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Introducing Resilience Practice to Watershed Groups: What Are the Learning Effects?

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ABSTRACT

Resilience as an organizing framework for addressing dynamics of social–ecological systems has experienced strong uptake; however, its application is nascent. This research study aimed to address the gap between resilience thinking and practice by focusing on learning, a key aspect of resilience. Two Canadian watershed groups were led in 2-day workshops focused on resilience. Learning effects were measured using a survey administered both before and after the workshop, and a qualitative survey was administered 6 months later to understand longer term effects. Short-term learning effects were similar between the two case studies, with strong cognitive and relational learning and less normative learning. Longer term effects showed enduring cognitive and normative learning in both cases; however, relational learning persisted only in the watershed where a resilience practice approach to watershed planning had been incorporated. Future research directions include refinements to the learning measurement methodology and continuing to build resilience practice literature.

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Adaptive capacity; learning; resilience; resilience assessment/analysis; watershed management

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Resilience thinking serves as an organizing framework to address the dynamics of social–ecological systems. It is informed by three central ideas: resilience (the ability of a system to change by absorbing disturbances and reorganize while undergoing changes in an effort to retain the same identity), adaptability (the ability of actors to influence resilience), and transformability (the capability to become a different kind of system when structures [ecological, economic, social] make the present system untenable) (Folke 2006; Walker and Salt 2006; Folke et al. 2010). The uptake of resilience thinking has grown rapidly, with more than 900 cited publications appearing since the introduction of the concept in 1973, and with sharply increasing trends evident in bibliometric analysis since 1999 and 2005 (Xu and Marinova 2013).

While the concept of resilience has experienced considerable uptake, the application of resilience thinking in real-world settings is still nascent (Walker and Salt 2012; Wilkinson 2012). The publication of *Resilience Practice* (Walker and Salt 2012) starts to address this lacuna, but ongoing calls are being made by resource management practitioners who desire a better understanding of how to use the concepts of resilience in practice. As one response,

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Biggs et al. (2012) identify and review seven principles to enhance resilience of ecosystem services in dynamic social–ecological systems. One particular principle they emphasize involves the need for learning, which builds resilience in two ways: (1) by ensuring existing knowledge is revisited and new knowledge is incorporated to enable adaptation to disturbance and change, and (2) building shared values, trust, and relationships that facilitate collective action. Both can improve governance processes that impact resilience (Biggs et al. 2012).

A concerted line of inquiry associated with social–ecological resilience, and in particular environmental and adaptive governance, is concerned with learning (e.g., Armitage, Marschke, and Plummer 2008; Berkes 2009; Crona and Parker 2012; Mitchell et al. 2014). Yet, although widely recognized as a key aspect of resilience, gaps remain in the understanding of how to achieve learning for resilience, and whether there is in fact a direct correlation between learning and resilient capacity (e.g., Folke et al. 2002; Fazey et al. 2007; Engle 2011). Armitage, Marschke, and Plummer (2008) contend that this presents an important paradox, whereby learning is considered a high priority, but only vague notions of what and who it involves, how it occurs, and how its impact can be measured are provided in scholarship.

While researchers in other scholarly disciplines have expended considerable effort in trying to better understand learning processes, to the best of our knowledge it remains unclear whether any current resilience practices apply this knowledge and to what effect. This study aims to address this gap, by examining two specific research objectives: (1) to delivering resilience workshops intended to introduce key concepts of resilience and build a foundation of knowledge on the theory and its potential uses in practice, and (2) to evaluate the understanding of resilience (i.e., to measure learning) and the potential implications for governance and management practices before and after the workshop process.

Research Context

Threats and changes to freshwater systems are widespread (Vörösmarty et al. 2000; Carpenter, Stanley, and Vander Zanden 2011). Even in countries such as Canada, which may be perceived as "water rich," the myth of superabundance is being sharply called into question (Sprague 2007). Interest in resilience as an approach to governing and managing watersheds is emerging (e.g., Bunch et al. 2011; Mitchell et al. 2014), making it a valuable issue area in which to examine the research question around learning and resilience. Research experiences with testing resilience practice in watersheds are starting to appear, primarily from Australia (Walker and Salt 2012; Mitchell et al. 2014). However, these efforts have not been empirically measured in terms of their influence on learning and the resilience of water governance, nor have they been applied in a Canadian context. Therefore, delivering resilience analysis workshops to watershed groups in Canada provides an opportunity to ground the study in watersheds where there is a growing interest in applying resilience thinking due to concerns about complexity, uncertainty, and conflicts, and where the learning process could be tracked from the outset.

