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Hydrology and Earth System Sciences
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Discussions

Interactive comment on "Relationships between environmental governance and water quality in growing metropolitan areas: a synthetic view through the coupled natural and human system lens" *by* H. Chang et al.

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Reviewer comment: (1) This paper claims to use "coupled human and natural system (CHANS)" and/or "social ecological systems" (SES) approach for modeling the "feedback" effects between environmental governance and water quality. However a close reading of the paper reveals that this paper does not accomplish or develop either a CHANS or an SES model of the case study areas. Instead, as shown in ïňĄgures 1 and 2, a "conceptual" model is presented. It is not clear how the "feedbacks" are modeled

in this "conceptual" model. The introductory section sets the reader to anticipate a new CHANS or SES model, but instead a bunch of regression equations and t-tests are presented in the results section without even elaborating about the nature of "positive" or "negative" feedbacks in the coupled system.

==> Response: We appreciate this important concern raised by the reviewer. We understand that the SES framework has been adopted in the second round of two urban LTER sites (Baltimore and Phoenix), and cities have been used as scientific experiments such as the one in the North Desert village experiment (Cook et al. 2004). However, as stated by Grimm et al. (2000) in discussing the initial observations of their first NSF LTER project, which was a similar state as the current state of our project, a city can be used as a laboratory to test hypothetitico-deductive hypothesis for only a small set of research areas that researchers identified. Accordingly, it is not our intention to develop a formal dynamic model to investigate complex feedback mechanisms in SES. Unlike the two US urban LTER sites (Baltimore and Phoenix) that have collected sufficient socioeconomic and biophysical data to formally test such linkages and possible feedbacks, we have only recently initiated this project as part of a NSF-sponsored ULTRA-ex program in 2010. Due to funding constraints, our new data collection has been limited to residential survey, policy maker interviews, green infrastructure information, and riparian area responses to municipal management actions. We have been using biophysical data, particularly water quality data, collected by many different agencies in the study area, and our intention is to suggest possible linkages and feedbacks in the study area without formally testing hypotheses (which is not yet possible with the current data we have). However, we added possible positive or negative feedbacks in our conceptual model. Hence our conceptual model lays out some of the relationships we feel are important to test, and our initial data analyses provide some beginning observations on some of the socio-ecological patterns that exist in this metropolitan area.

Cook W, Casagrande D, Hope D, Groffman P, and Collins S (2004) Learning to roll with the punches: adaptive experimentation in human-dominated systems. Frontiers in Ecology and the Environment 2: 467-474

Grimm, N.B. J.M. Grove, C.L. Redman, and S.T.A. Pickett. 2000. Integrated approaches to long-term studies of urban ecological systems. BioScience 50:571-584

Reviewer comment: (2) It is not clear why the following three questions are even included in the manuscript (as they are not addressed later in the manuscript): "1. How do differences in local and state levels of governance and policy affect the resilience of both social and ecological landscapes? 2. How do alternative land use planning strategies affect provision of ecosystem services in response to different disturbance factors? 3. How effectively do the processes and outcomes of monitoring ecosystem services provide a usable feedback loop in urban socio-ecological systems?"

==> Response: We excluded these three questions.

Reviewer comment: While there is a growing and, often contested literature on "resilience" in SES modeling, this study does not provide any clear idea about what do the authors imply about "resilience", i.e. how is "resilience" measured and operationalized in the case study context.

We reviewed relevant literature that defined resilience, including Alberti and Marzluff (2004), Alberti (2008),Berkes and Folke (1998), Berkes (2003) and Ostrom (2009), and addressed the reviewer's concern.

Like previous researchers, we define resilience as "the ability of the coupled system to return back from any internal or external perturbations (e.g., land development)." We attempt to identify and understand how differently structured government agencies learn about and respond to ecosystem indicators (water temperature). We do not formally test any hypotheses that examined feedback loops. Instead, we conceptualize two different types of mechanisms (direct versus indirect governance mechanisms) that are thought to impact water quality and investigate how they have affected water quality

differently in turn. We thus qualitatively assess resilience by measuring the frequency of monitoring as a component of feedback between the social and biophysical parts of the system in the two study area.

Alberti and Marzluff (2004) Resilience in urban ecosystems: linking urban patterns to human and ecological functions. Urban Ecosystems 53 (12), 1169-1179.

