetlands are slightly more variable, mostly with respect to potassium, chloride, and sulfate.

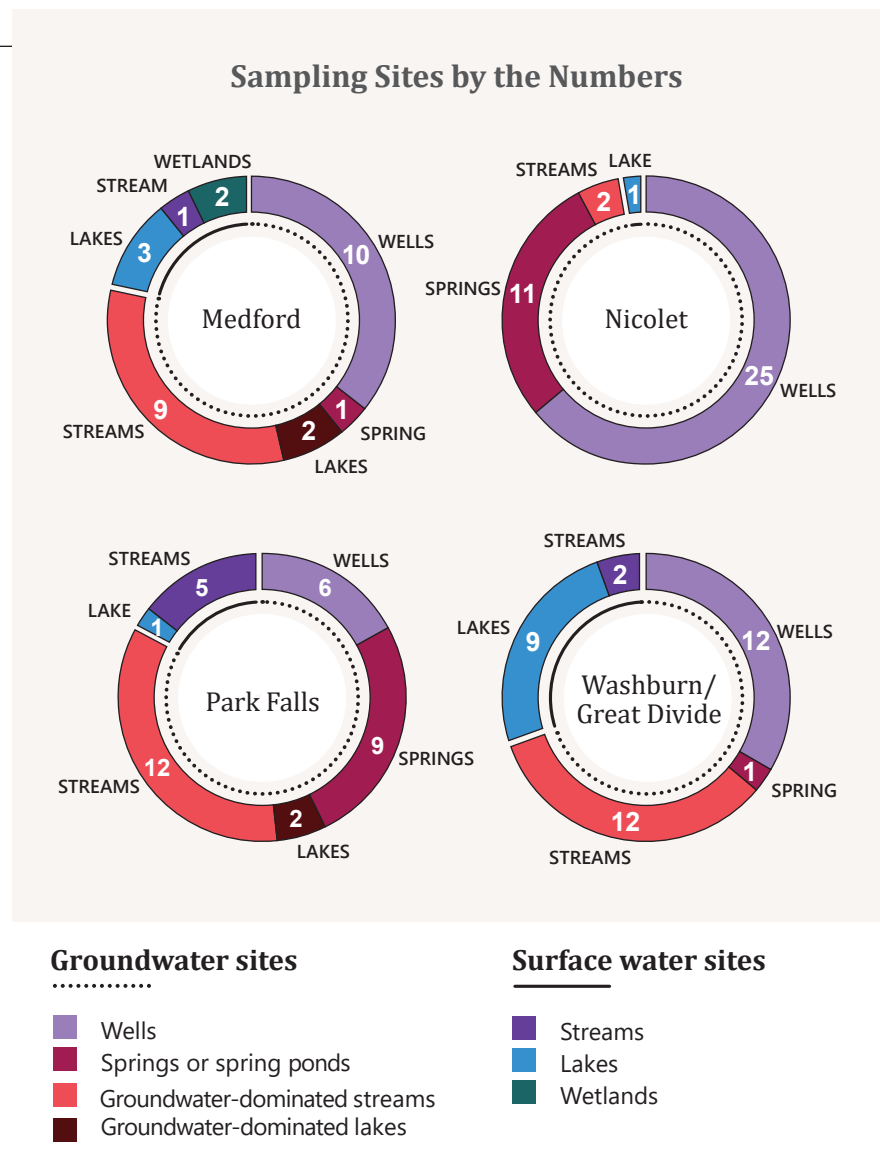


Figure 2. Sampling sites by the numbers in each of the four units of the CNNF. Numbers correspond to sites sampled in both sampling periods.

Although overall water quality is high, a few well samples were elevated in one or more water quality parameters. Drinking water standards are established to protect public health by limiting the levels of contaminants in groundwater and drinking water (table 1). Wisconsin's NR140 Public health enforcement standards (ES) are based on federal Safe Drinking Water Act standards. Wisconsin's NR140 preventive action limits (PAL) are set at a percentage of an established ES concentration (typically 10–20%). Similar numbers of well samples exceeded the Wisconsin NR140 public health ES and PAL for manganese in 2011–16 and 2021–22. Fewer well samples exceeded PALs for arsenic and lead

in 2021–22. Manganese, arsenic, and lead are naturally occurring elements in minerals and rocks in the region. Wells with a manganese concentration in exceedance of the enforcement standard were either out of service at the time samples were collected or samples were collected during the off season when the wells were not in use by the public. It is recommended that these wells be re-sampled periodically to ensure levels do not exceed drinking water standards. If exceedance levels are identified during operational timeframe wells would be closed for public use.

