EPA United States Environmental Protection Agency

Using Regional Monitoring Network (RMN) Data to Track Climate Change Effects

The United States Environmental Protection Agency (U.S. EPA) is working with its regional offices, states, tribes and other entities to establish Regional Monitoring Networks (RMNs) for freshwater wadeable streams (EPA 2016). The objective of the RMNs is to detect potentially small, climate-related trends at a regional scale and in a decision-relevant timeframe. The RMN design calls for sampling at least 30 sites with similar environmental and biological characteristics in each region on an annual basis for 10 or more years. Biological, thermal, hydrologic, physical habitat and water chemistry data are being collected to document baseline conditions and detect long-term changes. Consistent methods are being used to increase the comparability of data and minimize biases and variability. The intent is to pool the data at a regional scale, which will enable more robust analyses and improve the ability to detect climate-related trends over shorter time periods.

One of the objectives of the RMNs is detection of climate change effects in the context of biomonitoring. Climate change requires managers to consider increasingly complex and uncertain futures, often at longer time horizons than typically considered in resource management. The RMN data are important in the context of climate change, as managers can use the monitoring data to help inform adaptive management options. There are a number of climate change projections that are relevant to aquatic life condition, including increasing temperatures (Figure 1), increasing frequency and magnitude of extreme precipitation events, and increasing frequency of summer low flow events (Karl et al. 2009, Melillo et al. 2014). The RMNs target high quality and least disturbed sites, since there is a higher likelihood of detecting climate change-related impacts in the absence of other non-climatic stressors.

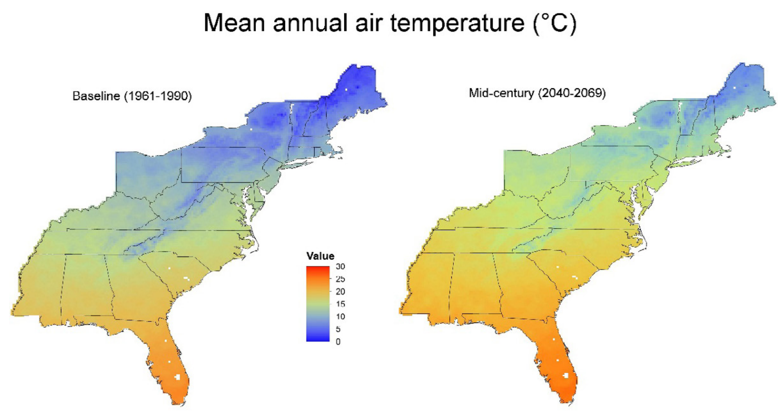

Figure 1. Mean annual air temperature (°C) is projected to increase across the eastern US by mid-century[1].

Vulnerability Assessment: Many organizations are performing climate change vulnerability assessments and developing hypotheses about which organisms, community types, watersheds or stream classes are likely to be most vulnerable to climate change effects. For example, the EPA and partners are conducting a broad-scale climate change vulnerability assessment on streams in the eastern US. This study assigns vulnerability ratings to each watershed[2] based on a scenario in which stream temperatures warm and the frequency and duration of summer low flow events increases (Figure 2). The RMN data can be used to help test these types of hypotheses and predictive models related to climate change. If certain types of streams show greater resilience to climate change effects than others, this type of information could help inform adaptation strategies and conservation planning.

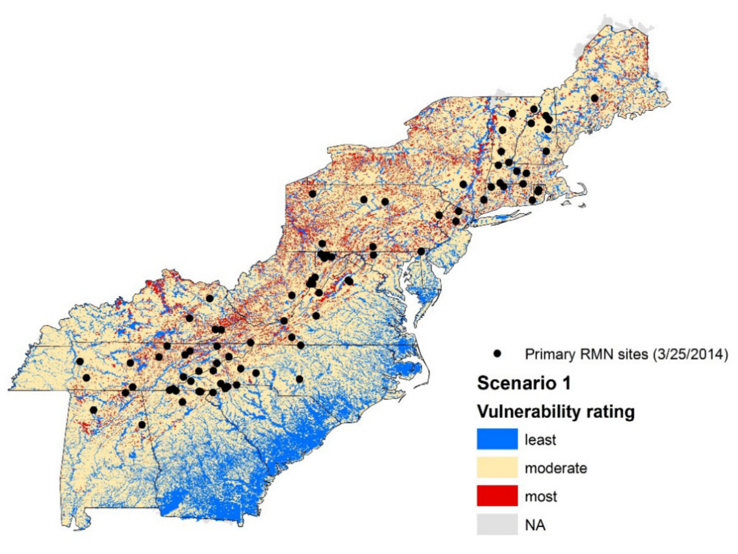

Figure 2. EPA and partners are conducting a broad-scale climate change vulnerability assessment on streams in the eastern US, based on a scenario in which stream temperatures warm and the frequency and duration of summer low flow events increases. Vulnerability ratings (least, moderate or most) are being assigned to each watershed.

Species Distribution: RMN data can also be used to monitor changes in spatial distributions of biological indicators and to evaluate whether these changes are associated with changing thermal and hydrologic conditions. Based on preliminary analyses, RMN sites in the Appalachians have relatively high proportions of cold water macroinvertebrate taxa (EPA 2016).

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[1] These data are based on the average of an ensemble of 15 General Circulation Models (GCMs) for the A2 (high) emissions scenario, and were obtained from the Climate Wizard website. We acknowledge the modeling groups, the Program for Climate Model Diagnosis and Intercomparison (PCMDI) and the WCRP's Working Group on Coupled Modelling (WGCM) for their roles in making available the WCRP CMIP3 multi-model dataset. Support of this dataset is provided by the Office of Science, U.S. Department of Energy.

