Water Sustainability and Climate
In the Yahara Watershed
UNIVERSITY OF WISCONSIN–MADISON

RESEARCH BRIEF

Optimizing the benefits of our ecosystems will require holistic landscape management

Summary

Different pieces of a given landscape provide different sets of natural benefits that sustain human life, called ecosystem services. The occurrence of both synergies and tradeoffs within ecosystem service bundles suggests that sustaining these natural benefits requires holistic landscape management.

Background

Knowledge of how ecosystem services, such as water quality and soil retention, interact with each other on a landscape has been limited, especially regarding where distinct synergies and tradeoffs between services exist. Synergies occur when multiple services could be enhanced or reduced simultaneously, while tradeoffs occur if the increased use of one service is at the expense of the provision of another service. Understanding the lay of the land in this regard could lead to targeted efforts to preserve or enhance ecosystem services, thereby strengthening landscape resilience and improving human well-being. This study focused on how ecosystem services are distributed across the Yahara Watershed, an urbanizing agricultural landscape in southern Wisconsin, and where synergies and tradeoffs occur.

Research Design

The study entailed mapping where and in what magnitude ten different ecosystem services are produced across the Yahara Watershed. The ten services were carbon storage, surface water quality, forest recreation, soil retention, flood regulation, pasture production, freshwater supply, crop production, groundwater quality, and hunting recreation. Three questions framed the analysis: 1) where are high and low supplies of individual services located, and do they co-exist with other services, 2) where do tradeoffs and synergies between services occur, and 3) where tradeoffs exist, why are there win-win anomalies?

Findings

Distribution on the landscape

Ecosystem services are scattered across the landscape and co-exist in various combinations. No single location produces all ten services. Most of the landscape (70%) provides a high supply of zero to two services and a low supply of three to five services.

Hot spots, or places with six or more services in high supply, are rare, comprising only 3.3% of the landscape, and often coincide with natural areas. These areas should be considered conservation priorities, since their degradation could mean the decline of multiple services.

Cold spots, or areas with a low supply of six or more services, are more common and cover more areas of the watershed. Intervention or restoration efforts might enhance the services provided in these locations.

Synergies and tradeoffs

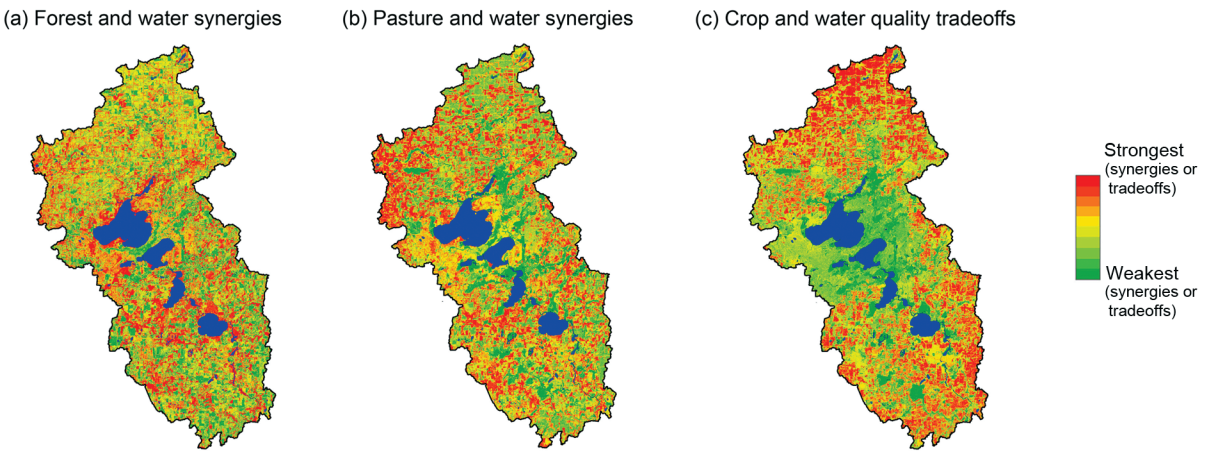
In most cases, synergistic relationships existed between co-existing ecosystem services. Two notable synergistic bundles are 1) forest recreation, soil retention, surface water quality, and carbon storage (called “forest and water synergies”); and 2) pasture production, freshwater supply, and flood regulation (called “pasture and water synergies”). In other words, managing to enhance one of these services would likely also enhance the others in the bundle.

Only one tradeoff emerged from the analysis: between crop production and water quality. This means increasing food production could be at the expense of freshwater quality. This tradeoff is common in agricultural landscapes, such as the Yahara Watershed, and exemplifies a potential compromise between current and future human

needs. However, there are win-win exceptions, wherein increasing crop production would not necessarily decrease water quality, or vice versa. These exceptions are uncommon (2.4% of the watershed), and they often coincide with features that facilitate water quality, such as adjacent wetlands, a deep water table, and less erodible soil.

maintaining the suite of services will require conserving locations that supply each one.

In agricultural landscapes, the pasture and water synergies imply that cultivating perennial crops could enhance flood regulation and freshwater supply. The forest and water synergies suggest that implementing practices to reduce soil erosion could improve surface water quality.



Maps A and B show where in the Yahara Watershed forest and water synergies and pasture and water synergies, respectively, exist. Red indicates where the associated ecosystem services are in high supply; green indicates where they are in low supply. Map C shows where crop production and water quality tradeoffs exist. Red means crop production is high, while surface and groundwater quality are low; green means crop production is low, but surface and groundwater quality are high..

Implications

Overall, findings indicate the importance of managing regional landscapes holistically to sustain multiple ecosystem services. There is no "silver bullet" for achieving water sustainability. Especially in agricultural landscapes, optimizing freshwater supply, groundwater and surface water quality, and flood regulation will not be simple. Sustaining individual services will require tailored strategies, and

Furthermore, win-win situations between agricultural production and water quality are possible in areas with flat topography, less erodible soil, a deep water table, soil with high water-holding capacity, favorable soil conditions for plant growth and filtration, and a nearby wetland or stream. Understanding why win-win situations exist may help mitigate tradeoffs and simultaneously maintain the supply of multiple ecosystem services.

Source

Qiu, Jiangxiao and Monica G. Turner. "Spatial interactions among ecosystem services in an urbanizing agricultural watershed." *Proceedings of the National Academy of Sciences of the United States of America* 110 (2013): 12149–54. doi: 10.1073/pnas.1310539110.

Research sponsor

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