The researchers sought and selected two "typical" or "representative" cases in Canada in which to undertake the investigation. Seawright and Gerring (2008, 299) explain that a typical or representative case of a phenomenon is desirable to "better explore the causal mechanisms at work in a general, cross-case relationship." A case was understood to encompass a geographical area defined by natural hydrological units of scale (i.e.,

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watershed or subwatershed), as well as a collection of active individuals with a shared interest in the stewardship of the area. The diverse characteristics of watersheds and watershed groups in Canada were acknowledged as commonplace, and variations in watershed size, location, and issues of concern were welcomed. Most importantly, the individuals constituting the watershed group had to be open to engaging with the concept of resilience and willing to attend the workshop. The Hammond River Watershed (HRW) in New Brunswick and the Cowichan Watershed (CW) on Vancouver Island, British Columbia, were selected as cases for the study.

Located in southwest New Brunswick, the HRW encompasses 513 km^2 of land, with the main river stem running 73.5 km through predominantly forested and agricultural land (New Brunswick Department of Environment 2007). A number of the tributaries provide habitat for cold-water species such as salmon and brook trout (Campbell and Prosser 2008). The Hammond River Angling Association (HRAA), formed in 1977 by a group of anglers and conservationists, remains the driving force behind the preservation and restoration of all resources of the HRW (Campbell and Prosser 2008). Today, the primary concerns of the HRAA continue to be around salmon habitat, largely as a result of rapid residential and commercial development underway in parts of the watershed. Erosion from development sites is believed to be responsible for sediment contamination of important salmon staging pools. Furthermore, the protective legislation currently in place related to these threats is not considered adequate.

With a total catchment area of 930 km^2, the CW drains approximately one-third of Vancouver Island's Cowichan Valley Regional District (Harper 2007). The watershed is characterized by its upper portion with high precipitation and storage and low population and demand, and its lower portion with low levels of precipitation and low storage with high population and demand (Hunter et al. 2014). Cowichan Lake and the Cowichan Estuary are the predominant features of the upper and lower portions of the watershed, respectively. There are a number of competing interests for water, including forestry, agriculture, industry, recreation, tourism, and cultural values (for more case study details, see Hunter et al. 2014). The Cowichan Watershed Board (CWB) was established in 2010 to provide leadership for water management that meets social, economic, cultural, and environmental needs (Hunter et al. 2014). Presently, considerable concern exists around water pollution from multiple sources, including agricultural runoff, industrial effluent, and sewage discharge. Additionally, management of a weir holding water back at the outlet of Cowichan Lake continues to be a primary concern for the CWB, as the water supply–demand gap between the upper and lower portions of the watershed makes matching water availability with demand a particularly difficult endeavor (Hunter et al. 2014).

Research Design and Methods

Workshop Design

To understand the learning effects from delivering resilience analysis workshops to watershed groups in Canada, an experimental approach was employed in this study whereby the workshops were the independent variable and the learning effects were the dependent variable. Following Shavelson et al. (2003) and Cobb et al. (2003) and the suggestion by Brown (1992, 141), workshop methods are an attempt to "engineer innovative educational

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environments and simultaneously conduct experimental studies of those innovations." While the workshop approach afforded an opportunity to address the nature of learning in a real-life context, it is important to also be cognizant of the limits of the approach due to the resistance of real-life situations to attempts at experimental control, and the difficulties of future case-study comparisons (Collins, Joseph, and Bielaczyc 2004). Also, it must be recognized that any workshop-based method provides only a snapshot in time of a single, short-term learning intervention.

The workshop design used in this study was intended to introduce participants to resilience thinking and illustrate how it could be applied in practice. The researchers (co-authors) developed the two-day workshop by drawing upon key resource materials designed to apply resilience thinking (Walker and Salt 2006; Resilience Alliance 2010; Walker and Salt 2012), as well as consulting with colleagues with expertise and experience with resilience assessments. In addition to designing the workshop, the researchers also delivered the material, facilitated the exercises, and reflected upon the experience. The workshop was consistently applied in both cases. Participants for each workshop were recruited by a local coordinator through e-mail invitations and followed up via phone or in-person discussions by a researcher. The population sample was defined as those individuals who participate in local watershed planning. In both cases, if participants completed only one or no surveys, they were not included in this analysis. Workshop participants in the HRW included long-time and newer members of the HRAA who work in a range of roles in the community, and employees tasked with programming and watershed planning ($n = 6$). Workshop participants in the CW included local politicians, First Nations, and community members who comprise the CWB and representatives of local nongovernmental organizations who work closely with the board ($n = 9$).

