Considerable progress has been made in past decades in watershed assessments to advance understanding of the FEW nexus, based on the combined contributions from catchment research, water monitoring, and watershed modeling. These contributions have improved process understanding about the nature of the interactions of food and energy production with water and nutrient cycles and the multi-scale and far-reaching impacts of agriculture and atmospheric deposition on nutrient and ecological conditions in terrestrial and aquatic ecosystems. However, important gaps remain in process understanding that affects management. These gaps could be potentially addressed by improved multi-scale sharing and integration of the measurements and models from watershed assessments. This includes the integration of multiple modeling and assessment techniques and data platforms to provide a more seamless use of methods and data across broad spatial and temporal scales, institutions, and environmental media (e.g., ground and surface waters, soils). Trends in modeling methods that can support this approach include the use of parsimonious model specifications, spatially explicit model structures, parameter and uncertainty estimation, and modular and coupled mechanistic models as well as hybrid statistical-mechanistic models. Examples include a recent coupling of USGS ground and surface water models of nitrogen sources and transport in the Potomac River Basin; this provides an improved assessment of nitrogen residence times in base and total streamflows and projections of response times to management scenarios. The coupling of a USDA mechanistic model of farm-scale conservation practices in the Upper Mississippi Basin with a USGS statistical model allowed estimation of Basin-scale conservation effectiveness. In addition, a recent coupling of a more computationally efficient, new-generation Bayesian method with a USGS hydrological model illustrates opportunities for enhancing data sharing in models over time and space to improve model accuracy and interpretability.

Improvements in geospatial data and spatial interpolation methods are critical to support advances in the use of more integrated watershed assessment methods. For example, more strategic sampling and methods of data integration and sharing are needed to address mismatches in scale between routine stream monitoring by public agencies on larger streams and rivers and intensive field and catchment-scale studies conducted by research institutions. The routine sampling for conventional constituents has generally undergone large declines from the 1970s peak in monitoring, with evidence of some stability during the past two decades. A perhaps larger concern though is the limited co-location of routine water-quality monitoring with streamflow gauges, which complicates the estimation of mass flux in streams that is essential to track sources and assess processes in models; coordinated applications of streamflow models are needed to estimate flow at ungauged locations. \textit{In-situ} stream sensor technologies, such as continuous nitrate probes, are on the rise, with USGS monitoring sites increasing to nearly 100 nationally in 2014. These offer high frequency, accurate measures that provide new opportunities to improve flux and source quantification and process understanding; however, the methods are expensive with high maintenance costs. Many challenges in assessing water runoff from agricultural production systems stem from the limited spatial and temporal resolution of key geospatial data. These include farm fertilizer use, water use (irrigation), tile drainage systems, livestock waste nutrients, and conservation practices, many of which are reported at very coarse spatial scales (counties) and limited by legal restrictions on the public disclosure of farm practices. Spatial methods are needed to reliably disaggregate to smaller scales and spatially smooth protected data. Finally, there are key gaps in process knowledge that limit understanding of the FEW nexus, related to nutrient storage, transport, and fate in watersheds, including agricultural emissions of ammonia. Notable among these is quantifying nitrogen losses from denitrification and leaching to ground waters. The former represents an important permanent loss of nitrogen that is poorly quantified in soils and aquatic systems. By contrast, leaching to ground water contributes to future nutrient releases to streams that may be delayed by years to decades and pose serious challenges for managing agricultural runoff.