Improving watershed conservation efforts using existent ecohydology data

Ryan Utz
Aquatic Ecologist, National Ecological Observatory Network (NEON)

Discharge represents the most dominant physical control on ecosystem function and structure in flowing waters. The timing, duration and magnitude of episodic flow events (floods, desiccation and stable baseflow), hereafter the flow regime, defines the physical stressors lotic organisms must routinely cope with and therefore directly shapes entire assemblages of taxa (Poff et al. 1997). Flow regimes exert substantial control on the geophysical and chemical properties of riverine ecosystems as well. The highly integrated connection between watersheds and stream ecosystems, perhaps the major theme in stream ecosystem ecology over the past 40 years, exists largely due to flow regime dynamics, as landform features dictate flow paths during precipitation events for water that eventually becomes stream flow.

First, the good news: data and tools required for intensive flow regime analysis abounds. For instance, the United States Geological Survey (USGS) has operated a stream gaging program for over one hundred years, collecting data on thousands of rivers and streams throughout the continent. USGS discharge data is quality controlled, freely available for download in multiple formats and represents a broad diversity of lotic ecosystems. Some local governments, notably the California Department of Water Resources, compliment USGS data with similar high-quality discharge data collection programs of their own.

The challenge: data and tools required for intensive flow regime analysis abounds. Hydrologic datasets represent time series and are thus inherently large. Ten years of 15 minute-interval data, the standard for USGS gages and the resolution required to calculate some metrics, involves 175,200 lines of data. Many ecologists, particularly in early career stages, primarily use spreadsheet-based programs for analytical procedures that minimize their capacity to analyze multiple sites consisting of such large datasets. A wealth of software resources exists for hydrologic data analysis, but many of these have been developed for civil engineering applications that offer limited utility for ecologists. Others interface with interactive maps that constrict functionality, especially when assessing multiple sites. All such analytical resources involve some degree of mastering a new program and the limited scope of most programs decreases the rewards of investing time in self-education.

The inherent potential of freely available hydrologic data

For my doctoral dissertation, I was granted access to a database of fish and macroinvertebrate from 2,300 streams located throughout the state of Maryland. After early work revealed that biological sensitivity to urbanization (the primary environmental stressor in Maryland) was more severe in streams of the Piedmont physiographic province relative to the Coastal Plain (Utz et al. 2009, 2010), I dedicated the remainder of my dissertation attempting to determine why. Using data freely available from the USGS, I documented distinct hydrologic responses to watershed urbanization between the two physiologically different but geographically adjacent provinces that were previously undetected. Fewer and less severe flood events occur in Coastal Plain streams lacking urban development relative to those in the Piedmont, potentially due to extensive natural wetland cover (Utz et al. 2011). As watersheds develop, Coastal Plain streams remain relatively less flood-prone up to a certain level of watershed urbanization. Such inherent differential responses of stream ecosystems to land use change among physiographic regions are likely commonplace. Exploring such heterogeneity in other regions and gaining an understanding of underlying mechanisms could vastly improve the efficacy of watershed conservation efforts in catchments threatened with land use conversion worldwide.

As described above, the hydrologic data required to elucidate these patterns further already freely exist. The data needed to integrate flow regime structure (and changes associated with land use conversion) with ecological patterns also exists, albeit typically embedded in the initiatives of local agencies rather than a national program with open-access data. From a personal perspective, two related factors inhibit progress. First, hydrologic data exist in heterogeneous formats among a suite of national and regional institutions while the programs available to assess these data offer limited functionality for large-scale ecological inquiry. Second, many ecologists, particularly in early career stages, are averse to acquiring the necessary analytical skills required to assess hydrologic data (especially in light of the previously stated problem) and couple such findings with ecological data. I do not claim to possess the solutions to these issues, and yet another limited-scope analytical tool to assess hydrologic data with specific applications in ecology is likely not the answer. Nevertheless, spreading the word that assessing existent hydrologic data can help further stream ecosystem conservation and restoration efforts through my own research and the education of others represents a fundamental personal career goal.

The National Ecological and Stream Observatory Networks (NEON and STREON)

At NEON, we will be collecting data on >100 environmental variables in 36 streams and lakes throughout the continent using standardized methodology at each site (in addition to a broad suite of terrestrial and atmospheric measurements). Our time frame for data collection is a minimum of 30 years. Most importantly, data we collect will be freely available for use by the scientific and general public. A subcomponent of our aquatics program involves an 8-year experiment that simultaneously explores the effects of nutrient enrichment and predator exclusion 10 streams (STREON). At NEON, we have a complete cyber-infrastructure team whose mission is to ensure that our data are shared in a coherent, usable interface. Such resources greatly expand our potential to facilitate scientific inquiry using complex ecological data. In the following years at NEON, I hope to use my experiences to avoid the problems that block advances in ecohydrology described above.