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Social Learning and Learning Effects

Given the workshop approach, where individuals from watershed boards or associations and their relevant partners were brought together, the research focused specifically on social learning processes. The literature on social learning, even when considering only environmental learning, a substrand of scholarship within which this research is situated, is vast and complex, but with a well-developed foundation (for an overview see Lundholm and Plummer 2010). Social learning within environmental management, and specifically water governance and management, is growing (e.g., Ison, Röling, and Watson 2007; Pahl-Wostl et al. 2007). The literature exhibits conflicting perspectives and criticisms on how learning is understood (Armitage, Marschke, and Plummer 2008; Diduck 2010), employed (Muro and Jeffrey 2008), and measured (Haug, Huitema, and Wenzler 2011; Rodela 2011).

Several conceptual frameworks of social learning have been developed (e.g., Schusler, Decker, and Pfeffer 2003; Pelling et al. 2008; Pahl-Wostl 2009). This study draws upon an established typology (Huitema, Cornelisse, and Ottow 2010; Haug, Huitema, and Wenzler 2011; Munaretto and Huitema 2012; Baird et al. 2014) that sets out three types of learning: cognitive, normative, and relational (Table 1). This typology addresses some of the perceived shortcomings of other existing typologies in the area of environmental learning, and their operationalization. Specifically, it includes a relational learning type, which is often not explicitly considered in other typologies (Baird et al. 2014). In addition, it treats all learning types as equivalent, rather than considering normative learning as of a

Table 1. Learning types, indicators, and measures.

Type	Definition/indicators of learning effects	Measures of indicators
Cognitive learning	Acquisition of new knowledge; restructuring of existing knowledge	Test scores; change in centrality and specificity of knowledge presented in concept maps; participant reflections immediately after the workshop and 6 months later
Normative learning	Changes in norms; change in values; change in paradigms; convergence of group opinion	Change in, and convergence around, values assigned to ecosystem functions; participant reflections immediately after the workshop and 6 months later
Relational learning	Improved understanding of mindsets of others; building of relationships; enhanced trust and cooperation	Participant self-reported reflections immediately after the workshop and 6 months later

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higher value than cognitive learning, as other authors have done (Haug, Huitema, and Wenzler 2011). Equivalency is important because the potential effects from each learning type can be equally valuable (e.g., understanding another's viewpoint may have a degree of impact similar to that of learning a new fact and neither is a precondition for the other) (Haug, Huitema, and Wenzler 2011; Baird et al. 2014). The typology is well suited for the purpose of capturing learning in a resilience analysis, as it is consistent with the way learning is described in the context of enhancing resilience by building and revisiting existing knowledge, inclusion of diverse stakeholders and consideration of their values and worldviews, and building relationships (Biggs et al. 2012).

In adopting the typology and method set forth and tested by Baird et al. (2014), the survey administered to workshop participants was designed to capture three types of learning (Table 1), which are described in further detail in the following. The survey was the main method of collecting data about the learning and was administered to the study participants prior to commencement of the resilience workshop and again immediately following its conclusion to both establish and measure the change from a baseline. All learning types were assessed and responses were triangulated using self-reported learning with a series of questions that queried the extent to which the workshop contributed to learning about resilience concepts and the implications for practice (using a 4-point Likert scale).

Cognitive

Survey questions focused on evaluating cognitive learning via testing knowledge of resilience concepts (indicator: acquisition of new knowledge) and through the analysis of concept maps using resilience in the respective watersheds as the focus. Concept maps allow participants to record thoughts and ideas related to a central concept (using nodes) and connect them to one another using lines. Concept maps were created by each participant as part of the survey following the method of Baird et al. (2014) and Haug, Huitema, and Wenzler (2011) (indicator: restructuring of existing knowledge). Entries on all concept maps within each case were coded for themes using content analysis. Each entry on a concept map was assigned a code associated with a theme. Additionally, the maps were analyzed to understand the "structure of knowledge" by examining two variables: (1) centrality (i.e., the distance from themes on the map to the central concept of "resilience of the watershed") (see Baird et al. 2014) and (2) frequency (i.e., how often each theme was present in a concept map). Both of these measures serve as separate indicators of the importance of a theme in relation to the central concept. Mean centrality and frequency measures for each

case were calculated and plotted in a scatterplot for visual assessment of changes in knowledge structure, and were tested for statistically significant changes from pre- to post-workshop using a nonparametric Wilcoxon signed ranks test (SPSS 20, IBM, Inc.).

