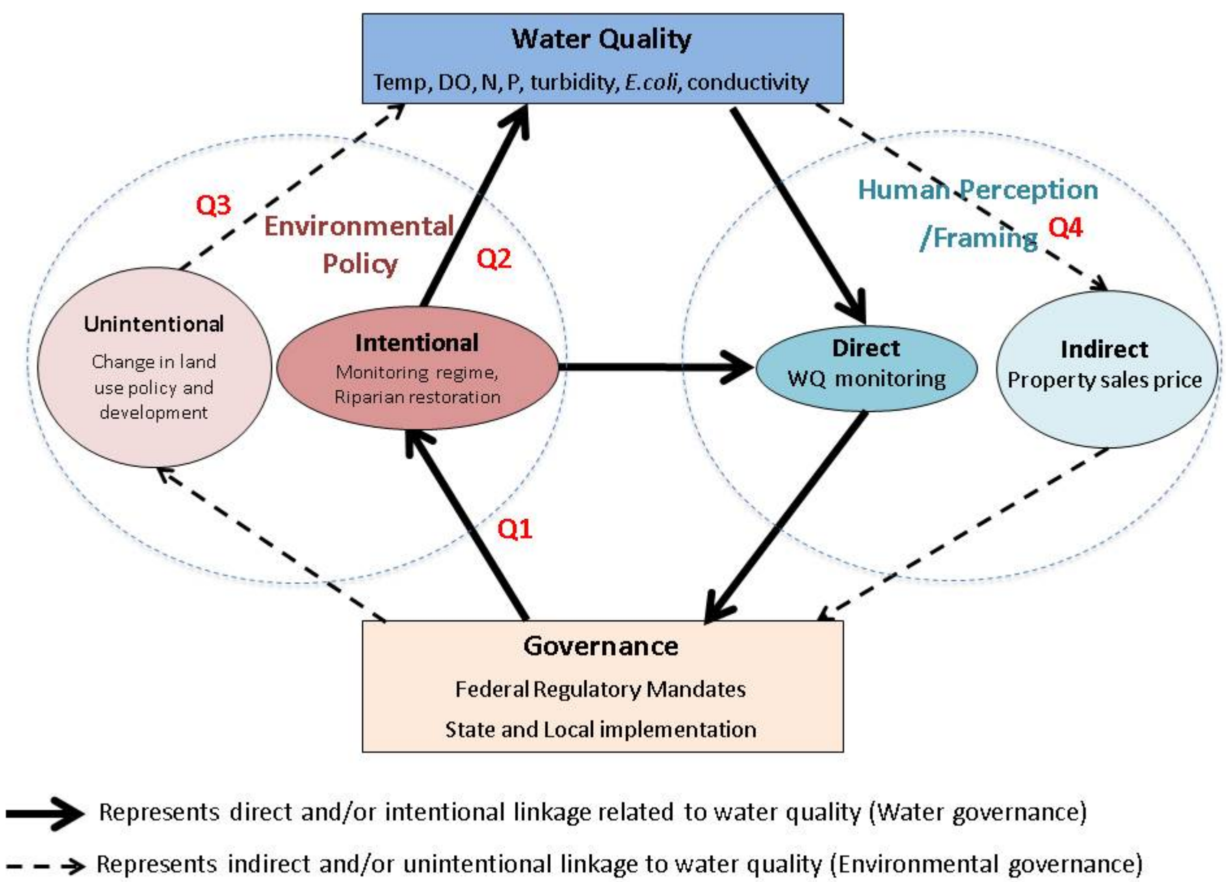
1. **Governance structures:** Chang et al. are interested in the relationship between governance and stream monitoring efforts. However, there are no clear measurable indicators such as number of regulatory agencies, level of local involvement (to establish top-down vs participatory management), etc. to compare outcomes in the two regions. The paper describes number of litigations and size of budget allocations as governance indicators. However, both these factors are likely to be influenced by water quality itself and are not objective measures of environmental governance structures.

Response:

We agree with the reviewer that our indicators of governance represent an incomplete list of variables, and that it would be desirable to more thoroughly investigate further indicators of governance. As discussed on pages 7406-07, however, we are basing our estimation of governance on common federal regulatory mandates and differing state and local responses to those mandates, including changes in monitoring effort itself. (See the revised Figure 2). We agree with the reviewers that some aspects of governance may be influenced by water quality. These dynamic linkages are the essence of the conceptualized direct and intentional feedback loop between water quality and water governance.



