Taking the pulse on uncertainty in EA: Perspectives about uncertainty location and consideration

Wanda Leung
Department of Geography and Planning, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, Email wanda.leung@usask.ca

Bram Noble
Department of Geography and Planning, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, Email b.noble@usask.ca

Abstract
This paper explores perspectives about the location and consideration of uncertainty in environmental assessment (EA). The study is based on a survey of 77 Canadian EA regulators, proponents, consultants, environmental groups and academics. Results indicate that the nature of uncertainty varies throughout the EA process, and there is a misalignment between where participants believe the most uncertainty to be present and the level of attention or consideration it receives. The most uncertainty was associated with predicting impacts and assessing cumulative effects; aspects of the EA process also identified as receiving the least amount of uncertainty consideration. Uncertainty was believed to be sufficiently considered in screening, preparing the project description and scoping the assessment – aspects of the EA process characterized by relatively low uncertainty. Significant differences were also found between participants in terms of uncertainty consideration in EA, with those engaged in the process typically depicting more confidence than those external to conducting the assessment.

Keywords
Uncertainty location, uncertainty consideration, environmental assessment

Introduction
The need for more explicit consideration and disclosure of uncertainty in environmental assessment (EA) is well-recognized, and scholars have persistently demanded that practitioners of EA do a better job of considering uncertainty and communicating that uncertainty to the public and decision makers (De Jongh, 1988; Wood, 2008; Larsen et al., 2013; Leung et al., 2015). However, the extent to which uncertainties exist in EA, and the types of uncertainties, may vary throughout the assessment process – from describing a project and determining the need for assessment, to making decisions about the acceptability of a project and prescribing follow-up requirements. Limited attention has been given to understanding where in the assessment process uncertainty is believed to be most prevalent and whether it is perceived by those engaged in the EA process, and by those affected by the process, as receiving sufficient attention. The purpose of this paper is to assess where uncertainty is believed to be most prevalent in EA and where it is perceived to be given the most attention in practice. We do so based on a survey of the Canadian EA community. Our argument is that understanding the location of uncertainty, and perceptions about how it is addressed, is important to ensuring that efforts to improve uncertainty consideration and communication in EA are consistent with where uncertainty is most prevalent in EA and with stakeholder understandings about, and expectations of, uncertainty treatment. This results presented in this paper are based, in part, on a paper published in Environmental Impact Assessment Review and the reader is directed to Leung et al. (2016) for complete study results on uncertainty in EA.

Methods

The study consisted of a survey of the Canadian EA community to explore perceptions about where uncertainty is most prevalent in the EA process, and where uncertainty is given the most consideration in practice. A survey invitation was sent by email to an initial 260 potential participants, identified through EA mailing lists, consulting firms, and websites of EA agencies. Additional participants were then identified using a snowball approach (Hay, 2010). The intent was to capture participants with federal, provincial and territorial EA experience. A total of 77 individuals participated in the survey: 27 consultants, 27 regulators/decision makers, 8 environmental non-governmental organizations (ENGOs)/interest groups, 9 proponents, and 6 academics/researchers. The survey was administered using Fluid Surveys and consisted of point-assignment and Likert-scale questions. Survey responses were exported to SPSS v. 22, a statistical analysis software, and investigated using non-parametric statistical tests. Median responses and 95% confidence intervals about the median were calculated based on Tukey's hinges (Krzywinski and Altman, 2014) and were used to examine the meaningfulness of response differences between participant groups (Hoenig and Heisey, 2001).

Results

Location of uncertainty

Participants were asked to identify where uncertainty is most prevalent in EA by assigning 100-points across 10 basic EA phases, from project description to follow-up and monitoring (Table 1). The more points assigned to a particular phase indicates a greater perceived presence of uncertainty. Participants identified the most uncertainty in predicting potential impacts (A5) and identifying and assessing potential cumulative effects (A8), each assigned a median of 15 points or a combined 36% of total points. This was followed by identifying impact mitigation measures (A6, 14%). The least amount of uncertainty was a believed to be found in screening, or determining whether an EA is required (A2, 2.5%), followed by preparing the project description (A1, 5%) and determining the scope of assessment (A3, 6%). There were no significant differences between participants based on professional affiliation; however, participants with 5 to 10 years EA experience identified significantly less uncertainty with identifying impact mitigation measures (A6, median = 10.0 ± 1.8) than did those with less than 5 (U= 82.5, p=0.06) or greater than 10 (U= 278, p= 0.004) years EA experience.

