Reilly, K. H., and J. F. Adamowski. 2017. Stakeholders' frames and ecosystem service use in the context of a debate over rebuilding or removing a dam in New Brunswick, Canada. *Ecology and Society* 22(1):17. https://doi.org/10.5751/ES-09045-220117

Research

Stakeholders' frames and ecosystem service use in the context of a debate over rebuilding or removing a dam in New Brunswick, Canada

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ABSTRACT. As many dams are starting to reach the end of their life spans, discussions about whether they should be retained or removed are becoming more common. Such debates are often controversial, but little is known about stakeholders' opinions about the issue. We use frame theory to describe how stakeholders perceive a decision on the future of the Mactaquac Dam in New Brunswick, Canada. Frames describe how people make sense of a situation by determining what is important and inside the frame, and what is outside the frame, based on their past experiences and knowledge. We explore whether the benefits that people realize from ecosystems (ecosystem services) influence their frames of dam removal. Based on interviews with 30 stakeholders, we found that participants who preferred to retain the dam aimed to prioritize the social and economic stability of the area, which relied on the ecosystem services provided by the dammed river. They emphasized the quality of the current ecosystem that has developed around the dam and preferred to avoid disturbing it. By contrast, those who preferred to remove the dam framed the decision as an opportunity to restore the ecology and social and economic activities that were present before the dam was built. These frames were influenced by participants' use of ecosystem services—both focus on the ecosystem services they use, while minimizing the benefits of others. Exploring frames allowed us to uncover the assumptions and biases implicit in their views, and identify topics for education campaigns as well as possible areas of agreement between parties. We conclude that ecosystem services are a relevant source of frames of a decision on a dam's future.

Key Words: *dam refurbishment; dam removal; ecosystem services; frames; stakeholders*

INTRODUCTION

Dams were constructed with increasing frequency during the 20th century to ensure water supply, control floods, and generate hydroelectricity (World Commission on Dams 2000). On the other hand, dam building has often been controversial due to its cost, modification of ecological processes, landscape changes, and displacement of communities (Nilsson and Berggren 2000, Poff and Zimmerman 2010, Vörösmarty et al. 2010). For example, dams change ecosystem functioning by forming a barrier to migrating fish, changing sediment transport and flow regimes, and affecting water temperature and quality (Bunn and Arthington 2002, Poff and Hart 2002, Richter and Thomas 2007, Van Looy et al. 2014). Now that dams built in the early to mid-1900s are starting to reach the end of their planned life spans, decisions must be made about their future. Dam removal is increasingly being considered as an alternative to rebuilding affected dams in order to reverse ecological changes, avoid costly repairs, and/or minimize public health risks (Babbitt 2002, Doyle et al. 2003, 2008, O'Connor et al. 2015).

In making a decision about whether to remove or retain a dam, the societal, ecological, and economic functions of the dammed river must be balanced with those of a free-flowing river (Born et al. 1998, Babbitt 2002). However, this is not straightforward—stakeholder perspectives of that balance must also be taken into account alongside scientific and economic analyses (Born et al. 1998, Reed 2008). We use the concept of frames to understand those perspectives. How a person frames a problem describes which aspects of the issue they consider important and which are minimized, as well as how they define the problem's boundaries (Dewulf 2013). Frames are rooted in people's experiences, knowledge, and other cognitions, which determine how they make sense of the issue at hand (Bartlett 1932, Minsky 1974, Dewulf et al. 2009). We explore whether people's experiences of ecosystems—i.e., the benefits they realize from ecosystem services—result in different frames of ecological change (Kovács et al. 2014).

Identifying stakeholders' frames allows decision-makers to determine not only people's different positions on an issue but how they arrived at that position, the assumptions inherent in their choice, and which factors they consider to be most important. A particularly relevant type of framing, which has received some attention in the literature on ecological management and conflict, is whether individuals perceive management options to result in losses or gains (Lewicki 2003, Wilson et al. 2008, Singh et al. 2013). Prospect theory states that how a person frames a change in terms of losses and gains depends on which reference point they use to evaluate the consequences of the change and the degree to which they will accept risk. According to this theory, people prefer to forego gains than to accept losses (Kahneman and Tversky 1979, Tversky and Kahneman 1981). Understanding differences in framing can allow all relevant perspectives to be included in decision-making, reveal alternative solutions, ensure problem-solving is focused on the correct issue, and inform conflict resolution measures, if necessary (Bardwell 1991, Lewicki 2003, Shmueli et al. 2006, Asah et al. 2012*b*).

We combine frame theory and an ecosystem services approach to describe how people's interactions with their environment lead to different frames, and reveal the assumptions and contradictions inherent in people's views of a decision about the future of the Mactaquac Dam in New Brunswick, Canada. To do this, we answer two questions:

1. How do stakeholders currently benefit from ecosystem services, and how do they expect those benefits to change if the dam were removed?

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Erratum: This article was originally published incorrectly stating the publishing year as 2016. The change to the correct year (2017) was made on 14 July 2017.

2. How do different people frame the decision about whether the dam should be removed, and how does that relate to how they benefit from ecosystem services?

We first discuss the concepts of framing and use of ecosystem services before describing the study area in more detail. We then explain the methods used for data collection and analysis. Following that, we discuss the results of how the study participants used ecosystem services and how they framed the upcoming decision on the dam. Lastly, we put our findings into the context of literature on frames, ecosystem services, and dam removals.

CONCEPTUAL FRAMEWORK

Frames of environmental conflicts

Frames describe how people make sense of the world and their experiences (Lewicki 2003). We adopted the cognitive framing paradigm, which allowed us to explore the role of experiences of ecosystem services in contributing to frames and to investigate the variation in frames between individuals (Dewulf et al. 2009, Jacobs and Buijs 2011). Cognitive frames are a way of organizing memories of past knowledge and experiences, as well as other cognitions, to make sense of a particular situation (Lewicki 2003, Dewulf et al. 2009). In doing this, some aspects of the situation are brought to the foreground—i.e., inside the frame—while others are relegated to the periphery of the frame (Davis and Lewicki 2003). The process of framing involves selecting which pre-existing frame(s) apply to a given situation (Van Gorp 2007, Dewulf et al. 2009).

The study of environmental conflicts suggests that divergences in people's cognitive frames of the problem at the center of a conflict are important contributors to conflict dynamics (Lewicki 2003, Shmueli 2008, Dewulf et al. 2009). The different understandings of the problem can hinder effective communication, which can prevent agreement on or identification of a solution and cause the parties to become entrenched in their views (Shmueli et al. 2006, Asah et al. 2012*b*). This can feed a self-perpetuating cycle, whereby entrenchment reduces willingness to compromise and creates further difficulty in finding a solution (Shmueli et al. 2006). Furthermore, cognitive frames can be used strategically by parties to communicate their message to others and reinforce their position (Gray and Putnam 2003, Shmueli et al. 2006). Explicit understanding of people's cognitive frames can break this cycle by helping people appreciate others' points of view and find points of agreement (or frame convergence). It can also inform conflict resolution strategies by ensuring that information biases are corrected and that effective compromises can be identified (Lewicki 2003, Shmueli et al. 2006, Dewulf et al. 2009).