Alberti, M. (2008) Advances in Urban Ecology: Integrating Humans and Ecological Processes in Urban Ecosystems. Springer, New York.

Berkes, F., Colding, J., and Folke, C (2003) Navigating social-ecological systems: Building resilience for complexity and change. Cambridge, UK: Cambridge University Press.

Berkes, F., and Folke, C. (1998) Linking social and ecological systems for resilience and sustainability. In F. Berkes, and C. Folke (eds). Linking Social and Ecological Systems (pp. 1-25). Cambridge: Cambridge University Press.

Folke, C. (2006) Resilience: The emergence of a perspective for social-ecological systems analyses. Global Environmental Change, 16 (3), 253-267.

Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science, 325 (5939), 419–422.

Reviewer comment: Further, the notion of "governance" is never deïňĄned and rather reduced to a proxy variable (monitoring) that might not even reïňĆect "governance" in a social and/or political system. What is the nature of intergovernmental system in place? How are civil society actors included in "governing" the water quality in the case study regions and so forth are perhaps more important "governance" questions than the easily measurable proxy of "monitoring".

==> Response: While we agree that governmental monitoring is only a part of the very broad concept of water governance, we feel that this is an appropriate and tractable variable from which to begin to look for and describe interactions within the system.

Monitoring is an intentional attempt by some of the social actors in the system to understand the biophysical status and responses of the system to management actions. It is also an opportunity to observe several components of water governance across these two different governance systems (i.e. comparing cities in Washington and Oregon). As noted in the paper, monitoring regimes in one jurisdiction appear to have been altered in response to citizen organization lawsuits, while in the other jurisdiction, intentional planning and adaptive management appears to have played a greater role. This significance of these and other differences (for example, the timing of TMDL development) will be made more explicit in the revised version of the paper.

The reviewer's question about differences in intergovernmental interactions in the two governance systems is well taken. This significance of two different state policy environments, different regional governance structures (Clark County as compared to METRO) and two different urban regimes is the focus of other manuscripts being developed simultaneously (Thiers et al. in review, Kline in review.)

Reviewer comment: Discussion about alternative land use planning strategies that are available to the case study policy makers never takes place in the manuscript. The NLCD database is used to re-construct the "baseline" land use patterns in the case study areas, but the discussion about "alternate land use planning strategies is missing in the paper (both theoretically and methodologically).

==> Response: We included the “alternative land use planning strategies” in our discussion. We have a separate paper (currently in review Kline et al. 2013) discussing this aspect in more detail.

While urban growth boundaries in both metropolitan areas have affected the location of new development and conserved areas of forest and agricultural lands, these effects vary between Oregon and Washington Counties that contain our study area. This is likely due to different land use planning histories and associated development patterns between the two States. Oregon's started with the Land Use Act in 1973 while Clark

County in Washington implemented land use planning in 1990 with the adoption of the Growth Management Act. Oregon's Land Use Act is unique in that it limits growth outside of urban growth boundaries while it promotes in fill development or redevelopment of existing developed areas with higher density. On the other hand, under the Growth Management Act, the great supply of undeveloped land within the current urban growth boundary promotes more sparse development. As a result, it is likely that Burnt Bridge Creek in Washington was developed more rapidly with sprawl development while new development in the Johnson Creek area in Oregon has been somewhat limited with denser development.

Reviewer comment: Similarly, the notions of "ecosystem services" and "useable feedback loop" are also not clear.

==>Response: We removed these concepts in the revised manuscript as they are not central to our analysis.

Reviewer comment: (3) After a rather ambitious section that lays out large claims about CHANS and SES modeling, authors reduce the research paper's goals to addressing the following speciïňĄc research questions:

"1. Does monitoring effort differ as a function of governance? 2. Do riparian conditions differ between the two watersheds and do they correlate with indicators of water quality? 3. Do land development patterns differ between the two watersheds and do they correlate with water quality? 4. Is there a relationship between water quality and the sale price of properties and, if so, does that relationship vary between the two watersheds?" None of these four speciïňĄc questions inform the discussion about "usable feedback loops" for SES modeling. In fact, some of these questions are even redundant. For example, governance is deïňĄned as "monitoring" and then "monitoring" is used to (mis)characterize the governance in the case study regions. The feedback effect of water quality on governance (as claimed earlier in the paper) is not even addressed in the ïňĄrst speciïňĄc question.

