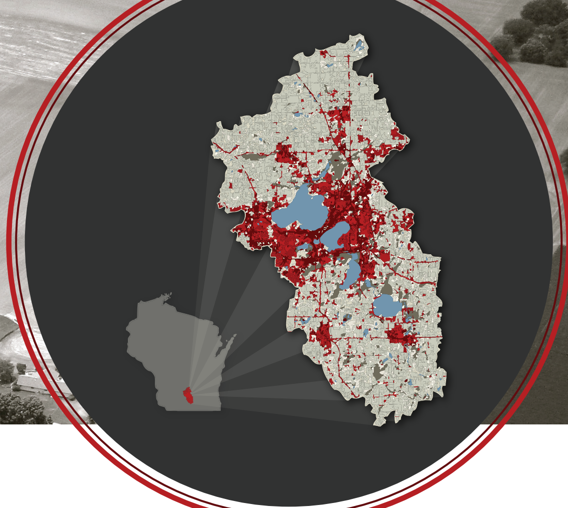
Water Sustainability and Climate
In the Yahara Watershed
UNIVERSITY OF WISCONSIN–MADISON



RESEARCH BRIEF

A method to bridge scenario narratives and biophysical models to explore multiple drivers of regional socio-ecological change

Summary

Ensuring a sustainable future requires an ever-improving ability to assess potential directions and impacts of socio-ecological changes. The method described here offers a comprehensive way to examine potential trajectories of long-term change in a given region.

Background

Scenarios are plausible accounts of how change could unfold and the logical consequences. Scientists use scenarios to shed light on ways societies and stakeholders could cope with socio-ecological changes and build resilience. As the popularity of scenarios grows, methodological needs have emerged. A particular challenge has been how to connect two common scenario elements: stories depicting possible futures and modeling tools that estimate future ecological conditions. Stories serve to engage non-technical audiences in future thinking, while models assess the consequences of socio-ecological change based on established knowledge of how natural systems work. Effectively bridging stories and models can provide a richer, more accurate, and more credible look into the future that resonates with multiple user groups.

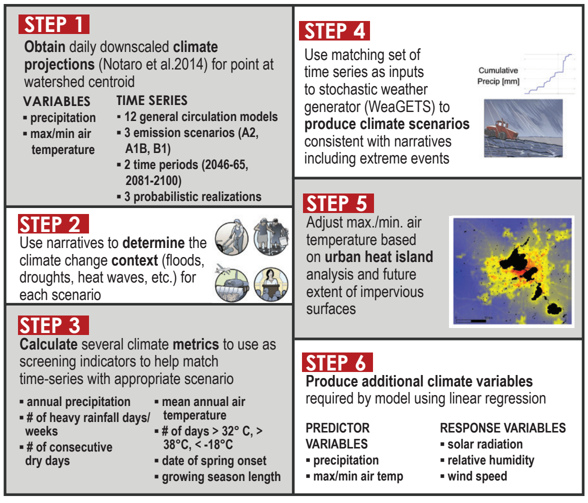
A scenarios project about Wisconsin's Yahara watershed, called Yahara 2070, sought to address this methodological challenge. The technique could be replicated by research or planning teams seeking a comprehensive outlook on future change and multiple ways to engage decision makers and the public in future thinking.

The Method

The development of Yahara 2070 began with the creation of four detailed storylines based on input by local stakeholders and ideas from the global scenarios literature. The stories are place-specific and address several socio-ecological drivers of change that will affect the future of ecosystem services in the Yahara watershed – namely, climate, land use/land cover, and nutrient management. Researchers then estimated trajectories for these drivers based on the events in the narratives. These estimations served as the model input data, used to calculate the outcomes for ecosystem services in each scenario. Below is a brief explanation of each model driver's development.

