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VELMA ECO-HYDROLOGICAL MODEL, VERSION 2.0

Identifying Green Infrastructure for Enhancing Water Quality & Ecosystem Service Co-Benefits

Background

Sustainable supplies of clean water are vital to human health, local economies, recreational opportunities, and protection of aquatic habitat. Increasing pressures from population growth and land use change have compromised water quality of many U.S. rivers and estuaries. Projected changes in climate are expected to further impact water resources. As a result, many communities are exploring green infrastructure (GI) options for protecting water quality.

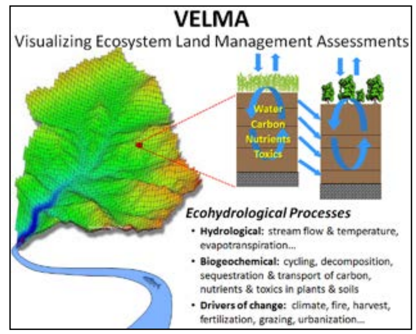
GI involves the establishment of riparian buffers, cover crops, constructed wetlands, and other measures to intercept, store and transform nutrients, toxics and other contaminants that might otherwise reach surface and ground waters.

Although many communities and landowners are already using or planning to invest in GI, sufficient data often do not exist to make informed decisions about where, how much and what kinds of GI will be required to meet water quality goals at local and regional scales. In particular, it has been difficult to identify general rules that can be applied to any given location or set of conditions. Social and economic considerations also cloud the picture, as stakeholders are often in disagreement on the effectiveness and need for riparian buffers. Tradeoffs in land-use (e.g. agricultural demand vs. water quality) often drive the debate and decision making process. Thus, there is a clear need for scientifically defensible tools that stakeholders can use to predict trade-offs and estimate benefits of GI options appropriate for specific regions, habitats and conditions.

VELMA predicts the effectiveness of alternative green infrastructure scenarios for protecting water quality, and also estimates potential ecosystem service co-benefits and tradeoffs.

Approach

We developed an enhanced version (2.0) of the VELMA eco-hydrological model to help communities, land managers, policy makers and other decision makers assess the effectiveness of GI options for improving water quality of streams, rivers and estuaries. VELMA (Visualizing Ecosystem Land Management Assessments) predicts how natural and engineered GI options control the fate and transport of water, nutrients and toxics across multiple spatial and temporal scales – from plots to basins, from days to centuries.



VELMA also quantifies how different GI strategies affect ecosystem service co-benefits and tradeoffs – that is, the ecosystem's capacity to simultaneously provide clean water, flood control, food and fiber, climate (greenhouse gas) regulation, fish and wildlife habitat, etc.

These GI model enhancements include (1) major changes to the biogeochemical and hydrological submodels; (2) addition of a graphical user interface with powerful visualization capabilities; (3) a detailed user manual to assist novice and experienced model users in developing scenarios and applying VELMA for planning, policy and scientific applications; and (4) recoding the model in Java Eclipse to better support open source (community) model development.

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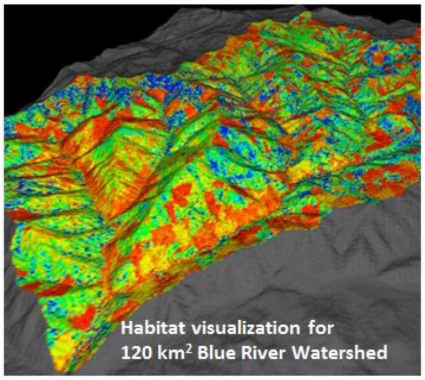

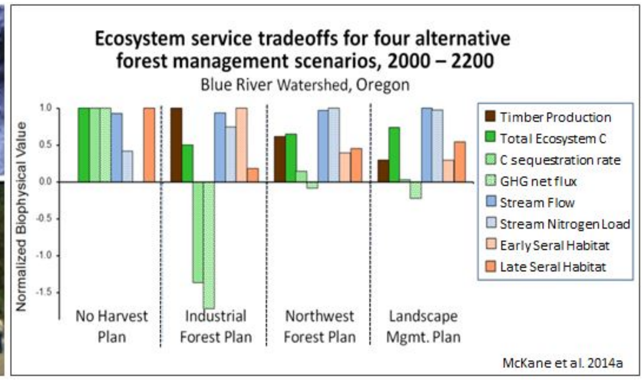

Results

VELMA 2.0 has been validated for GI in the Pacific Northwest and Chesapeake Bay (Abdelnour et al. 2011, 2013; McKane et al. 2014a, b). These applications focus on the use of riparian buffers, cover crops and other GI practices in agricultural and forest watersheds. Results illustrate how stream nutrient loads can be significantly reduced by locating riparian buffers in areas with shallow groundwater flow, and by maintaining buffer widths above nutrient-specific “breakthrough” thresholds. Results also illustrate how once-effective riparian buffers can fail, depending upon contaminant loads, soil properties, changes in climate and other factors.

VELMA 2.0 has also been used to quantify ecosystem service co-benefits under alternative GI strategies, including greenhouse gas mitigation, enhancement of fish and wildlife habitat, among others (McKane et al. 2014b).

Significance

VELMA 2.0 advances GI and ecosystem service assessments in a number of ways:

(1) Provides advanced visualization capabilities for assessing the effectiveness of GI strategies for improving water quality of streams, rivers and estuaries.

(2) Supports quantification of ecosystem service co-benefits and tradeoffs associated with alternative GI and climate change scenarios.

(3) Provides a transferable framework for making consistent comparisons of GI benefits across habitats and ecoregions. The aforementioned GI demonstrations for the Pacific Northwest and Chesapeake Bay watersheds are included with the VELMA 2.0 package (McKane et al. 2014a).

(4) VELMA is being linked with other tools, such as the BlueSky and BenMap air quality models, to better understand ecological, economic and human health tradeoffs associated with alternative decision scenarios, such as when and where to conduct rangeland prescribed fires for particular fuel load and atmospheric conditions (collaborative project with EPA Region 7).

VELMA Users

The VELMA 2.0 software and user manual are designed for several kinds of user groups, based on experience and need:

- **Group 1:** User describes questions and goals, VELMA team does the rest. Example: EPA clients (Regions, Office of Water, Office of Air and Radiation) who require information on potential effects of a policy change on water quality and ecosystem service tradeoffs.
- **Group 2:** User assembles GIS data, creates GI and climate scenarios, runs simulations and analyzes data. VELMA team provides model input files and calibrated parameters. Example: federal and state land managers, tribes, watershed councils and other community groups with sufficient GIS expertise.
- **Group 3:** User works independently to assemble model input files, calibrate parameters, and analyze model output. Example: academics and other professionals with expertise in hydrology, biogeochemistry and GIS methods.

References:

Abdelnour et al. (2011). Catchment hydrological responses to forest harvest amount and spatial pattern. Water Resources Research, 47(9).

Abdelnour et al. (2013). Effects of harvest on carbon and nitrogen dynamics in a Pacific Northwest forest catchment. Water Resources Research, 49(3).

McKane et al. (2014a). Enhanced version of VELMA eco-hydrological modeling and decision support framework to address engineered and natural applications of green infrastructure for reducing nonpoint inputs of nutrients and contaminants. Report ORD-010080, US EPA, Washington, DC.

McKane et al. (2014b). Sustainable and Healthy Communities Pacific Northwest Demonstration Study. Report ORD-007386, US EPA, Washington, DC.

VELMA WEBSITE:
https://www.epa.gov/water-research/visualizing-ecosystem-land-management-assessments-velma-model-20

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