2. **Hedonic model**: Hedonic pricing models are commonly used to estimate the impact of changes in environmental quality. It is unclear what other variables are being controlled for in this analysis. At the very least, I would expect to see a table with summary statistics describing the data. How do you control for confounding and unobservable factors that influence housing value? Do you control for spatial and temporal trends (using spatial and time fixed effects) in the regression? How are percentage impacts derived? The presentation of results in Figure 8 is not very clear. A complete table of results will be better.

Response:

Page 10, line 15

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 original research paper includes the tables (included below) with variables names and summary statistics.

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 for spatial correlation and appropriate corrections as well as fixed effects for neighborhoods and month time dummies.

The percentage impacts are calculated by:

(1) Transforming the estimated coefficient to get its exact value using the formula $e^{\hat{\beta}-1}$

(2) Multiplying the transformed coefficient by the spatial multiplier $\frac{1}{1-\rho}$

(3) Multiplying the value from part (2) by the unit change in the water quality parameter

(4) Multiplying the value in part (3) by the mean sale price of a single-family residential property in each study area ($264,194 for Johnson Creek and $238,878 for Burnt Bridge Creek).

(5) Dividing the number in part (4) by the mean sale price of each property and then multiplying that value by 100.

Variables used in Hedonic Price Analysis

Variable	Description	Units
Dependent Variable		
Price	Natural Log of Real Sale Price (adjusted to December 2007 dollars using the CPI-U)	$ 2007
Structural Variables		
Lotsqft	Lot square feet	Square feet
Buildsqft	Building square feet	Square feet
Numfire	Total number of fireplaces	Count

Age	Age of building	Count
Fullbaths	Number of full baths	Count
Halfbaths	Number of half baths	Count
3-4Baths	Number of three-quarter baths	Count
Numfire	Number of fire places	Count
Location Variables		
Proportion White	Proportion white at the census tract level in 2000	Proportion
Median Income	Median income at the census tract level in 2000	$
Watershed	Dummy=1 if property is in JC or BBC	
Dum1_4, Dum1_2, Dum1mi	Dummy=1 if property is within ¼ mile, ½ mile, or 1 mile of JC or BBC (greater than 1 mile is excluded)	
Dist_trail	Street network distance to Springwater Corridor (JC) or Burnt Bridge Greenway (BBC)	Feet
Environmental Variables		
Elevation	Elevation at the property's centroid	Feet
Slope	Proportion of property with slope ≥ 25%	Proportion
Flood	Proportion of property in flood zone	Proportion
Prop_high, Prop_low, Prop_water,…	Proportion of land cover on a property and within 200 feet, 200 feet-¼ mile, ¼ mile to ½ mile (impervious surface is excluded)	Proportion
Water Quality Variables		
DO	Dissolved oxygen	mg/L
E-Coli	E. coli	mg/L
Fecal	Fecal coliform	count/100mL
pH	pH	
Temp	Temperature	°C
TSS	Total suspended solids	mg/L

Structural, Environmental, and Neighborhood Variables in Burnt Bridge Creek (BC) and Johnson Creek (JC) Study Areas

			Johnson Creek (N=10,479)		Burnt Bridge Creek (N=5,093)	
	Definition	Units	Mean	Std Dev	Mean	Std Dev
Price	Real sale price	$ 2007	264,194	116,096	238,878	107,601
Structural Variables						
Lotsqft	Lot square feet	Square feet	7,968	14,889	8,256	6,051
Sqft	Building square feet	Square feet	1,739	721	1,504	595
Numfire	Total number of fireplaces	Count	0.81	0.62	0.77	0.57
Age	Age of building	Count	42.33	31.08	34.80	26.32
Environmental Variables						
%Slope	Percentage of property with slope $\geq$ 25%	Propor-tion	0.0087	0.0744	0.0049	0.0504
Elevation	Property elevation	Feet	281.44	118.49	223	71.50
Flood	Percentage of property in flood zone	Propor-tion	0.0108	0.1033	0.0196	0.1347
High	High structure vegetation on the property	Propor-tion	0.2309	0.2053	0.2097	0.1542
Low	Low structure vegetation on the property	Propor-tion	0.3160	0.1922	0.3356	0.1310
Impervious	Impervious surface area on the property	Propor-tion	0.4529	0.1965	0.4456	0.1716
High_200	High structure vegetation within a 200 foot buffer	Propor-tion	0.2306	0.1261	0.2018	0.0871
Low_200	Low structure vegetation within a 200 foot buffer	Propor-tion	0.2995	0.1029	0.2920	0.0829
Water200	Water within a 200 foot buffer	Propor-tion	0.0004	0.0064	0.0001	0.0022
Impervious200	Impervious surface area	Propor-tion	0.4694	0.1214	0.4920	0.1088