For example, Asah et al. (2012*b*) found that despite differences in framing the problem of all-terrain vehicle use on state public lands in Minnesota, disputants also agreed on several aspects, including the need for protection of the natural resource. With this information, it would then be possible for land managers to move forward on specific management actions that build on those areas of agreement (Asah et al. 2012*a*, *b*). Similarly, Buijs (2009) found three frames of river restoration projects in the Netherlands that led to different solutions being supported. Some people opposed river restoration; they held an attachment frame, thereby emphasizing their personal attachment to the cultural heritage of the river floodplain that was to be restored. Other opponents held a "rurality" frame, in which they prioritized maintaining the agricultural functions of the area. By contrast, supporters of river restoration preferred to enhance the river's natural function and its aesthetic quality. Revealing these frames was useful for initiators of river restoration projects to understand why their rationales for the projects did not resonate with residents and how the latter could be included in decision-making (Buijs 2009).

Whether a person frames a decision as producing a loss or a gain may be particularly relevant to understanding how stakeholders respond to a decision with uncertain outcomes (Lewicki 2003, Wilson et al. 2008, Singh et al. 2013). As previously mentioned, prospect theory states that individuals frame a change as either a loss or a gain compared to a reference point, and take more action to avoid potential losses than to seek potential gains (Tversky and Kahneman 1981, Wilson et al. 2011, Singh et al. 2013). Differences in people's loss or gain frames arise from variations in their perceptions of the decision's outcomes, as well as from their different reference points, which can reflect the status quo, a past state, or goals for a future state (Kahneman and Tversky 1979, Tversky and Kahneman 1981, Kahneman 1992, Heath et al. 1999). For example, in a conflict over water use from an aquifer in Texas, a judge framed the situation of overuse as an "emergency" and implied that water use restrictions would deliver gains. On the other hand, rural water users framed restrictions as a loss in agricultural irrigation that offered few gains (Elliott 2003).

We explore how different people frame a potential dam removal in terms of losses and gains in ecosystem services. We focus on dam removal because it is the option for the dam's future that constitutes a significant change from the status quo in terms of ecology, ecosystem services, and socio-economic factors, and involves some uncertainty and risk. Rebuilding the dam, by contrast, would result in an outcome that is relatively similar to the river's current dammed state.

The role of ecosystem service use in environmental conflicts

The concept of ecosystem services was first developed to link ecological functioning with human well-being to build support for nature conservation (Tallis et al. 2008, Norgaard 2010). Therefore, it is a useful framework to explicitly link changes in ecological functioning as a result of dam removal to perceived losses and gains in people's well-being.

Dam removal is frequently offered as a means to increase ecosystem service provision, including improved migration of fish upstream and downstream, which can be used for food supply or recreation and has nonuse value (Naiman and Dudgeon 2011, Auerbach et al. 2014). Such increases in fish populations may improve local economies, such as through tourism, or enhance local people's connection to place through restoration of traditional activities (McClenachan et al. 2015). Reconnection of the river with its floodplain can increase soil fertility, which supports agriculture (Opperman et al. 2009, Auerbach et al. 2014). However, changes to ecosystems often result in trade-offs between services provided (Bennett et al. 2009, Hirsch et al. 2011, McShane et al. 2011, Kovács et al. 2014). For example, the reservoirs created by dams are frequently used for boating and fishing, which would be lost or reduced following dam removal (Auerbach et al. 2014). When ecological restoration causes some people to benefit more

from ecosystem services and others to benefit less, conflict can develop (Adams et al. 2003, Kari and Korhonen-Kurki 2013, Kovács et al. 2014).

Social groups, and individuals within particular social groups, will experiences different changes in benefits from ecosystem services because people have different needs, values, and perspectives, which are met by ecosystem services in differing ways (Bengston et al. 2011, Fish 2011, Martín-López et al. 2012, Milcu et al. 2013). For example, some people may value a service for their direct experience of it, whereas others might value its existence for moral reasons regardless of whether they themselves experience it (Spash et al. 2009, Chan et al. 2012). The principal benefits of ecosystem service provision may also be experienced differently depending on a person's knowledge and experiences (Asah et al. 2012*c*, Chan et al. 2012, Martín-López et al. 2012, Plieninger et al. 2013). For example, a study of perceptions of grassland ecosystem services found that local farmers and regional experts in agriculture, nature conservation, tourism, or rural development ranked local grassland ecosystem services differently depending on their technical and experiential knowledge (Lamarque et al. 2011). Similarly, people's preferences for the Bilbao Metropolitan Greenbelt, Spain, also showed that ecosystem services preferences differed depending on people's familiarity with the area. People who visited the area for walking or sports showed a strong demand for aesthetic services, whereas specialists (teachers, students, environmental association workers) demanded regulating services (e.g., soil formation) (Casado-Arzuaga et al. 2013).

Several studies have found that people's use of ecosystem services can contribute to how they frame a decision at the heart of an environmental conflict. Such services include aesthetics (Buijs 2009, Fischer and Bliss 2009, Fischer and Marshall 2010), recreational opportunities (Lewicki 2003, Asah et al. 2012*a*), and biodiversity protection (Fischer and Bliss 2009, Fischer and Marshall 2010). To advance these ideas, we explore whether the benefits that individuals currently obtain from ecosystem services are related to whether they frame dam removal as either a loss or gain.

STUDY AREA

The study area was centered on the Mactaquac Dam on the Saint John River in New Brunswick, one of Canada's Atlantic provinces. The Mactaquac Dam is one of the largest in the world ever considered for removal, making it an important opportunity to study frames of the decision and of changes in ecosystem services, and how they diverge between social groups. It was also chosen because the potential removal is controversial, which allowed the role of ecosystem services in framing a conflict situation to be studied. Lastly, it allowed the opportunity to study people's frames concurrently rather than retrospectively, as would have been the case for dams that have already been removed.

The Saint John River is approximately 700 km long with a watershed area of 55,000 km^2, and is shared between the Canadian provinces of New Brunswick and Quebec, and the state of Maine, United States. Land cover in the watershed is primarily forest, although there are some agricultural and small urban areas. The river has a mean annual discharge of approximately 1100 m^3/s and a flow regime typical of rivers in the east of Canada; peak flow occurs after snowmelt in spring, and a second, smaller peak occurs in autumn (Canadian Rivers Institute 2011).

The Mactaquac Dam is located approximately 19 km upstream of Fredericton (Fig. 1), on the middle reach of the river, and has operated since 1968. Its construction flooded the river to Hartland upstream, and created a reservoir known locally as the Mactaquac Headpond, which is approximately 96 km long and 84 km^2 (Canadian Rivers Institute 2013, Stantec 2015). The dam was built to generate hydroelectricity to power the province's industrialization. It has an installed generating capacity of approximately 670 MW, which currently supplies 12% of residences and businesses in New Brunswick (Stantec 2015). The limits of the study area were Hartland upstream and Fredericton downstream (Fig. 1) because this river reach was most hydrologically affected by the dam and would therefore be most changed by its removal.