[2] Watershed delineations are based on the NHDPlus v2 local catchment layer: http://www.horizon-systems.com/NHDPlus/NHDPlusV2_data.php

The RMN data can be used to detect whether shifts in the distributions of these taxa are occurring as temperatures warm. In some places, species distribution models (SDMs) have been developed. For example, Zheng et al.[3] generated models to predict how species occurrence will change by mid-century in the Northeast under conditions of rising air temperatures and changing precipitation patterns[4]. Results suggest an overall decline in species richness across much of the region (Figure 3). Models have been generated for other regions as well, including SDMs by Hawkins et al. (2013) that predict how the distributions of individual macroinvertebrate taxa and entire assemblages of taxa will change across the conterminous US by late century. These models could potentially be applied to RMN sites, and the modeled data compared to observed data. If the models perform well, they could serve as a valuable tool for watershed protection planning.

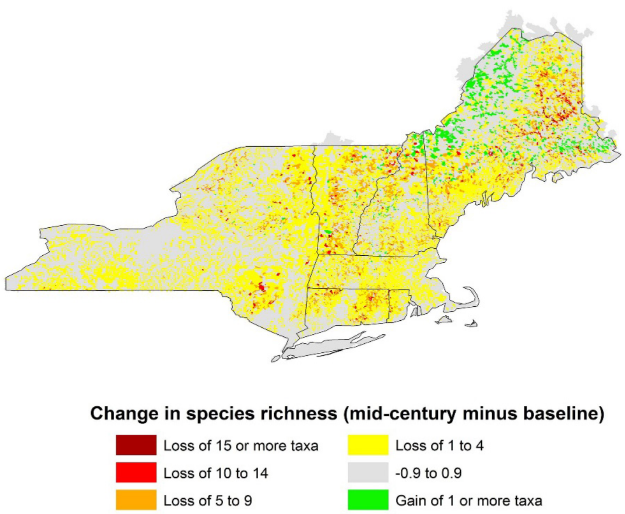

Figure 3. Modeling results by Zheng et al. predict declines in species richness across much of the Northeast by mid-century (2040-2069)[3].

Stream Temperature and Flow: Models also have been developed to predict climate change effects on stream temperature and flow. For example, at the national scale, Hill et al. (2014) developed an empirical stream temperature model for the conterminous US and simulated the effects of climate change on mean summer stream temperature. The model predicts a mean warming of 2.2°C for stream temperatures by late century (2090–2099) relative to a 2001–2010 baseline period, with increases at individual sites ranging from 0°C to +6.2°C. In another study, Dhungel (2014) developed statistical models to predict flow responses to projected changes in precipitation and temperature. Results suggest that changes in flow attributes will be most evident in rain-fed small perennial streams and intermittent streams in the central and eastern US. These models could potentially be applied to RMN sites, and the performance of the models could be tracked over time.

Response to Extreme Events: RMN data also may provide insights into how organisms respond to and recover from extreme events such as droughts and floods, which are projected to occur with greater frequency as the climate changes (Karl et al. 2009, Melillo et al. 2014). If an extreme event occurs at a RMN site, the data collected prior to the event can be used to characterize "baseline" (pre-event) conditions, and the continuous sensor data will capture the magnitude, frequency and duration of the event. Impacts can be evaluated through comparative analyses on the pre- and post-event data. Vermont Department of Environmental Conservation (VT DEC) performed these types of analyses on macroinvertebrate data collected before and after flooding from Tropical Storm Irene, which occurred in August 2011. Using data from 10 high-quality sentinel sites, VT DEC documented immediate decreases in invertebrate densities of 69% on average, but also found that most sites recovered to normal levels the following year (Figure 4). The substantial decline in density and the rapid recovery would have been missed if sampling had occurred at longer intervals, such as on a traditional 5-year rotational sampling schedule. Whether or not the RMN data can fully capture biological responses to events like this will depend on the timing of the event in relation to the RMN sampling period. It is possible that additional sampling may be warranted.

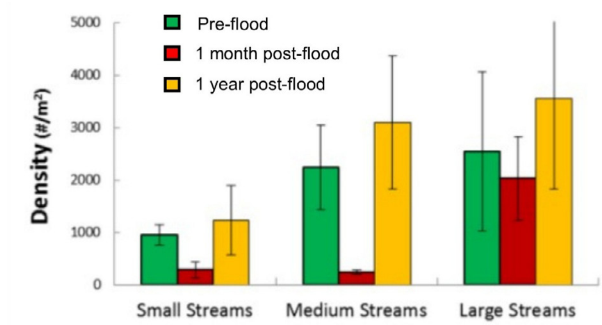

Figure 4. Comparison of macroinvertebrate density values at 10 stream sites in Vermont before and after Tropical Storm Irene (provided by Moore and Fiske, VT DEC, unpublished data).

More detailed information on how RMN data can be used to detect climate change effects can be found in the RMN report (U.S. EPA 2016: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=307973).

Literature cited:

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3 Zheng, L., Stamp, J., and Hamilton, A. (2014) Species Distribution Modeling: Impact of Climate Change and Species Vulnerability. Poster presented at the Joint Aquatic Sciences Meeting, Portland, OR.

4 Mid-century (2040–2069) projections for air temperature, precipitation and moisture surplus were based on average values from an ensemble of 15 GCMs, using the a2 (high) emissions scenario. Data were obtained from the Climate Wizard website and are based on the WCRP CMIP3 multi-model dataset.