	within a 200 foot buffer					
High1-4	High structure vegetation within a ¼ mile buffer	Proportion	0.2510	0.1144	0.2017	0.0631
Low1-4	Low structure vegetation within a ¼ mile buffer	Proportion	0.3057	0.0801	0.3097	0.0828
Water1-4	Water within a ¼ mile buffer	Proportion	0.0033	0.0151	0.0014	0.0134
Impervious1-4	Impervious surface area within a ¼ mile buffer	Proportion	0.4400	0.1161	0.4529	0.0924
High1-2	High structure vegetation within a ¼ mile buffer	Proportion	0.2585	0.1182	0.1907	0.0476
Low1-2	Low structure vegetation within a ¼ mile buffer	Proportion	0.3037	0.0700	0.3130	0.0807
Water1-2	Water within a ¼ mile buffer	Proportion	0.0087	0.0324	0.0024	0.0130
Impervious1-2	Impervious surface area within a ¼ mile buffer	Proportion	0.4291	0.1235	0.4531	0.8301
Neighborhood Variables						
Income	Median income at the census tract	$ (2000)	46,260	15,569	42,635	9,656
%White	Percentage white at the census tract in 2000	Proportion	0.8330	0.0719	0.8614	0.0370
Location Variables						
Dist_trail	Distance to recreation trail	Miles	1.338	0.699	1.49	0.813

Changes to manuscript:

Page 10, line 15

"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)."

Page 16, line 14

"Numerous studies have found a relationship between the sale price of single-family residential properties and water quality (Leggett and Bockstael, 2000; Gibbs et al., 2002; Poor et al., 2007). Water quality parameters that are most likely to be perceived by residents were selected for our analysis. For example, total suspended solids (TSS) affects water clarity; dissolved oxygen (DO), temperature and pH may impact fish and wildlife populations; and E. coli or fecal coliform concentration may produce foul odors. A priori we expected that increases in E. coli (in Johnson Creek) or fecal coliform concentration (in Burnt Bridge Creek), TSS, pH, and water temperature would have a negative effect on sale price, while increases in DO would have a positive effect. We believe that perceptions of water quality, rather than knowledge about the water quality measurements themselves, affects the sale price of single-family residential properties near Johnson Creek and Burnt Bridge Creek, and that estimated impacts would vary based on a property's distance from each creek.

Table 8 presents a summary of findings for Johnson Creek and Table 9 for Burnt Bridge Creek. The results for E. coli in Johnson Creek are statistically and economically significant, with estimated effects from a 100 E. coli per mL increase ranging from −2.57% for properties within 1/4 mile of Johnson Creek to −0.69% for properties located more than 1 mile from the creek. Increases in Fecal Coliform have a negative effect on sale prices in Burnt Bridge Creek with estimated effects from a 100 count per 100 mL increase of -3.26% for properties located between ¼ mile and ½ mile of the creek and -3.67% for properties within ½ mile to 1 mile of the creek.

pH has a large and significantly negative estimated impact on the sale price of properties in the ½ mile, 1 mile and greater than 1 mile buffers from Burnt Bridge Creek. Algae blooms in Vancouver Lake, which are correlated with pH levels (amongst other environmental variables), may explain this result (Lee et al., 2013). DO results are negative and statistically significant for 7 of the 8

buffers in the study areas, but the estimated effects are generally larger in Johnson Creek. This may be a result of the presence of listed species such as Steelhead and Coho Salmon in Johnson Creek and a demonstrated willingness of residents in the Johnson Creek area to pay for programs that improve fish and wildlife habitat (Larson and Lach, 2008).