Surface water sites

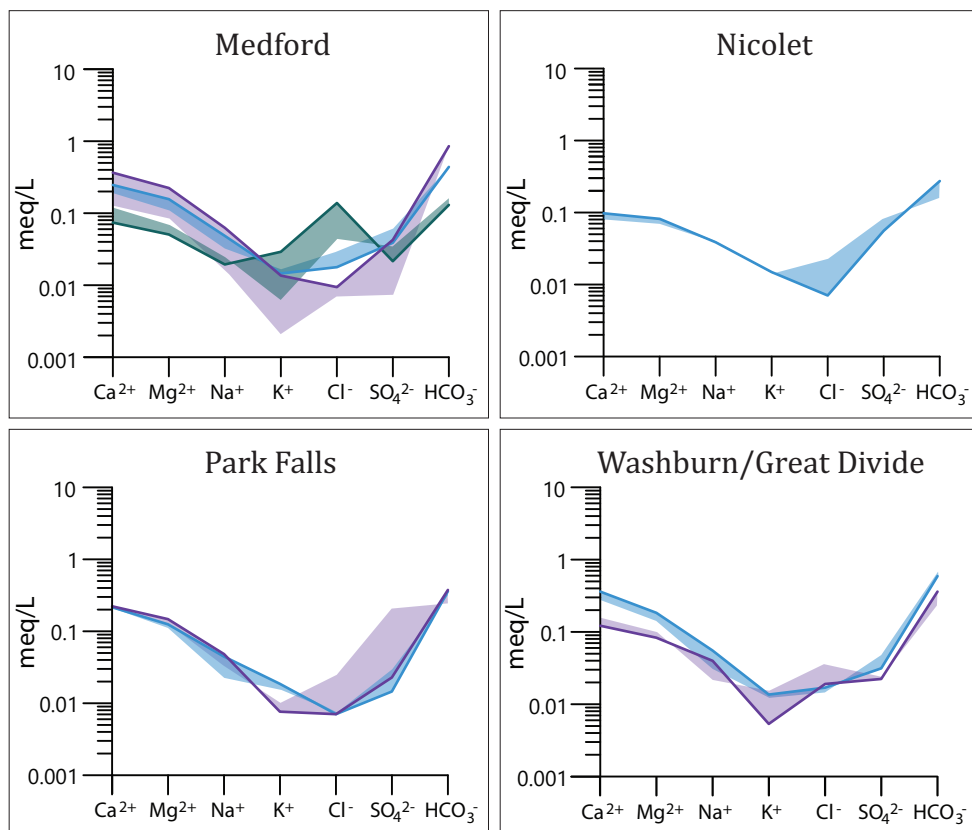
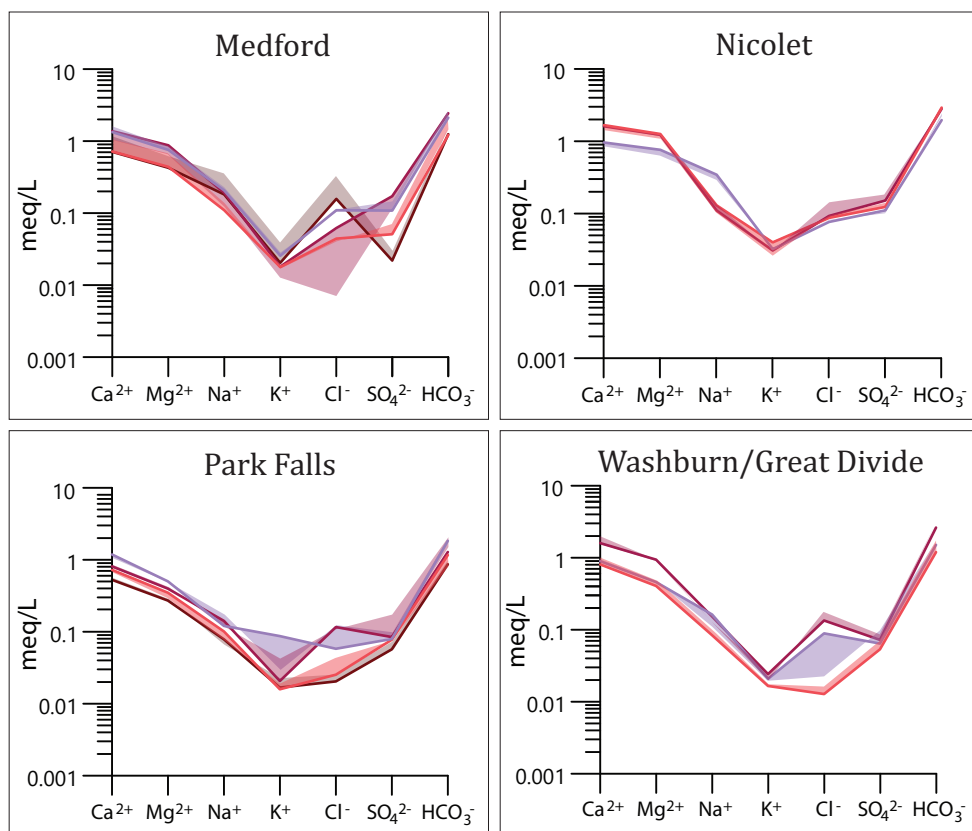


