Mapping the benefits of our ecosystems

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We rely on our physical environment for many things – clean water, land for crops or pastures, storm water absorption, and recreation, among others. Yet it has been challenging to figure out how to sustain the many benefits people obtain from nature—so-called "ecosystem services"—in any given landscape because an improvement in one may come at the cost of another.

Two ecologists at the University of Wisconsin–Madison report this week (July 1) in the *Proceedings of the National Academy of Sciences* a novel approach to analyzing the production and location of 10 different ecosystem services across a landscape, opening the door to being able to identify factors governing their synergies and tradeoffs.

Monica Turner, the Eugene P. Odum Professor of Zoology, and graduate student Jiangxiao Qiu mapped the production, distribution, and interactions of the services in three main categories: provisioning (providing resources like food, fiber, or fresh water), cultural (such as aesthetics and hunting), and regulating (including improving ground and surface water quality, handling floodwater, preventing erosion, and storing carbon). They focused on the Yahara River watershed, which covers much of central portion of Dane County and parts of Columbia and Rock Counties in southern Wisconsin and includes the chain of Madison lakes.

"We found that the main ecosystem services are not independent of each other. They interact spatially in very complex ways," says Qiu, lead author of the new study.

Some of those interactions were not surprising—for example, higher levels of crop production were generally associated with poorer surface and ground water quality. However, two other sets of services showed positive associations: flood regulation, pasture and freshwater supply all went together, as did forest recreation, soil retention, carbon storage and surface water quality.

"If you manage for one of these services, you can probably enhance others, as well," says Turner. "It also means that you can't take a narrow view of the landscape. You have to consider all of the things that it produces for us and recognize that we have to manage it very holistically."

Even in the expected tradeoff between crop production and water quality, the researchers found something unexpected.

"There is a strong tradeoff between crop production and surface and groundwater quality," Qiu says. "But despite this, there are still some locations that can be high for all three services—exceptions that can produce high crop yield and good water quality in general."

Preliminary analysis of these "win-win" areas suggests that factors like flat topography, a deep water table, less field runoff, soil with high water-holding capacity, more adjoining wetlands and proximity to streams with riparian vegetation may contribute to maintaining both crop production and good water quality.

The results also show that nearly all of the land in the watershed provides a high level of at least one of the measured services but that they are not uniformly distributed. Most areas offer a high level of just one or two services. But a few, termed "hotspots" and making up just three percent of the watershed (largely parks and protected areas), provide high levels of at least six of the measured services.

"A single piece of land can provide different kinds of services simultaneously but you cannot expect that this land can provide all of the benefits," Qiu says.

The work was undertaken as part of a larger project to improve water sustainability in a mixed urban and agricultural landscape, supported by the Water Sustainability and Climate Program of the National Science Foundation (NSF).

"This paper is an initial assessment that gives us a picture of the spatial distribution of ecosystem services in contemporary times, a starting point for comparison," says Chris Kucharik, a UW–Madison professor of agronomy and environmental studies and principal investigator of the overall NSF project. The project aims to use a combination of contemporary and historical data to understand how the watershed may change over the next 50 to 60 years.

"We ultimately want to be able to look at future scenarios for this watershed," Turner says. "If climate changes or land use changes, what's going to happen to the values that we care about?"

More information: Spatial interactions among ecosystem services in an urbanizing agricultural watershed, www.pnas.org/cgi/doi/10.1073/pnas.1310539110

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