Normative

Normative learning was evaluated through a "points assignment ranking" of the importance of a list of 23 ecosystem goods and services categorized under four broad ecosystem functions (established by de Groot, Wilson, and Boumans 2002). Briefly, 100 points were available for each respondent to assign to the 23 ecosystem functions based on how they perceived the relative importance of each ecosystem good or service. The sum of points assigned to each function was calculated and changes were identified in terms of how functions were ranked pre- and post-workshop (indicator: change in values). The mean number of points assigned to each function and standard deviations were calculated and differences in standard deviations were evaluated for reductions indicating group opinion convergence (following Huitema, Cornelisse, and Ottow 2010). The remaining indicators, change in viewpoint and change in paradigm, were assessed using a 4-point Likert scale rating of self-reported change in the post-workshop survey.

Relational

This aspect of learning was captured using the self-reported change questions with a Likert scale rating in the post-workshop survey. Mean responses for each case were calculated and are presented, along with minimum and maximum response values to provide a greater understanding of the range of responses from participants.

In an effort to gain insights into longer term learning effects and changes to watershed management, planning, or governance, an online questionnaire consisting of five open-ended follow-up questions probing the three learning types and overall effectiveness of the workshops was administered to the participants approximately 6 months after the workshops. An example of the type of questions asked is "Has your participation in the workshop influenced with whom you communicate about watershed management and/or planning? If so, how?," which queried relational learning. Participation by all workshop participants was requested by the local organizer of the workshops by e-mail or, in cases where participants did not regularly use Web-based communication, by telephone. A reminder was sent 2 weeks after the initial communication. Four participants responded from the HRW and six from the CW. The representativeness of these respondents was not assessed and this is an acknowledged limitation of the research. Responses to open-ended questions were analyzed using content analysis to identify themes within each case. Frequencies by which themes occurred were recorded.

Results

Learning effects as a consequence of participation in a two-day resilience analysis workshop in the HRW in NB and the CW in BC are presented in this section. Cognitive learning was assessed using an evaluation of knowledge of resilience concepts and cognitive mapping. In evaluating the acquisition of new knowledge, the percentage of correct responses to questions on resilience concepts was calculated before and after the workshop. In both cases respondents showed an increase of up to 30% in their knowledge of resilience. In the CW, knowledge increased related to adaptive capacity, system dynamics, and

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the role of uncertainty in decision making. In the HRW, knowledge increased related to consideration of scales in planning and the potential to be resilient to unknown disturbances. The post-workshop scores in the CW were significantly improved based on the Wilcoxon signed ranks test; however, the HRW scores were not. The difference between the two groups in terms of the change in scores was not statistically significant using the Mann–Whitney U-test ($U = 13.5$, $p = .10$).

Restructuring of existing knowledge was evaluated using concept maps. In the HRW, the mean number of items decreased over time (32.5–25.2) and the mean number of levels (i.e., number of items connecting the furthest item from the central concept) stayed the same at 3.5. Trends in the HRW concept maps over time reveal statistically significant differences (95% confidence level) in frequency and centrality, including decreases for "negative physical impacts," "watershed components," and, "social values." "Education/engagement" increased in both centrality and frequency, as did "informal actions" and "formal actions beyond boundary" (Figure 1). This indicated a shift in the variables that respondents considered most important to the resilience of the watershed from pre- to post-workshop. Overall, there was a greater focus on/more knowledge expressed regarding actions and a lesser focus on watershed values and threats after the workshop as compared