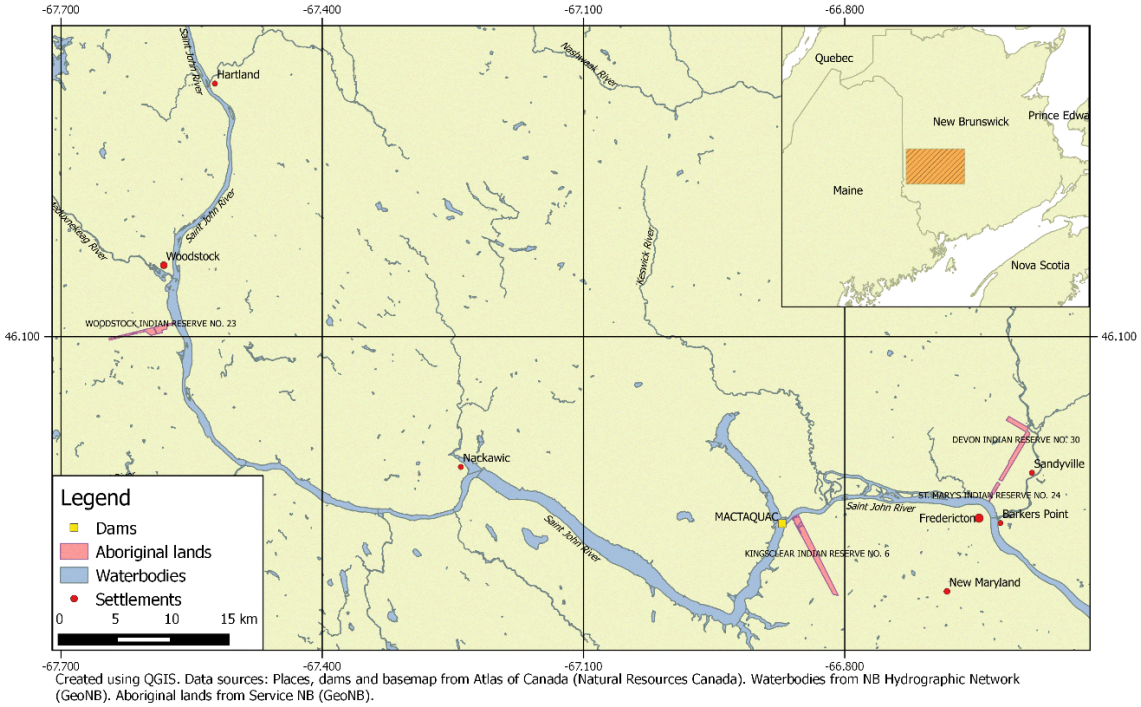
The dam is one of three on the mainstem of the Saint John River, and numerous other dams on its tributaries have combined to influence the river's hydroecology. The Mactaquac Dam is operated to release water in response to energy demands. This causes water levels in the 30–40 km downstream of the dam to change by up to 1 m on a diurnal timescale, which is a major stressor to taxa that are not adapted to withstand such rapid changes in flow (Canadian Rivers Institute 2011, Luiker et al. 2013, Jones 2014). In addition, the water level in the headpond is occasionally lowered in advance of large storms to reduce flood risk, which can result in stranding of some organisms in the shallow areas that become exposed (Martel et al. 2010).

The river's ecology upstream of the dam has also changed, primarily because the headpond is deeper and slower flowing than the undammed river (Stantec 2015). Its water is also generally warmer and has lower oxygen levels, which stresses native cold-water fish and benefits warm-water non-native species, such as smallmouth bass (*Micropterus dolomieu*) and muskellunge (*Esox masquinongy*) (Canadian Rivers Institute 2011). In particular, the headpond stratifies in summer, meaning that surface waters are up to 10°C warmer than waters at depth. This temperature difference prevents mixing, which causes deep waters to become oxygen depleted and limits their ability to support cold-water species such as Atlantic salmon (*Salmo salar*) (Stantec 2015). In addition, the low flow and shallow gradient can impede downstream navigation through the headpond. The gradient of the headpond is approximately 0.001% (Carr 2001); it is thought that juvenile Atlantic salmon habitat in the river is restricted to areas with gradients of 0.1–15% (Canadian Rivers Institute 2011). Because of this, a study of migrating Atlantic salmon smolts in the Mactaquac Headpond found that up to 100% could not locate the downstream exit, which means they could not migrate to the ocean (Carr 2001).

The dam was built without a fish ladder; therefore, the dam is a barrier to upstream migration for striped bass (*Morone saxatilis*), sea lamprey (*Petromuzon marinus*), American shad (*Alosa sapidissima*), and Atlantic salmon (Canadian Rivers Institute 2011). There is also no means of bypassing the dam for fish migrating downstream, which results in high mortality rates of individuals passing through the turbines (Penney 1987).

In addition to its ecological impacts, the construction of the dam was controversial socially. Opponents of the project organized into an action group that included residents of the area that would be flooded upstream of the proposed dam site, downstream residents, local farmers, and sports fishers. However, members of

Fig. 1. Study area: Saint John River from Hartland (upstream) to Fredericton (downstream), New Brunswick, Canada. Inset: Location of study area (in orange) within the province of New Brunswick.



Created using QGIS. Data sources: Places, dams and basemap from Atlas of Canada (Natural Resources Canada). Waterbodies from NB Hydrographic Network (GeoNB). Aboriginal lands from Service NB (GeoNB).

local Maliseet First Nations remained relatively quiet on the issue (Kenny and Secord 2010, Bourgoin 2013). The action group's concerns centered around relocation of communities, loss of First Nations and settler cultural heritage, including several graveyards, disruption to the salmon fishery, destruction of the area's natural beauty, and loss of productive farmland (Bourgoin 2013). Some in downstream communities, such as Fredericton, also worried about the consequences of the dam collapsing (Kenny and Secord 2010, Bourgoin 2013).

Now, however, house building around the headpond has proliferated and the headpond is popular for boating, fishing (particularly for smallmouth bass and muskellunge), snowmobiling, and other recreational uses (Dillon Consulting 2015). Tourism is the dominant economic activity in the area, and is widely seen as relying on the headpond's aesthetics and recreational opportunities (Stantec 2015). The dam provides considerable hydroelectricity for the province and reduces flood risk from ice jams downstream in Fredericton (Stantec 2015).

Current issue

The dam is currently experiencing a structural problem, specifically an alkali-aggregate reaction, that at the time of study was expected to shorten its life span from the planned 100 years to approximately 60 years. The alkali-aggregate reaction is occurring between the cement and the aggregate rocks that make up the concrete used in the power generating structures, which is causing the concrete to expand. The earthen dam that impounds the river and creates the headpond is unaffected (Stantec 2015).

The dam's owners, New Brunswick Power, and the provincial government must decide by the end of 2016 on the dam's future when it reaches the end of its shortened lifetime in 2030. Three options have been proposed: rebuild the affected structures to maintain electricity generation, retain the earthen dam to maintain the headpond, or remove the dam entirely to restore the river to its natural free-flowing condition, which would involve draining the headpond. At the time of writing, the environmental and social impacts of the three options had been comparatively reviewed (Dillon Consulting 2015, Stantec 2015), and consultations with stakeholders and First Nations were ongoing. The fieldwork for this study took place before any of the reviews were published and before the consultation with stakeholders began. The consultation with First Nations was already underway at the time the fieldwork was conducted.

Stakeholders and local people are again divided over whether the dam should be retained in some form or removed entirely (Keilty et al. 2016, Sherren et al. 2016). A local action group in favor of retaining the dam has been formed, some stakeholders advocate for removal, and different opinions have been expressed during New Brunswick Power's public meetings (NB Power 2015). However, little is known about what is driving those divergences in opinion.