Table 1. Points assigned to the typical stages of an EA process indicating the location of uncertainty

Stage of the EA process	Median 95% CI	% of total points	Rank
A1. Preparing the project description, including technical design and establishing the need for the project.	0.0 ± 1.0	5%	9
A2. Determining whether an EA is required.	0.0 ± 1.0	2.5%	10
A3. Determining the scope of assessment: what to include and exclude from the assessment.	5.0 ± 1.8	6%	8
A4. Establishing the environmental and/or socio-economic baseline, including identification of key issues or trends in valued components.	9.0 ± 1.8	9%	5
A5. Predicting the potential environmental and/or human impacts of the project.	15.0 ± 2.5	18%	1
A6. Identifying or designing proposed impact management or mitigation measures to manage or reduce potential adverse impacts.	10.0 ± 1.8	14%*	3
A7. Determining the significance of potential environmental and/or socioeconomic effects.	10.0 ± 3.2	12%	4
A8. Identifying and assessing the potential cumulative environmental effects of the project.	15.0 ± 1.8	18%	1
A9. Decision-making or determination by the responsible authority of the acceptability of the impact statement and proposed project.	5.0 ± 1.8	7%	7
A10. Follow-up and monitoring to verify impact predictions and the effectiveness of mitigation actions.	5.0 ± 1.8	8.5%	6

* Indicates a significant difference between participants based on years of EA experience

Consideration of uncertainty

Participants were then asked, based on their professional experience, to assess the extent to which uncertainty is considered in the current practice of EA. A 7-point response scale was used, from 'strongly disagree' to 'strongly agree' (Table 2).

Table 2. Participant responses about uncertainty consideration in the practice of EA[1]

	Median (95% CI)[2]	**Disagree to strongly disagree**	**Agree to strongly agree**	**Responses by professional affiliation** *median +/- 95% CI*				
				Consult.	Regulator Decision maker	ENGO/ Interest group	Proponent	Academic Researcher
B1. Uncertainty is given due consideration in the project description and technical design prepared by the project proponent.	4.0 (± 0.6*)	36%	22%	5.0 ± 1.4	4.0 ± 1.0	1.0 ± 0.8	5.0 ± 1.7	3.0 ± 1.4
B2. Uncertainty is given due consideration when decision makers make a determination as to whether an EA is required for a proposed project.	4.0 (± 0.4)	20%	24%	4.0 ± 1.1	4.0 ± 1.3	2.0 ± 3.2	5.0 ± 1.1	4.0 ± 1.4
B3. Uncertainty is given due consideration when determining the scope of assessment, including what to include and exclude from the assessment.	5.0 (± 0.4**)	19%	24%	5.0 ± 1.1	5.0 ± 1.0	1.0 ± 1.6	5.0 ± 1.1	3.0 ± 1.4
B4. Uncertainty is given due consideration when establishing the environmental or socio-economic baseline, including identification of key issues or trends in valued components.	4.0 (± 0.6**)	19%	27%	5.0 ± 1.1	3.0 ± 1.0	1.5 ± 0.8	5.0 ± 0.6	4.0 ± 2.1
B5. Uncertainty is given due consideration in the predictions of the potential environmental and/or socioeconomic impacts of the project.	3.0 (± 0.8**)	25%	27%	5.0 ± 1.1	3.0 ± 1.0	1.5 ± 0.8	5.5 ± 1.7	3.0 ± 2.1
B6. Uncertainty is given due consideration in the proposed impact management or mitigation measures and their efficacy.	4.0 (± 0.6*)	32%	24%	5.0 ± 1.1	3.0 ± 1.0	1.5 ± 0.8	5.0 ± 1.7	2.0 ± 2.1
B7. Uncertainty is given due consideration in determinations about the significance of potential environmental and/or socioeconomic effects.	4.0 (± 0.8**)	25%	25%	5.0 ± 1.1	4.0 ± 1.0	1.5 ± 0.8	5.0 ± 1.1	2.0 ± 2.1
B8. Uncertainty is given due consideration when assessing the potential cumulative effects of the project.	3.0 (± 0.6**)	27%	20%	4.0 ± 1.1	3.0 ± 1.0	1.0 ± 0.8	5.0 ± 1.1	2.0 ± 2.1
B9. Uncertainty is given due consideration in the final decision or determination made by the responsible authority about the project and its potential impacts.	4.0 (± 0.4*)	24%	19%	4.0 ± 1.1	5.0 ± 0.6	1.0 ± 1.6	5.0 ± 1.7	2.0 ± 0.7
B10. Uncertainty is given due consideration during follow-up and monitoring programs that report on impacts and the effectiveness of mitigation actions.	4.0 (± 0.4**)	20%	22%	4.0 ± 1.1	4.0 ± 0.6	1.5 ± 1.6	5.5 ± 0.6	3.0 ± 2.1

[1] Response scale of 1-7, where 1 = strongly disagree; 2 = disagree; 3 = somewhat disagree; 4 = neither agree nor disagree; 5 = somewhat agree; 6 = agree; 7 = strongly agree. For ease of presentation, and after statistical analysis, we present in the table only the aggregate responses for disagree to strongly disagree (1-2) and agree to strongly agree (6-7).

[2] Asterisks indicate significant difference based on professional affiliation at $p = 0.05$ (**) and $p = 0.10$ (*).