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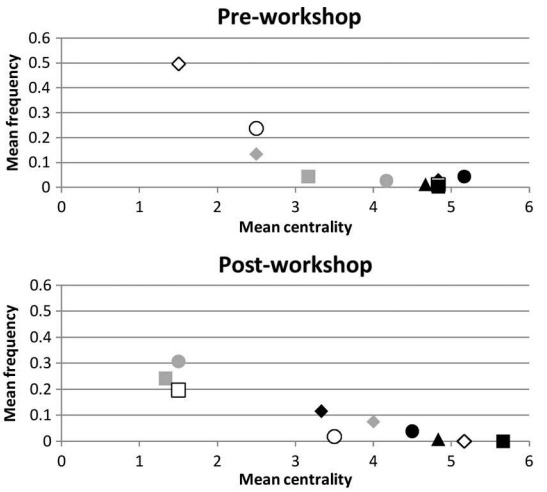
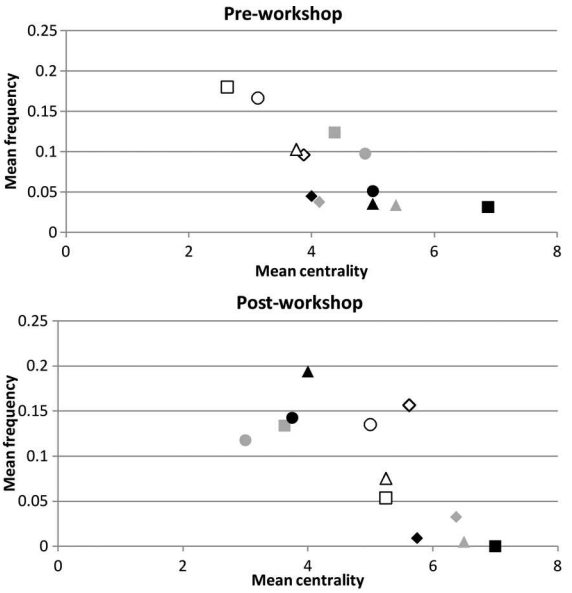


Legend and category descriptions for Hammond River Watershed		
Shape	**Category**	**Category description**
◆	Biophysical values	Biophysical values of watershed held by respondents
◆	Social values	Social values of watershed held by respondents
◇	Negative physical impacts	Negative physical influences and impacts on the watershed (problems)
■	Negative social impacts	Negative social influences on the watershed (problems)
■	Informal actions	Suggested and ongoing actions and institutions (other than formal political institutions) to address problems in watershed
□	Formal actions beyond boundary	Legislation/policy/enforcement needs beyond watershed scale to enhance resilience
●	Formal actions within boundary	Legislation/policy/enforcement needs within watershed to enhance resilience
●	Education / engagement	Education/engagement of community to raise awareness and build network for enhanced resilience
○	Watershed components	Changes to, or status of, components of the watershed (neutral tone)
▲	Resilience concepts	Broad mentions of resilience concepts

Figure 1. Pre- and post-workshop concept map categories for Hammond River Watershed.

to before it. When respondents were asked to reflect on the degree to which participation in the workshop led to increased knowledge (from 1 = not at all to 4 = a great deal), they reported a mean of 3.3.

In the CW, the mean change in number of items was −12.9 (35.5 pre-workshop and 22.6 post-workshop) and the mean change in levels was −0.13 (5.13 pre-workshop and 5.0 postworkshop). Statistically significant differences in frequency (95% confidence level) resulted from analysis of the trends in concept maps over time, while none were found from tests with centrality changes. The CW concept maps over time showed decreases in centrality and/or frequency of "biophysical actions," "biophysical values," and "cultural awareness," indicating a lesser focus on these themes. An increase in frequency occurred over time for "resilience concepts" and for "social actions," indicating an increase in perceived importance in relation to these themes (Figure 2). Overall, a decrease in the focus on the biophysical landscape and an increase in thinking in resilience terms and actions in the social sphere were evident after the workshop. Respondents in the CW reported a mean



Shape	Categories	Description of categories
◆	Biophysical values	Biophysical values of watershed held by respondents
◆	Social values	Social values of watershed held by respondents
◇	Negative physical influences	Negative physical influences and impacts on the watershed (problems)
■	Negative social influences	Negative social influences on the watershed (problems)
■	Formal action	Governance/legislation/enforcement needs to enhance resilience in the watershed
□	Biophysical actions	Suggested and ongoing actions directed at the biophysical landscape to improve/maintain the health of the watershed/address problems
●	Social actions	Suggested and ongoing actions in the social sphere intended to improve/maintain the health of the watershed/address problems
●	Education / engagement	Education/engagement of stakeholders to raise awareness and foster relationship/network building
○	Watershed components	Neutral mentions of changes to, or status of, components of the watershed
▲	Resilience concepts	Broad mentions of resilience concepts
▲	Health and wellness	Human health and wellness (mental and physical)
△	Cultural awareness	Knowledge and cultural values/awareness (includes opportunities to travel

Figure 2. Cowichan Watershed pre- and post-workshop concept map categories.

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response of 3.4 (with no responses below 3) when asked about the degree to which the workshop led to increase in their knowledge.