METHODS

We used a qualitative approach because it allows participants' subjective experiences and opinions to be explored in detail (Miles et al. 2013). It has the advantage of allowing individuals to provide information that might not have been revealed in response to the predetermined questions used in a quantitative approach, for example. It further allows participants to describe the values and attitudes that guide their understanding of an event, and therefore

reveals how the same events are interpreted differently by stakeholders (Sofaer 1999, Driscoll et al. 2007), meaning people's frames can be identified (Van Gorp 2007).

Interviews and documents, such as editorials and letters to the editor, were the main sources of data. Interviews are an ideal method of revealing an individual's experiences and opinions (i.e., how they frame the issue) directly, without being influenced by others, as might be the case in focus groups (Dewulf et al. 2009). Documents were analyzed to triangulate the data collected from interviews. Letters to the editor, editorials, and other documents have the advantage of allowing people's experiences and opinions to be expressed without the intervention of the researcher (Creswell and Miller 2000, Gray 2004).

Interviewees were selected using nonproportional quota sampling from a list of approximately 80 organizations, businesses, and groups that would be affected by the decision on the dam (Freeman 1994), as opposed to members of the general public or organizations that may not be affected. From this list, participants were selected to include the widest range of possible perspectives on the future dam. To achieve this, we selected participants who were located throughout the boundaries of the study area and aimed to represent all major interest groups, namely First Nations organizations, anglers, headpond residents, downstream residents, industry, businesses, environmental nongovernmental organizations (NGOs), watershed organizations, heritage groups, and recreational groups.

The final sample included 30 individuals who were located primarily throughout the area from Fredericton to Woodstock. However, two interviewees were physically located outside the study area but represented organizations with significant interests in the area, as well as strong personal interests in one case. The main interests of the stakeholders selected were business (10 interviewees), environment (9), recreation (6), property ownership on the headpond (2), municipalities (2), and heritage (1). However, most individuals interviewed from these organizations had several interests in the area. While some industry and First Nations organizations were invited to participate, none ultimately chose to be involved. This may have been because of lack of time, interest in the issue, or in the case of some of the First Nations, already being involved in New Brunswick Power's consultation process. Similarly, none of the invitees located in the river reach from Woodstock to Hartland (Fig. 1) participated. We also discussed the case with the decision-makers—i.e., New Brunswick Power—as well as others observing the decision-making process to improve our understanding of the decision and its context.

Most participants were interviewed individually, although nine were interviewed in pairs or groups at the participants' request. During group interviews, individuals were asked in turn to give their own opinions before a group discussion took place. All interviews but one were conducted in person in the study area; one interview was conducted by Skype due to geographical distance. Participants were interviewed until no further themes were raised; i.e., until theoretical saturation was reached (Strauss and Corbin 1998). However, it must again be noted that no First Nations individuals or groups who could be expected to introduce new themes participated .

Interviews were semistructured to give participants freedom to explore their own interpretations of the issues and related topics while still allowing responses to be compared between participants. The topics were introduced using open-ended questions, and closed, probing questions were used where necessary to check understanding and clarify ambiguous statements. The following topics relevant to this study were covered:

1. the participant's role in their main organization and any other organizations they were involved in that related to the river;
2. how the participant used the river throughout the study area in their personal and/or professional life;
3. what they thought should happen to the dam at the end of its life, their reasoning, and any factors that may change their opinion; and
4. how they expected each option to affect them, their organization, and others in the area.

Although the interviews discussed all three options, the focus was on removal of the dam because this was the option that represented the biggest change in ecosystem services, their use, and other aspects of the interviewees' livelihood and well-being compared to the status quo. Discussion was focused on the reach of the river affected by the dam—i.e., from Hartland to Fredericton (Fig. 1)—although interviewees could choose to focus on particular areas within those limits and bring up other areas if relevant. Interviewees were generally familiar with the area and the options for the dam's future, but maps (Fig. 1) and diagrams of the options were used to clarify as necessary.

Many interviewees had multiple stakeholder roles through their personal lives, employment, and voluntary work, each of which had the potential to give them different perspectives on the issue (Lewan and Söderqvist 2002, Lamarque et al. 2011). In these cases, the individuals were given the choice as to which perspective to speak from, according to which they felt was most relevant or which was most comfortable for them. This was therefore a personal, subjective choice. However, some of their employers had not yet developed a position on the dam's future, and in these cases, most interviewees talked more from their personal perspective. Most of the remaining interviewees talked of both their employers' or voluntary organizations' points of view and their own personal opinions.

Interviews took place in May and July 2015, lasted between 45 minutes and one hour, and were digitally recorded. Following transcription of the recorded interviews, summaries of the content were prepared and returned to each participant for member checking. The summaries were revised as requested by the participants, and those revisions were carried through the analysis. The changes requested included only minor points of clarification and nuance rather than significant changes in opinion.

Documents were collected by searching Google and an online subscription to local newspapers (the Fredericton Daily Gleaner, Saint John Telegraph Journal, and Woodstock Bugle-Observer) using the following key words: "Mactaquac Dam" and "Mactaquac". The original intention was to restrict the search to documents published in the same time period as the interviews (i.e., in May to July 2015) in order to ensure that both writers of

documents and interviewees had access to the same information. However, this did not yield a sufficient number of documents that met the criteria for selection. Therefore, the length of time was increased to one year from 31 August 2014 to 31 August 2015. The latter cut-off point was selected because it was prior to the publication of key documents, including the comparative environmental review of the three options, and the start of the consultation period in September 2015.

From the collected sample, documents were selected for further analysis based on the following criteria:

1. published and accessible online;
2. did not repeat information or narratives published in other locations; and
3. revealed the writer's personal opinion on the future of the dam, with sufficient justifying information that their framing of the issue could be analyzed.

Documents included blog posts, comments in internet forums, letters to the editor, and editorials. News articles and other purely factual documents were excluded because they did not reveal the writer's frames of the issue, although they were read for background information where relevant. In addition, articles in which others' views were reported secondhand were also excluded to remove the risk that their frames were inaccurately represented. In total, documents representing 19 unique points of view were analyzed. More than 100 other articles and documents published outside this time period were read to ensure understanding of the case and to further support the findings.

The documents and interview transcriptions were first categorized according to the writer's position on what should happen to the dam, as in whether they supported rebuilding the dam ("rebuilders") or removing the dam ("removers"), or whether they were neutral or undecided. The interviews were then coded inductively in RQDA (Huang 2014), a computer-aided qualitative data analysis package, to first identify the participants' reasoning for their chosen position on the dam's future (Van Gorp 2007, Saldana 2009). The themes that emerged from the data were coded, and the codes were entered into a codebook with a description of the theme and an example (Appendix 1). The codebook was revised and data were recoded in an iterative process to accommodate new data and to minimize overlap between codes (Thomas 2006).