Figure 3. Relative concentrations of major ions in different water sources in each of the four units of the CNNF. These Schoeller diagrams display average ion concentrations in electron milliequivalents (meq/L, milliequivalents per liter). The y-axis is in the logarithm scale to plot the milliequivalent concentrations of the ions. Cations plot along the left side of the x-axis, and anions plot on the right. The shape of the plots indicate the relative importance of individual ions. Shaded regions show changes in ion concentrations between 2011-16 and 2021-22. The most recent results (2021-22) are represented by lines that bound the shaded zones.

Surface water sites

- Surface water-dominated Streams
- Surface water-dominated Lakes
- Surface water-dominated Wetlands

Groundwater sites



Groundwater sites

- Wells
- Springs or Spring Ponds
- Groundwater-dominated Streams
- Groundwater-dominated Lakes

Water chemistry was mostly unchanged between 2011–16 and 2021–22. Locally elevated chloride suggests some influence from road salting and a few well samples exceed the Wisconsin NR140 ES or PAL for manganese or arsenic. However, water quality in all four units of the CNNF is very good and considered pristine in many areas, thus highlighting its vulnerability to human activities in the future.

Supplemental material

The following materials are available for download at: <https://doi.org/10.48358/mhqa1786>

- A water quality database for the Chequamegon-Nicolet National Forest including ion chemistry and basic nutrients results presented here, field measurements of temperature, pH, electrical conductivity, dissolved oxygen, and stable isotope ratios of hydrogen and oxygen.
- A supplemental report on the Chequamegon-Nicolet National Forest water quality database (Swanson and others, 2024).

Acknowledgments

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References

Bradbury, K.R., and others, 2018a, Characterization of groundwater resources in the Chequamegon-Nicolet National Forest, Wisconsin—Park Falls Unit: Wisconsin Geological and Natural History Survey Technical Report 004-3, 47 p., 10 plates., <https://doi.org/10.54915/pxjz8066>.

Table 1. Numbers of well samples exceeding NR 140 Public Health Standards.

Enforcement Standard

Analyte	Number of samples 2011-16	Number of samples 2021-22	Standard (µg/L)
Arsenic	0	0	10
Lead	0	0	15
Manganese	7	5	300

Preventive Action Limit

Analyte	Number of samples 2011-16	Number of samples 2021-22	Standard (µg/L)
Arsenic	7	2	1
Lead	6	0	1.5
Manganese	20	18	60

Bradbury, K.R., and others, 2018b, Characterization of groundwater resources in the Chequamegon-Nicolet National Forest, Wisconsin—Medford Unit: Wisconsin Geological and Natural History Survey Technical Report 004-1, 50 p., 10 plates, <https://doi.org/10.54915/ycpm2707>.

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