Normative learning was measured by the convergence of group opinion and a series of reflective questions. Convergence of group opinion was measured through ranking of ecosystem functions in terms of their importance, where a reduction in variability among the partcipant group over time would indicate convergence. A reduction in variability did not occur from pre- to post-workshop in either watershed. Despite a lack of convergence in variability, there were changes in how ecosystem functions were ranked from pre- to post-workshop that provided some evidence of a change in values. Most notably, "science and education" and "recreation" increased in ranking and points assigned after the workshop in the Hammond River Watershed, reinforcing their importance, and "water regulation" appeared in the top 10 functions when it had not ranked highly beforehand. In the CW, "disturbance prevention," "water regulation," and "science and education" were ranked much more prominently after the workshop than before (Table 2).

In terms of the post-workshop questions, normative learning indicators were assessed with a 4-point Likert scale from "not at all" to "a great deal" (Table 3). Median responses of 2–2.5 ("somewhat" to "moderately") for these questions indicate that changes in norms, values, and paradigms all occurred to some extent in both the HRW and the CW. The one exception was in the Hammond River Watershed, where the median response to a change in norms was 3.5 ("moderately" to "a great deal"). The responses in the HRW generally ranged from 2 to 4, while in the CW the range was larger, encompassing all four points on the scale. This indicates that a wider range of experiences in learning occurred among the CW workshop participants and some did not report experiences of some aspects of normative learning.

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Table 2. Values ranking for top-ranked ecosystem functions by respondents.

Cowichan Watershed				Hammond River Watershed			
Pre-workshop		Post-workshop		Pre-workshop		Post-workshop	
Function	Sum of points	Function	Sum of points	Function	Sum of points	Function	Sum of points
Nursery function	57.5	**Disturbance prevention**[a]	68	Nursery function	57	**Science and education**	**68**
Refugium function	52.5	**Water regulation**	55	Science and education	45	**Recreation**	**63**
Recreation	36	Refugium function	50	Recreation	40	**Water regulation**	**44**
Water regulation	34	Nursery function	50	Refugium function	38	Nursery function	41
Disturbance prevention	33	Water supply	41	Disturbance prevention	37	Refugium function	40
Water supply	32	**Science and education**	34	Climate regulation	36	Disturbance prevention	38
Food	32	Soil retention	28	Food	35	Soil retention	35
Aesthetics	32	Food	27.5	Aesthetics	33	Water supply	34
Soil retention	31	Aesthetics	25.5	Soil retention	32	Food	33
Pollination	29	Recreation	24.5	Water supply	32	Aesthetics	32

[a]Items that changed rank substantially from pre- to post-workshop are in bold font.

Table 3. Responses to reflective normative and relational learning questions by respondents.

Question: To what extent did your participation in this workshop contribute to …	Hammond River Watershed			Cowichan Watershed		
	Median	Min[a]	Max[b]	Median	Min	Max
Normative indicators						
Your views about governance of the watershed change	2.5[c]	2	4	2.5	1	4
Your values related to the watershed change	2.5	2	4	2	1	4
You question existing policies and procedures	2.5	1	4	2.5	1	4
You question watershed governance norms and protocols	3.5	1	4	3	2	4
Relational indicators						
You improve your understanding of the viewpoints of others	4	3	4	3	3	4
Enhanced interactions among participants	4	3	4	3	3	4
Enhanced trust with other participants	3	2	4	3	2	4
Building relationships	4	3	4	3	2	4
Increased network of people and orgs you communicate with	4	2	4	3	2	4

[a]Minimum value reported.
[b]Maximum value reported.
[c]Likert scale responses where 1 = not at all and 5 = to a great extent.

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Relational learning was measured using reflective questions with a 4-point Likert scale from "not at all" to "a great deal" in the post-workshop survey. Survey responses indicate that relational learning was high as a result of the workshops. Median values were 3 ("moderately") for all indicators for the CW and mostly 4 ("a great deal") for the HRW (Table 3). The minimum and maximum response values were very similar among indicators and between cases, and all participants felt that they had experienced relational learning to some degree for all indicators assessed.

Finally, open-ended questions were asked of respondents 6 months after the workshop to assess longer term learning. Respondents who participated in the HRW workshop and provided answers to these follow-up questions recalled most clearly (cognitive learning) the concepts of sharing values (places of personal meaning) and disturbances (and the value of those exercises) and thinking in terms of different scales. Respondents communicated an enduring belief that resilience analysis can and should be incorporated into watershed management and planning; however, they also reported that this had not been undertaken yet, but that the workshop has allowed for the inclusion of resilience concepts "on a notional level" in discussions. A change in whom respondents communicate with based on the workshop (relational learning) was not reported.