Because most of the themes that emerged for why participants chose their position were related to ecosystem services, we then continued with a more precise inductive coding process to identify the ecosystem services that the participants benefited from. The inductive process allowed the participants' own perceptions of the benefits they derived from ecosystems to emerge from the data, and therefore avoided the analysis being restricted by prior theories or frameworks (Jacobs and Buijs 2011). Codes of ecosystem services were again entered into a codebook with a definition and examples (Appendix 1), and the codes and codebook were revised iteratively to ensure a good explanation of the data and consistency between participants and within codes. We then compared the inductively derived ecosystem services to the categories defined in the Millennium Ecosystem Assessment ([MEA] 2005) to allow us to compare categories of ecosystem services between participants. Lastly, we counted the number of participants in each category (rebuilders, removers, and neutral/undecided) that benefited from each service. We determined that a participant benefited from a service if they described using or valuing it, would regret its loss, or relied on it for their business (such as camping).

To determine participants' perceptions of how the benefits they derived from ecosystems might change if the dam were removed, we constructed a table with a row for each participant and a column for each ecosystem service (Miles et al. 2013). The columns for each service were subdivided into a subcolumn for the river's current state (assumed to be the same as post-rebuild) and for its state post-removal. For each participant, we entered their perceptions of the service currently and their predictions of how it would change post-removal, and then color coded each cell of the table to show predicted losses, predicted gains, and neutral change. The findings were summarized according to the rebuilders' consensus and the removers' consensus on losses and gains in services post-removal.

Lastly, we identified the frames that interviewees used to justify the position. To do this, we first constructed a table with a row for each participant and a column for how they defined the problem and how they defined the solution. We chose this format because many framing effects are in people's understanding of a problem and its causes, which leads them to different solutions (Bardwell 1991, Asah et al. 2012*b*). We entered data in the form of quotes that represented the participants' perceptions. After comparing responses between participants, we then grouped them according to their definitions of the problem (Miles et al. 2013). This was an iterative process of sorting, rechecking the raw data, and resorting until the data within a category were consistent across the participants and documents and were different from other categories. Once we were confident that the frame categories explained participants' perceptions of the problem, we constructed diagrams of participants' expected consequences of removal, and whether they were positive or negative, to ensure that the problem frames and the solution frames were linked. Lastly, we coded the documents collected and summarized their themes, use of ecosystem services, and frames to confirm the findings derived from the interviews (Miles et al. 2013).

RESULTS

Throughout this section, we explain the differences between the 18 participants who supported retaining the dam in some form (hereafter referred to as "the retainers"), the six who supported removal of the dam ("the removers"), and the six who were neutral or undecided in order to show how ecosystem service use and frames of the issue contributed to disagreement between the three groups. Both groups included participants who represented organizations with a variety of main interests, and most included participants who were based upstream and downstream of the dam (Table 1). In addition, many of the individual participants also had several other interests in addition to their organization's main one, through being involved with other organizations as an employee, volunteer, or business owner, and by carrying out different activities in the area. The perspectives expressed in documents, including blogs, letters to the editor, editorials, and online comments, reflected these points of view. Direct quotes from the interviews, with identifying details removed, are used to

Table 1. Interests and locations of the three groups.

	Resident	Industry	Business	Environmental group	Municipality	Heritage group	Watershed group	Recreation	Upstream	Downstream
Retainers	X		X	X	X	X		X	X	X
Removers	X		X	X			X	X	X	X
Undecided or neutral	X		X	X	X	X	X			X

illustrate the points, and are labeled with the participant's unique identifying number (e.g., Participant 01).

The three groups talked about the decision on the dam differently, with different themes and issues being more important for each (Fig. 2). For example, while the words "think" and "know", and the words "people" and "dam" were very common for all groups, "salmon" was particularly common among the removers, and "river" was more frequently used by those who were neutral/undecided. The following sections expand on these differences.

Ecosystem service use

As expected, all participants who spoke from their personal perspectives (either instead of or in addition to their organizational/employers' perspectives), including all of the removers and the retainers, used or benefited from ecosystem services in some way, as did the writers of most of the documents analyzed. We refer here to the participants' recognized benefits from ecosystem services, meaning that the participant undertook activities that directly relied on an ecosystem service (e.g., recreational activities) or considered a service to be of general benefit, whether directly or indirectly (e.g., nonuse values). Many more individuals also commented on others' use of services and ability to access them. In addition, some who also spoke from their organizational/employers' perspectives mentioned ecosystem services that their activities relied on.

Services in all of the categories of the MEA (2005) were used, namely provisioning services (food provision, water supply, hydropower), regulating (disease regulation, water filtration, pollution dilution, flood regulation), cultural (aesthetics, bequest value [i.e., the value of leaving the ecosystem for future generations to enjoy], all types of recreation, movement/access, nonuse, place attachment, relaxation, social connections), and supporting (soil fertility). Cultural services were the most commonly used (Fig. 3).

Most of these ecosystem services (Fig. 3) were recognized as benefits by both retainers and removers. The exceptions were disease regulation and wildlife watching, which were recognized only by retainers, and bequest values, food provision, and water filtration, which were recognized only by removers.

Both retainers and removers most frequently recognized aesthetic appreciation and nonuse value (i.e., the intrinsic value of the ecosystem or species) as personally important (Fig. 3), but the groups interpreted these categories quite differently. Those retainers who valued the headpond's aesthetics liked open spaces, big views, bays, and forested slopes down to the water. Two of these participants described it as a unique example of a lake that is different from other lakes in New Brunswick: "The Mactaquac Dam has created a fantastic body of water that is a jewel of its own magnitude and significance in New Brunswick" (Participant 25). However, most retainers focused on what they thought the area would look like following removal, which they overwhelmingly described in negative terms, focusing on the mud, silt, debris, and bare hillsides that they expected to see: "That is going to be 90 feet of mud. Bare rock and mud. Because there's no vegetation, obviously there's nothing left" (Participant 23). By contrast, while the removers may have described the headpond as "pretty" or "beautiful", they tended to prefer the aesthetics of a flowing river, focusing on flowing water, intervales (low-lying land along the river), and "myriad channels" (Participant 15). They did not comment on any negative aesthetics that might arise after removal.

The majority of both groups also expressed concern for the intrinsic value of ecosystems or nature, regardless of how they personally benefited from them; i.e., nonuse values. Among the retainers, some suggested that removing the dam would destroy the ecosystem that has developed since the dam was built. Others had similar ideas but focused on specific species rather than the ecosystem in general, including fish, waterfowl, and other animals. Some who focused on specific species talked about loss of habitat and the destruction they thought would be caused by the draining process itself: "At the time [the dam was being removed], there would just be total devastation I think. Loss of life. Because they would be swept away" (Participant 19). The removers were more mixed but generally focused on the benefits removal would bring for the whole river ecosystem, namely improved biodiversity and populations of migratory fish, including Atlantic salmon: "Anadromous species that come and go out of salt and freshwater are sea-run brook trout, Atlantic salmon, maybe to a certain extent sturgeon, shad. So to me that would be a wonderful thing to at least create the opportunity where that could again, potentially at least, recover" (Participant 15). Therefore, the retainers and removers had a different view of the ecosystem or nature that they valued.

Overall, both ecosystems and the services they provide were very important to all retainers and removers but were either not used or not discussed by those who were neutral or undecided, who also focused on speaking from their organizations' perspective.

Effect of removal on ecosystem services

Retainers and removers differed substantially in how they expected the benefits they recognized from ecosystem services to change following removal of the dam. Most retainers expected that they would lose the use of ecosystem services after removal, while the removers generally expected gains in most services, although their situation was less clear-cut (Table 2).