Table 8: Estimated effect on property sale price from a change in water quality parameter for Johnson Creek (significance for a 1-tail test, 10% level; values marked "NS" are not statistically significant)

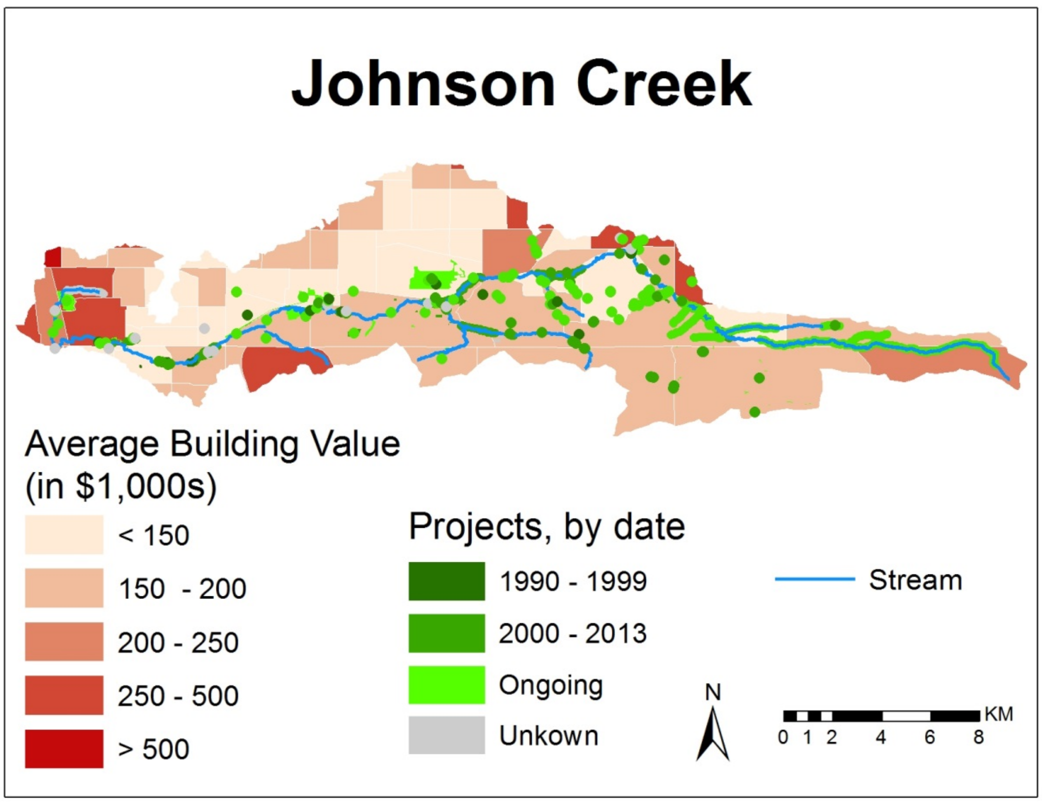
Water quality parameter	¼ mile	½ mile	1 mile	> 1 mile
E-coli (100 count per 100 mL increase)	-2.57%	-0.84%	-1.14%	-0.69%
pH (0.5 unit increase)	-4.83%NS	-0.77%NS	-0.81%NS	6.18%
TSS (1 mg/L increase)	1.55%NS	1.73%	0.71%	-0.05NS
Temperature (1 ° C increase)	-0.52%NS	-1.42%NS	-1.31%NS	-4.46%
DO (1 mg/L increase)	10.70%	5.50%	6.38%	2.44%

Table 9: Estimated effect on property sale price from a change in water quality parameter for Burnt Bridge Creek (significance for a 1-tail test, 10% level: values marked "NS" are not statistically significant)

Water quality parameter	¼ mile	½ mile	1 mile	> 1 mile
Fecal Coliform (100 count per 100 mL increase)	-3.81%NS	-3.26%	-3.67%	-1.57%NS
pH (0.5 unit increase)	4.35%NS	-11.56%	-9.51%	-12.86%
TSS (1 mg/L increase)	-0.78%NS	-0.97%	-0.07%NS	0.18NS
Temperature (1 ° C increase)	-4.92%NS	0.14%NS	1.63%NS	1.51%NS
DO (1 mg/L increase)	2.71%NS	4.49%	2.95%	3.17%

3. A larger concern, relevant to dynamic feedbacks in the system, relates to whether housing values influence the nature of management effort? Are riparian restoration efforts focused around regions that have higher (or lower) property values? Do budgets for riparian management depend on property taxes? If management efforts are influenced by property values (that reflect peoples' willingness to pay for improved water quality), the hedonic model must control for this endogenous feedback effect. Addressing this feedback in the empirical estimation of the value of water quality and in predicting future management efforts or land use changes will be a step towards developing a coupled model.