For the assessment of longer term cognitive learning in the CW, resilience concepts that participants recalled most clearly were community engagement, interconnectedness (two people mentioned this), the need to consider multiple scales, and "forward thinking" and considering unknown disturbances. In terms of normative learning, participants all believed that resilience analysis can and should be incorporated into watershed planning, and there was some reported evidence that efforts have been made to do so. Two-thirds of respondents to the follow-up questions also indicated that they increased the network of people they were communicating with and sharing information about resilience in the 6 months after the workshop.

Discussion

Delivering resilience workshops to two watershed groups in Canada engendered measurable learning outcomes. This overarching finding confirms findings from an extensive

amount of scholarship within natural resources and environmental management that has explored the participation of individuals in workshops or similar events, learning processes, and outcomes (e.g., Schusler, Decker, and Pfeffer 2003; Plummer and FitzGibbon 2007; Rodela 2010). But where this research goes further is in exploring the multidimensional conceptualization of learning and its multifaceted measurement, the development and delivery of resilience workshops to watershed groups (i.e., learning the focused specifically on translating theory into practice), and the attempt to nurture resilience in two distinct watersheds.

In adopting the typology and multidimensional measures set out by Baird et al. (2014), effects from the resilience workshops were transparently and systematically assessed in terms of cognitive learning, normative learning, and relational learning. At least some evidence of learning effects from the resilience workshop was found for all types of learning and all indicators for both cases, with the exception of convergence of group opinion.

Pelling et al. (2008) identifies the need to create space for collaboration among stakeholders as an essential pathway for enabling social learning. The workshops, through the two-day model described in this study, created an opportunity for such a space to emerge in the context of watershed resilience and showed that learning occurred. Learning is also identified as a key to enhancing resilience (Biggs et al. 2012); thus, in this study we identify learning as both an effect and an outcome. The effects of learning on watershed planning, and resilience, are not necessarily tangible actions taken by watershed groups immediately or 6 months after the workshops, but rather intangible influences that may shape individuals' and the group's communication, approaches, or strategies over time in a myriad of ways. Thus, learning effects may interact with other variables and processes over time, and tangible outcomes may manifest in multiple ways in the future.

Others have found similar inconclusive results related to the measurement of normative learning in short-term policy exercises (Haug, Huitema, and Wenzler 2011) and in longer term lagoon management (Munaretto and Huitema 2012). Baird et al. (2014) note the challenges of methodologically ascertaining normative learning effects and also identify the slow speed of change of norms. Further and longitudinal investigations using the typology may ultimately allow additional insights into "what type of learning works and under what conditions" (Biggs et al. 2012, 435), but this study demonstrates that cognitive and relational learning can take place in fairly short time frame (two-day workshop). This reinforces that the workshop design itself is also a useful tool for building resilience practice in watersheds.

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Methodological Development and Challenges

Although the typology and methods were developed through prior research (Baird et al. 2014), their application here does respond to the repeatedly expressed calls for conceptual and methodological rigor in assessing learning in natural resource and environmental governance (Armitage, Marschke, and Plummer 2008; Rodela 2010; Crona and Parker 2012). In adding to the critical assessment of the learning typology and measurements by Baird et al. (2014), we would emphasize the benefits derived from conceptually untangling previous understanding of learning, utilizing multiple indicators and methods for learning types, and taking robust measurements. Through the addition of a qualitative assessment of learning 6 months after the workshop, longer-term learning

effects were captured and add to the methodological rigor of the approach to measuring learning.

Some methodological challenges emerged through this study. At the suggestion by Baird et al. (2014) to find an alternative to the New Ecological Paradigm to gauge normative learning, we used "points assignment ranking" of 23 ecosystem functions from de Groot, Wilson, and Boumans (2002) to measure the change in values and convergence of group opinion indicators. While this new approach proved to be useful for evaluating changes in values, it failed to find a convergence in group opinion and confirmed the ongoing challenge of measuring normative change through instruments other than self-reporting questions. Whether normative change occurs to the same extent as cognitive and relational learning, particularly over a short period of time, remains an open question (Haug, Huitema, and Wenzler 2011; Baird et al. 2014). The challenge in measuring normative learning highlights the limitations of the 2-day workshop approach. While this design allowed for an intensive introduction to resilience concepts, the short time period created for learning to occur resulted in the following additional challenges: Participants found the concept maps laborious to complete before and after the workshop (i.e., one per day), and we anticipate the decline in number of items and levels in both cases was due to fatigue. Thus, concept maps, while a rich source of data for evaluating cognitive learning, may not be the instrument best suited for short-term learning assessment. Also, the 2-day workshops may have overemphasized short-term changes, which the research design addressed by the addition of a follow-up questionnaires that were distributed 6 months after the workshops; however, the response rates were low for these questionnaires.