==> Response: It is our intention to focus the overarching research questions into questions that can be addressed based on the data we have available so far in a coupled SES.

Reviewer comment: The other three speciïňĄc questions 2, 3 and 4 are reduced to estimating "correlations". Methodologically, "correlations" can NOT be used to measure "feedback loops" in SES modeling. More importantly, none of the correlation questions 2, 3 and 4 contribute any new knowledge in the hydrological sciences. For example, it is already well known that different riparian conditions "correlate" with different water indicators. It is also well known that different land development patterns affect water quality differentially.

==> Response: Yes, agree, but our intention is to provide possible cascading mechanisms of linkages in the SES framework even though we illustrate such linkages one by one. Given that we were unable to conduct formal experiments (unlike the other LTER sites), it is not our intention to formally test such questions. See our responses above.

Reviewer comment: (4) There are host of speciïňĄc technical and methodological issues that also require serious reconsideration: Why is water temperature used as the key indicator for water quality? Why other indicators are not used (except in the case of property price sub-study!!)? Worse, water temperature is a function of a large number of parameters (in addition to the canopy cover), however none of these other parameters, e.g. climatology, that can potentially affect water temperature are even controlled for. A t-test cannot be used to control for other parameters that also affect the water temperature in the streams.

==> Response: We selected water temperature since it is one of the key barometers of stream health that affect in-stream biogeochemical processes. We have a separate paper that investigates the relationship between water quality and other landscape factors in the study area (See Pratt and Chang 2012) and are currently working on another follow-up paper. Yes, we acknowledge that water temperature is a function of multiple

environmental factors, including air temperature, land cover, canopy extent, groundwater input, etc. Since our primary interest is comparing relative differences between the two study areas as a result of stream restoration, we primarily focus on canopy cover and suspect that any improvements in stream temperature might be associated with increasing canopy cover. Due to proximity and relatively similar elevation, the air temperatures of the study areas are not much different, and there are no significant trends in air temperature during the study period in both regions.

Reviewer comment: Similar issues are evident for the hedonic pricing model. Prices of the properties are not mere simple functions of water quality, or distance, rather other factors such as distance from highways, schools, hospitals or even macroeconomic cycles and so forth can also affect the housing prices. The time series pricing data has typical problems of temporal and spatial autocorrelation; however none of these issues are even identiïňĄed in the manuscript, let alone addressed.

=> Response:Full details about the structural, location, and environmental control variables, functional form, and calculation of estimated effects are available in the original research paper by Netusil et al. (2013) referenced in the Chang et al. paper. The application of the hedonic price technique is consistent with other papers in the literature (Leggett and Bockstael 200, Poor et al. 2007, Champ et al. 2003). The analysis includes tests and appropriate corrections for spatial correlation as well as fixed effects for neighborhoods and month dummies.

The description of the hedonic price model has been modified as follows to include additional information about the control variables used in the analysis and tests performed for spatial correlation. See below.

“Single-family residential property sale data for 2005–2007 were obtained from the Multnomah County, OR, and Clark County, WA, Assessors. We used the hedonic price method, a statistical technique, to examine if water quality is correlated with the sale price of single-family properties sold between 2005–2007 within a 2-mile buffer of Johnson Creek and Burnt Bridge Creek. We associated 10,479 property transactions from 2005–2007 within a 2-mile buffer of Johnson Creek with water quality at the nearest water quality monitoring site in the year the property was sold. We associated 5,093 property transactions that occurred within a 2-mile buffer of Burnt Bridge Creek between 2005–2007 with water quality at the nearest water quality monitoring station in 2007.

Models included detailed information about each property's structural (lot square footage, building square footage, etc.), location (median income at the census tract level, distance to central business district, etc.), and environmental variables (percentage of property in floodplain, slope, etc.); neighborhood fixed effects were used in the Burnt Bridge Creek model and quadrant fixed effects in Johnson Creek. A semi-log function form, the most commonly used specification, was used for both models (Champ et al. 2003) and each model was tested and corrected for spatial correlation. Additional details are provided in Netusil et al. (2013)."

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