Mapping loading rates and sources of reactive nitrogen across the United States suggests regional interactions with climate change

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Accurate, up-to-date information describing Nr inputs by source is needed for effective Nr management and for guiding Nr research. Here we present a new synthesis of spatial data describing present Nr inputs to terrestrial and aquatic ecosystems across the conterminous US to help prioritize watersheds for Nr management and direct additional research at local to regional scales. Using published data and models, we estimated annual Nr inputs from fertilizer, biological nitrogen fixation (in agricultural and non-cultivated ecosystems), atmospheric deposition, livestock manure, and human sewage for the early 2000s at the spatial scale of small watershed units (8-digit US Geologic Survey Hydrologic Unit Codes; HUC8s). These maps show that the degree of human modification of Nr inputs is quite spatially variable across the US. HUC8s in sparsely populated regions, such as those in the Desert Southwest and Pacific Northwest, currently receive annual anthropogenic Nr inputs equivalent to 0.1 times background Nr inputs, with atmospheric deposition the largest anthropogenic Nr source in these areas. HUC8s in major agricultural and urban areas, such as those in the Upper Midwest, California's Central Valley, and the Northeast, presently receive annual anthropogenic N inputs up to 35 times greater than background inputs. Across these areas, synthetic Nr fertilizer is usually the single largest Nr source, although atmospheric deposition and human sewage can also be particularly important in urban areas. In addition to providing new insights on the spatial distribution of Nr loading and sources across the US, these data also provide a baseline for investigating spatially explicit interactions between Nr loading and anticipated effects of climate change. For example, areas where Nr loading is currently most intense, such as agricultural portions of the Upper Midwest and California's Central Valley, are also places where the frequency and severity of droughts and flood events are forecasted to increase in the coming decades because of global climate change. Such climate change effects could dampen or exacerbate Nr losses to air and water resources in these regions.