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Resilience Practice Efforts and Outcomes

The workshop designed and delivered to introduce participants to resilience thinking and illustrate how it could be applied in a water resources context was informed by guides that existed at that time to translate resilience thinking to practice (Walker and Salt 2006; Resilience Alliance 2007 Walker and Salt 2012). It predated tools now available for planning resilient watersheds (Tyler and Tyler 2014) and information on efforts to combine and apply resilience thinking and collective learning in catchments (Mitchell et al. 2014). The latter research initiative is particularly germane to this study, as it combined resilience thinking with Brown's (2008) collective learning principles to undertake a participatory action research project in Wakool Shire, as part of a longer case study involving the Murray Catchment Authority. Despite the many contextual differences, the experiences in Australia and Canada appear strikingly similar in several respects. First, there appears to be consistency as to the general approach to introduce resilience thinking, the questions explored throughout the sessions, and the heuristics/exercises employed to engage with resilience practice. Second, the researchers in Australia and Canada found that translating resilience thinking into resilience practice posed a concerted challenge and was difficult to facilitate. Finally, neither introduction to resilience led to independent and sustained resilience practice after 6 months, and it is unclear how learning has been incorporated into watershed planning and management practice since that time. However, the CW showed some promising indications that resilience practice was beginning to be incorporated and that the workshop had a longer term impact on learning. Sustained resilience practice was an explicit aim in Australia, where the pilot project did not lead to community-direct

transformation. While sustained resilience practice was not an intention in the Canadian cases, evidence from the follow-up questionnaires suggests resilience practice was not systematically incorporated into practices of the watershed groups 6 months after the workshops; however, the intangible outcomes of learning to "on the ground" processes may manifest into tangible actions over a longer period of time, and specific individuals did identify personal benefits from the workshop.

Conclusions

Society needs to nurture resilience of social–ecological systems (Folke et al. 2010). Translating resilience thinking into practice in the context of watersheds is increasingly capturing attention due to concerns about fresh water along with experiences of complexity, uncertainty, and conflict. Social learning is recognized as one important process for building resilience practice. Yet a consensus on how best to determine or measure the impacts of the forums aimed at building knowledge and translating it for practice remains a gap in resilience research.

A workshop format was developed in this research to introduce resilience thinking and illustrate how it could be applied in practice. Workshops were delivered in the HRW in New Brunswick and the CW on Vancouver Island, British Columbia Canada. The research examined learning that came about from these workshops. Learning was examined because it is a key aspect of resilience (Folke et al. 2002; Folke 2006); because encouraging learning is one of seven key principles argued to enhance resilience (Biggs et al. 2012); and because recent advancements in scholarship of learning in relation to environmental governance permit specificity and robustness in how it is conceptualized and measured (Baird et al. 2014). The learning effects from delivering these resilience workshops to watershed groups in Canada were marked. Effects were found for all types of learning: cognitive, normative, and relational. While the issues of concern to participants in each case varied, the pattern of evidence for learning effects was remarkably similar. All indicators of learning effects measured before and after the workshop showed a change, with the exception in both cases being the convergence of group opinions, which was inconclusive.

How to nurture resilience in smaller social–ecological systems and to apply resilience in a way that effectively resonates with individuals engaged in practice is a much larger, complicated, and open question. This research, alongside other early efforts addressing resilience practice (Walker and Salt 2012; Mitchell et al. 2014), provides valuable experience and insights upon which future research may build. The focus on learning in these early efforts made sound sense, given its relationship to resilience and advancements in conceptual and methodological rigor. Early signals from this research, along with insights from others (Biggs et al. 2012; Mitchell et al. 2014), suggest that learning is a necessary but insufficient ingredient for resilience. As Biggs et al. (2012, 439) observe, "None of the principles are universally beneficial, and all require a nuanced understanding of how, when, and where they apply, as well as how they interact with or depend on other principles." A formidable challenge thus exists for researchers if they are to gain a sufficient understanding of how to nurture resilience. Efforts directed to understanding how and in what ways learning leads to action in collaborative processes offer a fruitful avenue for future research.

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