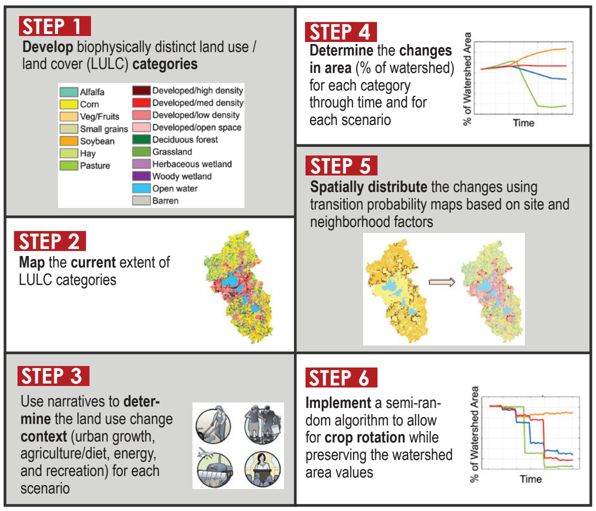
Climate

The models needed daily temperature and precipitation data from 2011 to 2070 to simulate climate impacts. To generate these data, the research team used both downscaled global climate projections and a stochastic weather generator. This enabled them to balance long-term validated trajectories with an ability to simulate specific weather events that happen in the storylines, such as droughts and storms. The researchers generated 234 unique twenty-year time intervals for climate in the specified timespan. Then they screened the intervals for climatic features such as annual air temperature, extreme precipitation, and extreme heat and cold events, selecting those that best matched the storylines. They also accounted for the urban heat island effect and land-surface variables that affect weather, such as solar radiation, relative humidity, and wind speed.



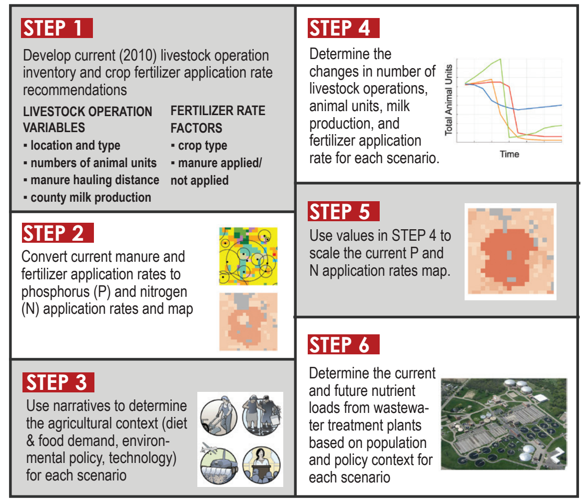
Land use/Land cover

The research team developed categories of land use/land cover (LULC) that are specific to the region and could be modeled, such as high-density urban area, grassland, and corn. Using these categories, they then created maps to represent the present-day landscape. For each scenario, they estimated the change in area of each LULC category that occurs throughout the scenarios' time period, based on the events of the narrative, such as increases or decreases in urban land. They then developed maps to illustrate these landscape transitions in ten-year intervals, distributing the changes across the landscape according to where they would most likely occur. For example, urban growth would likely occur adjacent to existing urban area.



Nutrient Management

Phosphorus and nitrogen from manure and fertilizer are important variables in future soil health and water quality in the watershed. The researchers inventoried the region's current livestock operations, manure production, and recommended fertilizer application rates, and then applied those amounts and spread areas to a map. Following the events of each narrative, the researchers estimated changes to the number of livestock operations, animal units, milk production, and fertilizer application rates. Using the resulting values, they scaled the manure and fertilizer application maps accordingly. Finally, they incorporated current and estimated future nutrient loads from local municipal wastewater treatment plants.



Key Lessons

This method provides a transparent and reproducible roadmap for researchers seeking to marry storylines and computer models to produce comprehensive outlooks for the future. Key lessons learned include the following:

- It is important to examine multiple drivers of change to paint a more realistic picture of the future. For example, changes in climate, human diet, and land-use combined will determine future conditions; examining only one driver in isolation will generate a limited outlook.
- When using climate projections, it is important that they are consistent with the stories to preserve plausibility. Drivers should include specific climatic events, like extreme storms, that mimic the narratives.
- Regular communication between the scenario writer and the modeling team ensures there is consistency between the narratives and drivers of change. For example, if the modeling team needs to know a detail that is absent from the narrative, they should discuss with the writer how the stories should represent that detail. Careful communication also enhances the transparency of the process and requires researchers to be comfortable working across disciplines.

An approach like this can both advance the scientific capacity to understand long-term change and help people imagine possible futures. Only with transformative thinking across society can we build the resilience necessary for stronger and more sustainable communities.

Source

Booth, E.B., J. Qiu, S.R. Carpenter, J. Schatz, X. Chen, C.J. Kucharik, S.P. Loheide, M.M. Motew, J.M. Seifert, and M.G. Turner. "From qualitative to quantitative: Translating storylines into biophysical modeling inputs at the watershed scale." Environmental Modeling & Software 85 (2016): 80-97. doi: 10.1016/j.envsoft.2016.08.008

Research sponsor

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Water Sustainability and Climate Project

The Water Sustainability and Climate Project (WSC) at the University of Wisconsin-Madison is an integrated effort to understand how water and the many other benefits people derive from nature could change over time. The five-year project (2011–2016) was focused on the Yahara Watershed in southern Wisconsin and funded by the National Science Foundation. Visit wsc.limnology.wisc.edu.