Fig. 2. One hundred most frequently used words in the processed data for (a) the retainers, (b) the removers, and (c) those who were neutral/undecided. Words are sized and colored according to frequency. (Produced using text mining and word cloud packages in R.)

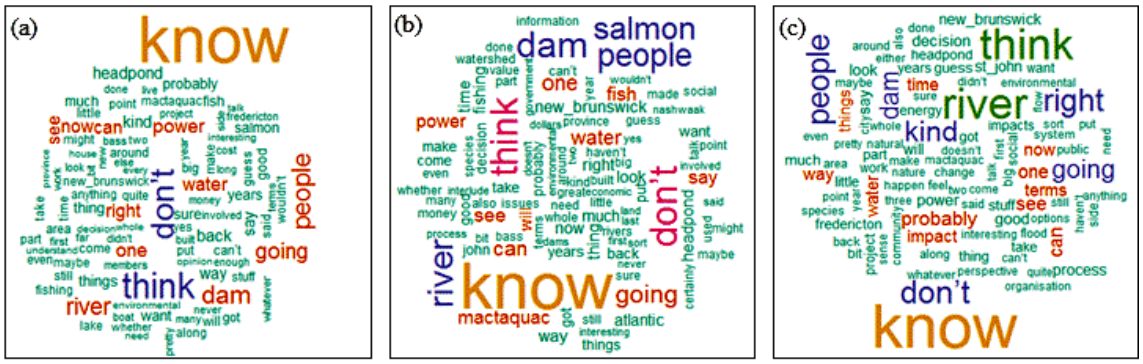


Table 2. Anticipated losses and gains in ecosystem services post dam removal. Empty cells represent services for which participants did not discuss whether it would be lost or gained following removal.

Service type (MEA 2005)	Service	Retainers	Removers
Provisioning	Food provision		Gain
	Water supply	Loss	
	Hydropower	Loss	Not a loss
Regulating	Disease regulation	Loss	
	Water filtration		Gain
	Pollution dilution	Loss	Gain
	Flood regulation (natural)		
Cultural	Aesthetic value	Loss	Gain
	Bequest value		Gain
	Boating	Loss	Unclear
	Camping		
	Fishing	Loss	Gain
	Wildlife watching	Loss	
	Recreation—other		
	Movement/access	Loss	Gain
	Nonuse value	Loss	Gain
	Place attachment	Loss	Gain
	Relaxation	Loss	
	Social connections	Loss	Unclear
Supporting	Soil fertility	Not a gain	Gain

Many of these anticipated changes were directly related to perceived changes in water depth, volume, and surface area if the headpond were converted to its original river morphology, which explained many of the differences between retainers and removers. Fishing and boating are the key illustrations of this point. Retainers were more likely to fish smallmouth bass and muskellunge in the headpond, species which retainers thought required large volumes of water to support adequate populations. In addition, these species are fished from large boats, for which retainers thought the river would not be deep enough following removal: "When it went back to its normal level, there wouldn't be enough depth of water in the majority of the river within a mile of each side of [town] to support the boats…. You'd be dragging bottom" (Participant 01). Similarly, one participant mentioned needing sufficient river width for sailing.

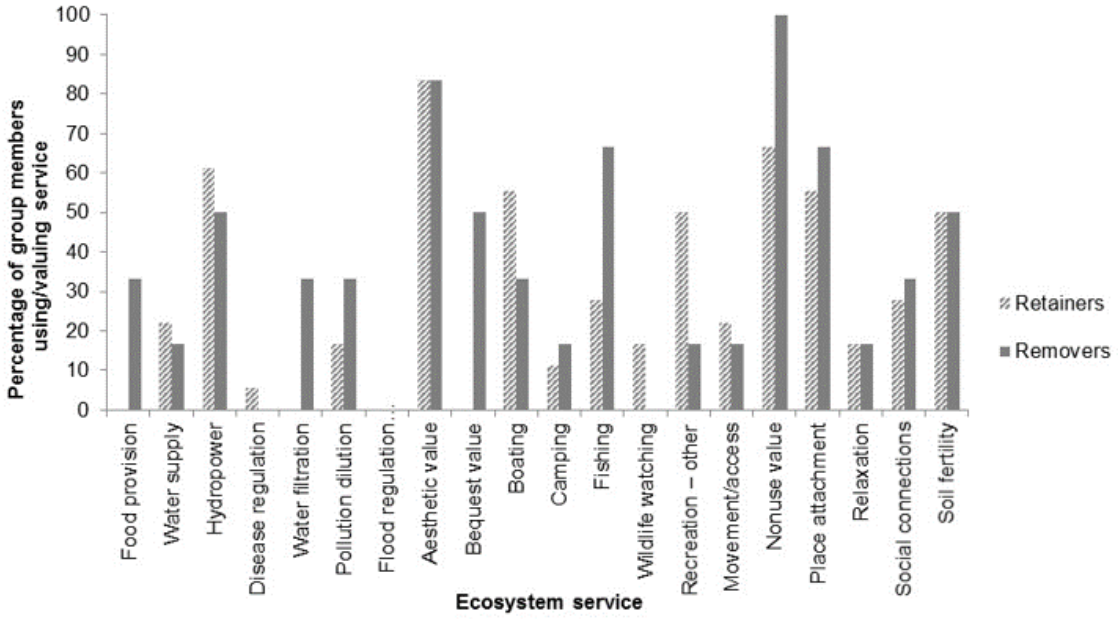
By contrast, removers did not use boats that require deep water; instead, some of them preferred canoes and kayaks, which can be used even in relatively shallow water. Furthermore, if they fished, they fished salmon, brook trout, or other species in other rivers, tributaries of the Saint John River, or upstream of the headpond: "We just came back from the Restigouche [River]. Atlantic salmon fishing" (Participant 30). There was one exception to this dichotomy: one of the retainers also fished Atlantic salmon on other New Brunswick rivers but did not see any gain for their fishing in removing the dam. This was primarily because they did not think that removal would restore the salmon populations in the Saint John River.

Framing the decision

In this section, we discuss how the participants framed the decision (i.e., the problem) more generally in terms of how they perceived the problem, its causes, and the consequences of removal as a solution.

Most of the removers were less attached to their position than were the retainers. For example, three removers would prefer the dam to be removed but would change their mind if the dam were shown to reduce downstream flood risk, if the electricity produced was needed for the province, or if an objective and thorough assessment of the costs and benefits found that rebuilding the dam would be the better option: "If the dam helps control that [flooding], then I guess I would rethink my position on the dam. If it doesn't make a difference one way or the other, then my preference would be to see it gone" (Participant 21). None of the retainers, by contrast, presented any circumstances in which they would change their mind, and presented rebuilding the dam as the only real option: "I definitely feel it should stay…. It's not logical to take it down" (Participant 19). The document writers who preferred removal were generally more strongly attached to their position than were the interviewees, which is unsurprising for people who are willing to argue for their viewpoint in letters to the editor or blogs.

Fig. 3. Ecosystem services used by interviewees grouped according to Millennium Ecosystem Assessment (2005) classification.



We identified four main frames that explain how participants view the problem and how that perception supports their different opinions on the future of the dam and how strongly they hold those opinions. The main frames were (A) social and economic stability should be prioritized, (B) the current ecosystem should not be disrupted, and (C) this is an opportunity that should be taken. In addition, the six neutral or undecided participants were waiting for more information on the three options before they made their decision (frame D). The participants were waiting for this information either to inform their own position or as the basis for the decision-makers to choose an option for the dam's future.