<u>Response</u>: Please see the attached Figure. The map shows the locations of restoration projects using the conservation registry data (http://jcwc.conservationregistry.org/)and tax accessed data summarized by census track for the Johnson Creek Watershed. Riparian restoration projects in the JC watershed are located throughout the watershed regardless of building value. It seems that there is no clear relationship between riparian management and property tax in Johnson Creek, but it seems to be the case in BBC at least based on the available data. At the city scale, Portland collects more tax for restoring streams while this may be not the case in Vancouver. Conservation Registry data for BBC are much less complete than JC, so we are unable to investigate this question for the BBC watershed.



Response: The property tax systems are very different in the two study areas, so implying that restoration is done to maximize property tax revenue is a stretch—especially since we don't know the relationship between restoration and property values (the results were for water quality and property values). In Oregon there is a rate-based limit of $10 per $1,000 for local governments and $5 per $1,000 for education as a result of Ballot Measure 5 which passed in 1990. Measure 5 resulted in a shift of education funding with the majority of education funding coming from the state. In 1997 Measure 50 was passed—this measure froze assessed values at 90% of 1995 real market value and capped the growth rate of the minimum assessed value at 3% per year. Most of this information comes from: http://www.oregon.gov/DOR/ptd/Pages/property.aspx

We agree the referee's comment about incorporating this (if the linkage exists) would be a way to develop a coupled model. However, currently available data limit the development of such a model.

4. Similarly, the paper compares snapshots of land cover between 1992 and 2006 but does not build a predictive model for land use change. I realize that a model of land use change is perhaps outside the scope of this analysis but to develop a CHANS or SES framework, these dynamic linkages need to be addressed.

Response: Yes, developing a predictive model for land use change is beyond the scope of the current paper. However, we addressed the dynamic linkages between human and natural systems that shape land cover change and discussed possible feedback mechanisms. In one of our earlier papers, Ozawa and Yeakley 2007 (cited in our reference list), we more thoroughly investigate differences in regulatory and enforcement practices at the municipal level, and that work is presently extended by researchers in the Portland-Vancouver ULTRA-Ex to include municipalities in both Washington and Oregon. Additionally, work in review (Kline et al 2013) investigates some of the patterns in land cover change for the four counties for the period 1976-2005 that encompasses the Portland-Vancouver metropolitan area. We will include some of the conclusions from these research teams in our revised manuscript.

5. Policy implications are not discussed for any of the questions that the paper addresses. A more detailed discussion of the policy relevance of the results and the implications of potential feedbacks that connects these findings is needed.

Response: We do discuss some implications for public policy in the final paragraph of the manuscript, noting that if there are multiple pathways to improve water quality, potential tradeoffs among management strategies should be considered. However, we agree with the reviewer that policy implications could be discussed more fully. In the revised manuscript we will expand the discussion of the findings in the conclusion by inserting the following paragraph before the final paragraph in the manuscript:

Our finding that federal regulatory mandates in response to common water quality characteristics (303 (d) listing) led to very different governance responses at the local level (differences in the development of TMDLs; differences in changes in monitoring effort) has implications for environmental policy. This finding would tend to support Gibbs and Jonas' (2000) argument that as "national environmental narratives enter the local policy arena they are *renarrated*." The significance of different policy environments and political regimes in the interpretation of federal and state policy at the local level is the subject of another part of the PV ULTRA-Ex project (Thiers et. al. 2013). For the present study, these findings imply that federal policy makers and regulators should consider that local government responses to the detection of impaired water quality are complex and may vary greatly from one jurisdiction to another. Regulatory efforts designed to anticipate these different responses may reduce implementation deficit in some locations and take fuller advantage of willingness to go beyond mandates in others.

Gibbs, David and Andrew Jonas. 2000. “Governance and Regulation in Local Environmental Policy: the Utility of a Regime Approach.” *Geoforum* 31: 299-313.

6. As Reviewer 1 pointed out, the first three broader research questions on page 7399 are not relevant for this analysis. If the authors want to tie the results of this preliminary analysis to the broader goals of the project, a discussion of how their findings fit in as building blocks to address the broader questions is essential.

Response: We removed these questions.