The strongest level of uncertainty consideration was identified for determining the scope of assessment (B3, median = 5.0 ± 0.4). Amongst the EA process where uncertainty was reported to be given the least sufficient consideration is when assessing or predicting the potential impacts of the project (B5, 3.0 ± 0.8) and assessing the potential cumulative effects of the project (B8, median 3.0 ± 0.6). There were no significant differences between participants based on years EA experience. Responses did, however, differ based on participant affiliation. Proponents and consultants typically provided higher median responses than ENGOs/interest groups, indicating more favourable views about how uncertainty is treated in EA practice. For example, participants were divided as to whether uncertainty is given due consideration in the project technical designs submitted by proponents; 36% disagreed to strongly disagreed and 22% agreed to strongly agreed. Proponents (B1, 5.0 ± 1.7) and consultants (B1, 5.0 ± 1.4), who share responsibility for developing the project description as part of a EA application, more strongly agreed that uncertainty is considered ($p < 0.05$, between-group U-test statistics) than did those who are typically not engaged in the project description, specifically ENGO/interest group participants (B1, 1.0 ± 0.8). Regarding whether uncertainty is given due consideration in the final decision or determination made by the responsible authority, only 19% of participants agreed to strongly agreed. The views of proponents (B10, 5.0 ± 1.7) and regulators (B10, 5.9 ± 0.6) were much more positive than either academics (B10, 2.0 ± 0.7) or ENGO/interest group participants (B10, 1.0 ± 1.6) ($p< 0.05$, between-group U test statistics).

Discussion

The scholarly indicates inadequate consideration of uncertainty in EA (Geneletti et al., 2003; Tennøy et al., 2006; Wood, 2008; Leung et al., 2015), and persistently demands improvements in how uncertainty is considered and communicated (De Jongh, 1988; Duncan, 2008; Wiklund, 2011; Bond et al., 2015). Based on our survey of the Canadian EA community, we suggest that improving uncertainty consideration in EA requires greater attention to at least two aspects: understanding where uncertainty is most prevalent in EA, and understanding how the different interests engaged in EA perceive the current level of treatment or consideration of uncertainty.

First, particular aspects of the EA process may be of higher priority than others regarding focusing our efforts to address uncertainty. Participants indicated that the early stages of EA (e.g. project description, screening) are characterized by low levels of uncertainty. Uncertainty was identified as higher in the middle stages of EA, specifically predicting a project's impacts and its cumulative effects, and relatively low again near the end of the EA life-cycle – in the project decision and follow-up and monitoring. This was not surprising, as impact prediction has been a major focus of uncertainty studies in EA (Locke and Storey, 1997; Tennøy et al., 2006), and assessing cumulative effects has been identified as one of the most challenging aspects of the entire EA process (Duinker and Greig, 2006; Noble, 2015). Importantly, however, results suggest a misalignment between where participants believed the most uncertainty to be present and the level of attention or consideration that it receives. For example, participants identified the highest levels of uncertainty in EA to be associated with predicting potential impacts and identifying and assessing cumulative effects (Table 1: A5, A8). However, participants also identified predicting impacts and assessing cumulative effects as aspects that currently receive the least consideration of uncertainty in practice (Table 2: B5, B8). Uncertainty consideration was also identified as insufficient in other stages of EA, including determining whether an EA is necessary (Table 2: B2) and when making

the final determination about the acceptability of a project (Table 2: B9); however, these were stages of EA that were characterized by as having relatively low levels of uncertainty (Table 1: A2, A9).

Second, proponents and consultants were generally more satisfied with the extent to which uncertainty is addressed in EA practice compared to other EA interests. Uncertainty information must be effectively and accurately communicated to the appropriate audience, whether it is the public, policy makers, decision makers, or other scientists (Ekwurzel et al., 2011). We observed that for some aspects of the EA process, the more intimately the participant was involved the higher the level of satisfaction about how uncertainty is considered. For example, consultants and proponents indicated that uncertainty is given due consideration in a project's description and technical design, which they are responsible for; however, ENGOs and academic participants, far removed from the source of knowledge generation, indicated that uncertainty is *not* given due consideration in these stages of the EA process. The difference in perceptions about uncertainty between those responsible for the different aspects of EA, compared to those who are more removed from the process, suggests that communication about uncertainty is poor or participants' understandings about what is considered 'good' are very different.

Conclusion

Researchers have lobbied those engaged in EA to disclose assumptions and uncertainties, calling for greater use of the precautionary principle (e.g., Geneletti et al., 2003; Tennøy et al., 2006; Wood, 2008). Based on the results of our research, there is a need for those engaged in EA, specifically those conducting EA and responsible for the various stages of the EA process, to provide greater clarity about what uncertainties exist and how they were addressed. There is also a need for greater research about what the different interests engaged in EA consider to be adequate consideration of uncertainty, and the range of expectations about what is considered good practice regarding uncertainty consideration and communication. Since the perceptions and attitudes toward the EA process are often influenced by the actions of those who disclose information, understanding perceptions about uncertainty of those conducting and using EA is as important as understanding public perceptions. In conclusion, we suggest the need to move beyond generic calls for greater consideration and disclosure of uncertainty and focus more attention on where in the EA process uncertainty is most prevalent and influential on EA outcomes, and on where greater consideration and communication of uncertainty will lead to more informed decisions and a greater practitioner and public understanding about uncertainty.

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