The frames explain how the participants interpreted the current problem differently, both in terms of the state of the river ecosystem and the social and economic context in which the decision takes place. The frames also therefore explain participants' different perceptions of the consequences of removal and their different preferred solutions (Table 3).

Frame A: Social and economic stability should be prioritized

This frame argues that the current configuration of the river, particularly the headpond, is needed for all social and economic activity in the area. This perspective therefore not only contributes to the rebuilders' view that there is no problem with the current situation, but that dam removal would create a considerably worse situation socially and economically. In doing so, the participants using this frame did not see any relevant benefits of an undammed river: "All you've done is just put it back to a river, and a river has no benefit really to anybody other than fishing from shore" (Participant 01). They also tended to refer to removal as a substantial disruption: "I think from a social, economic point of view, we'd be creating a disaster similar to what happened in the 60s when they created the headpond" (Participant 05). This may suggest that the underlying reason for arguing to maintain stability is an unwillingness to again go through the upheaval and distress that occurred when the dam was built.

More specifically, the central idea of this frame is that the tourism industry, a major industrial employer, and the population in the area, vital both for community and tax revenues, are dependent on the current conditions in the headpond area. Without those conditions, there would be significant disruption to the area: "Without the draws that are beside the dam—the tourism, the park, the camping, the lodges and small businesses that have grown up because of the accessibility…This whole area in the dam area would be devastated without the water being there" (Participant 08). For these participants, these economic activities maintain the local population: "Come 65 [when the industry was established], if you look at the yearbook, everybody stayed and got jobs. So the growth of the communities, rural communities, is very much tied to that. I'm not sure how long [the industry]'s going to be around to begin with, but that certainly would be death to those communities" (Participant 04).

Similarly, participants using this frame generally considered that hydropower production from the dam is the best option for producing energy. Again, much of the reasoning for this relates to the perceived stability of the dam's energy production. For example, by producing hydropower, there is no need to be subject to other provinces changing the price of imported power, it produces revenue to support the province, and other energy sources in the province can be unreliable: "If they take it out, we've got to get that power from somewhere else and people don't think there's a real good option for producing power" (Participant 26).

Table 3. Differences in framing the current state, the problem, and possible solutions between retainers and removers.

Element of framing	Retainers	Removers
What is the problem?	There is no problem—the current river configuration is the best possible state.	There is a problem—the current river configuration could be better.
What is the solution?	Keep the river configuration as it is (retain the dam).	Improve the river configuration (remove the dam).
What has the presence of the dam done?	It created good social and economic conditions that now need the dam (frame A).	It worsened the ecological, social, and economic conditions.
What is the current condition of the ecosystem?	It is in a good state and any problems cannot be fixed. It should be protected (frame B).	The ecosystem could be better.
What would removal do?	It would create a social and economic disaster. It would reduce species populations and not create any ecological benefits.	It would create the possibility of improving the ecological, social, and economic conditions (frame C).

Frame B: The current ecosystem should not be disrupted

This frame argues that the headpond is in good condition ecologically and therefore should not be disrupted by removing the dam. It does not argue that the headpond is needed, in contrast to frame A, but that it would be better to protect the current state of the ecosystem. Therefore, participants using this frame argued that the current good state of the ecosystem is because of the dam's presence creating the headpond, not in spite of it. The main justification for this is that the participants have observed large populations of fish and other wildlife in and around the headpond, and see the surrounding vegetation as being in good condition. For example, one participant talked about how the eagle population in the area had recovered in recent years: "So that's I think a great example of an improved ecosystem. And I don't think it would be there if we went back to the sludge" (Participant 05).

This frame also assumes that removing the dam would constitute a significant disruption to the headpond ecosystem. For these participants, the damage would occur in two major ways: the short-term disturbance during drainage of the headpond, and the loss of habitat, primarily due to reduced water volume and depth, following dam removal. For example, one participant described the effect of draining the headpond on fish: "It's a huge ecosystem and if they…compact it down to almost nothing, there's just not going to be room for all the fish that there are now" (Participant 22). Therefore, this frame dismisses the possibility of any ecological adaptation post-removal, either in terms of populations and habitats re-establishing or through carrying out restoration activities: "The old ecosystem is gone forever. You can't put it back to the way it was 60 years ago" (Participant 23).

Although most participants using this frame acknowledged the decline of salmon in the river, they either blamed the problem on other parts of the system, such as at-sea predation, or accepted that the dam was somewhat responsible for the decline, but they did not think removing it would improve the situation: "Salmon are gone. They're not coming back to the Saint John River ever" (Participant 22). In this way, their perception of the ecosystem as being in good condition was maintained by removing the possibility that it could be better, for salmon specifically.

Frame C: An opportunity that should be taken

Removers mostly framed the current situation as one that could be improved ecologically, socially, and economically by removing the dam. For them, there was no element of need (in contrast to frame A) but rather an opportunity that should be taken to make all those elements better. This frame is therefore based on the assumption that the positive economic, social, and/or ecological conditions arising from restoring river flow and its natural characteristics would outweigh the negative effects from draining the headpond. The key elements that participants using this frame thought would be improved included populations of salmon and other migratory fish; tourism and other economic activities, primarily due to the enhanced salmon run; farmland; aesthetics; and sustainability: "What an opportunity, an unprecedented opportunity to bring something back that's beautiful" (Participant 15). As part of this, the participants also assumed that the period of disturbance to the system would be relatively short compared to the duration of the benefits: "The currents would I think bring the river back, in my view, to a state much like it was before in a very short period of time" (Participant 15). Two of the removers mentioned that removing the dam would likely be beneficial for the local Maliseet First Nations.

At a general level, this frame assumes that the positive elements of the area before the dam was built could be re-created, particularly that the salmon would be restored and that the dewatered land following removal would have value either as farmland or for local landowners. More specifically, it assumes that the dam and the headpond are a major cause of declining salmon numbers and that despite other causes, such as at-sea predation, removing the dam offers the potential to restore numbers: "[There's a] salmon pool out here that used to be famous for salmon fishing. Wiped out. Gone. Now, whether you blame it on the dam…Certainly I do" (Participant 21). It also assumes that salmon fishing will attract significant numbers of tourists to the area to support economic activity: "If you could open up the Saint John River system to salmon fishing like it was in the 80s, it would be worth by now 15 million dollars a year to local communities up there of people angling for salmon" (Participant 29).

The participants using this frame acknowledged the current economic, ecological, and social value of the headpond and dam but minimized its importance relative to the opportunities in removal: "You don't want to see people lose money, particularly on their real estate investments, but…they're decommissioning dams that weren't a very good idea at all" (Participant 18). They also dismissed hydropower as an environmentally friendly energy source, compared to those holding frame A, for whom it was

important: "Mactaquac Dam does not generate green energy. It's renewable energy but it is not green energy. Because of the environmental impacts associated with that dam" (Participant 29). Energy efficiency and other renewable sources were offered as alternatives.

Frame D: More information needed

This frame was held by the participants who were neutral or who had not yet decided. Most of them had no strong personal interests in the area, and many worked for organizations that had organizational requirements for remaining somewhat neutral. Despite this, the participants using this frame all thought that more information should be sought before making a final decision on the future of the dam.

