LETTER

Physics attributed to curve number model illustrate need for caution, and ecological responses often lag restoration efforts

The article by Simonit and Perrings (1) describes development of a spatially explicit model of ecosystem service flows associated with reforestation of the Panama Canal watershed. Critical to their study are estimates of water flows, particularly during dry seasons.

We have two concerns. First, we agree with Ogden and Stallard's (2) critique of the authors' spatially explicit "curve number" (CN) method to estimate runoff. We note that in their response to the critique, Simonit and Perrings attempted to justify applying this method on a pixel-by-pixel basis by citing work by one of us (3) that showed the CN approach applied at various spatial scales provides "reasonable predictive power." In fact, this work (3) did not demonstrate this, but instead simply explored the consequences of adding new physics to the CN approach at the scale of runoff generated by individual pixels. This work (3) was meant to be a cautionary examination of both positive and negative biases that could be imparted to the modeled runoff through augmentation of the CN approach to capture spatial variability in runoff production. Moglen (3) clearly stated that "if a new approach systematically changes the answer in a single direction, the value of this new approach needs to be questioned." Citing this paper as support for the approach taken in ref. 1 is an incorrect interpretation of ref. 3.

An alternative approach that Simonit and Perrings (1) could have taken is to use a widely recognized continuous streamflow model such as Hydrological Simulation Program–FORTRAN (4). Use of such a model would have been appropriate for modeling effects of deforestation/afforestation and would have also avoided their questionable use of a CN-based approach. Perhaps their results are not that sensitive to the modeling approach taken; however, because they did not provide figures comparing observed and simulated streamflow or goodness-of-fit measures such as the Nash-Sutcliffe index (5), it is difficult to determine. The volume comparisons provided by the authors appear favorable, but these are at aggregated temporal scales (wet season, dry season) and large spatial scales. With the authors' emphasis on dry season streamflow, it would be enlightening to be able to visually assess the quality of fit between observed and simulated streamflow at a daily temporal scale.

Finally, they join many others who develop biophysical production functions for ecosystem services assuming that data from a current land use (e.g., forested area) is applicable to a restored (e.g., forested area), but we wondered if they considered testing this assumption. Significant hysteresis and time lags in ecological responses often characterize return to some former land use, and hydrologic equilibrium following reforestation may take years.

***Glenn E. Moglen*[a,1] *and Margaret A. Palmer*[b,c]**

[a]*Occoquan Watershed Monitoring Laboratory, Department of Civil and Environmental Engineering, Virginia Tech, Manassas, VA 20110;* [b]*National Socio-Environmental Synthesis Center, Annapolis, MD 21401; and* [c]*Department of Entomology, University of Maryland, College Park, MD 20742*

1 Simonit S, Perrings C (2013) Bundling ecosystem services in the Panama Canal watershed. *Proc Natl Acad Sci USA* 110(23):9326–9331.

2 Ogden FL, Stallard RF (2013) Land use effects on ecosystem service provisioning in tropical watersheds, still an important unsolved problem. *Proc Natl Acad Sci USA* 110(52):E5037.

3 Moglen GE (2000) Effect of orientation of spatially distributed curve numbers in runoff calculations. *J Am Water Resour Assoc* 36(6):1391–1400.

4 Bicknell BR, Imhoff JC, Kittle JL, Jr., Donigian AS, Jr., Johanson RC (1997) *Hydrological Simulation Program–Fortran, User's Manual for Version* 11 (US Environmental Protection Agency, National Exposure Research Laboratory, Athens, GA).

5 Nash JE, Sutcliffe JV (1970) River flow forecasting through conceptual models. Part 1: A discussion of principles. *J Hydrol (Amst)* 10(3):282–290.

Author contributions: G.E.M. and M.A.P. wrote the paper.

The authors declare no conflict of interest.

[1]To whom correspondence should be addressed. E-mail: moglen@vt.edu.

 www.pnas.org/cgi/doi/10.1073/pnas.1400119111