The frame was characterized by participants who either had no strong opinion of the three options, found negative impacts in all options, or thought that all had some positive outcomes: "I think all of the options have something that I can get behind" (Participant 10). For this participant, rebuilding the dam had the advantage of producing power from nonfossil fuel sources, retaining the headpond preserved recreational opportunities, and removing the dam allowed for restoration of the river. Others focused on the economic advantages and disadvantages of each option. Therefore, the participants did not generally have a preconception about which option was better, but rather most of them viewed each option as having a combination of negative and positive outcomes, and many viewed the negative impacts as being possible to mitigate: "We would want to look at is there a way of rehabilitating that natural flow or managing the dam flow in a better way" (Participant 24). Participant 27 was somewhat of an exception to this in having particular concerns about removing the dam, but thought that more information was still needed before making a final decision.

Because of this lack of prior opinion about which option would be better, the participants wanted particular types of information that could differentiate between the three options. They varied on the types of information that would be needed. Two participants wanted information on the economics of the three options because for them, that should be the basis of the decision: "The math of it makes the most sense to me" (Participant 20). Two particularly thought that the decision should be based on scientific information on ecological impacts, including the results of environmental studies that were ongoing at the time of the interview. One interviewee was most concerned with social impacts and ensuring that affected residents would have sufficient opportunity to participate, and the final participant wanted general information on the best choice from the decision-maker. Therefore, they all wanted relatively objective information on specific impacts of each option in order to choose the most appropriate one, which could then be combined with actions to mitigate its negative effects, if needed.

Other frames

As previously mentioned, two participants used slightly different frames of the issue in addition to one of the main frames. One of the retainers (Participant 11) used primarily frame B (the current ecosystem should not be disrupted frame). However, they also framed removal as presenting an opportunity, but in a different way to those removers who used frame C (an opportunity that should be taken frame). Instead, this retainer saw it as an opportunity to look forward and to reimagine environmentally friendly communities and restore ecosystems rather than seeing it as an opportunity to recreate the past: "So if you look at what the river could be, model communities, restoration, case study for the rest of the world to look at" (Participant 11). In addition, they thought that other options for generating hydropower were possible, other than using the dam and headpond.

One of the removers also used the opportunity to fix past mistakes frame (frame C), but mostly needed convincing that rebuilding the dam would be a good idea. They were concerned primarily that in rebuilding the dam, the mistakes of the past, particularly using the wrong materials in the dam, would be repeated.

DISCUSSION

Ecosystem service use and decisions on retaining or removing dams

As expected, given the participant selection process, all of the participants who spoke from their personal perspectives (the retainers and the removers) recognized benefits from ecosystem services and considered that ecosystem services underlay many economic activities in the study area. The ecosystem services that they benefited from currently and their perceptions of future benefits mostly reflected the findings of other studies that have assessed changes in ecosystem services post-dam removal. For example, such studies found that people who opposed removal valued recreation on reservoirs, especially boating and fishing, were concerned about local property values, and supported hydropower (Born et al. 1998, Lejon et al. 2009, Auerbach et al. 2014). In disagreement with these studies, nonuse or intrinsic values for the ecosystem and for particular species appeared to be more important for both retainers and removers in this study. While both Born et al. (1998) and Jorgensen and Renöfält (2012) found that loss of wildlife habitat or particular species was mentioned by those who opposed dam removals, they were of much greater concern in this study. However, Fox et al. (2016) also noted that opposition to dam removals in New England focused on the value of the ecosystems created by dams. The reason for these differences is unclear—it could be related to context, such as the type of dam and the associated landscape changes, or to social uses of the area.

The finding that retainers and removers used the same types of ecosystem services in different ways contradicted Jorgensen and Renöfält's (2012) finding that supporters and opposers of dam removals used different types of services. Some of the differences in how the same types of services were used can be explained by location. The retainers were more likely to be located near the headpond, so were more likely to use ecosystem services in ways that required large, deep bodies of water. They also may have had greater first-hand experience of the wildlife in the headpond, and therefore may have been motivated to protect it (Hein et al. 2006). The differences in perception of nonuse or intrinsic value could be related to participants having different types of knowledge about the environment and therefore interpreting ecosystems differently (Fox et al. 2016).

Overall, although the finding on nonuse values requires further investigation, it challenges the conventional wisdom that those opposing ecological restoration projects such as dam removal do not value ecosystems (Tallis et al. 2008, Redford and Adams

2009). Instead, it may be the case that such people have a different perception of which ecosystem should be protected or restored (Fox et al. 2016). This suggests that the parties agree on one of the motives that should drive the decision—namely ecosystem protection—but not on what action should be taken to achieve that (Emery et al. 2013). Similarly, the results indicate that restoring an ecosystem to its natural state will not automatically increase access to ecosystem services for everybody, and may indeed reduce access for some. This reinforces the point made in the literature on cultural ecosystem services that individuals benefit from ecosystem services differently (Fish 2011, Martín-López et al. 2012, Milcu et al. 2013). Therefore, it is important for decision-makers to consider not only the biophysical provision of ecosystem services, but also how access for users will change and how trade-offs in services may produce conflict (Bullock et al. 2011, Kari and Korhonen-Kurki 2013, Kovács et al. 2014).

Lastly, the decision on the future of the dam would also change the area's economy, communities, and culture, which, according to many of the participants, are supported by ecosystem services. This may partially explain the high importance of ecosystem services to the participants—in areas where social and ecological systems are closely related, value given to ecosystem services is high (Casado-Arzuaga et al. 2013).

Framing the problem

The frames used by retainers and removers show a clear link to ecosystem services. For example, frame A (social and economic stability should be prioritized) follows from the retainers' assumption that their access to ecosystem services will decline by assuming that others, including tourists and residents, will be equally affected. In doing so, they focus on how they personally benefit from services, while minimizing any other benefits that may also be valuable socially and economically. Frame C similarly links social and economic benefits with how removers, in general, personally use ecosystem services; i.e., fishing for migratory species like Atlantic salmon. By contrast, those who used frame C tended to acknowledge the ways others use services.

Therefore, we argue that use of ecosystem services contributes to how people frame dam removal, which in turn informs their attitudes toward it. Ecosystem services describe people's interactions with the affected ecosystem, which are then a source of the knowledge and experiences that are sources of frames (Lewicki 2003, Dewulf et al. 2009, Jacobs and Buijs 2011). There is overlap between our categorization of ecosystem services and Jacobs and Buijs' (2011) model of place meanings being a source of frames of river restoration. For example, their "functionality" category of place meanings corresponds to some of the recreational services that we identified, as well as potentially other uses of the river, such as hydropower. This convergence suggests that these ways of interacting with ecosystems are indeed a source of frames of dam removals and river restoration more generally (Buijs 2009, Jacobs and Buijs 2011, Jorgensen and Renöfält 2012).

The frames of the decision reflect the tenets of prospect theory that were previously discussed; i.e., that people frame a change as a loss or a gain depending on their reference point (Tversky and Kahneman 1981, Kahneman 1992, Lewicki 2003). The retainers emphasized the importance of the status quo, and in doing so highlighted what would be lost if the area were changed by removing the dam. Conversely, the removers perceived fewer advantages of the status quo, and therefore focused on what would be gained. This suggests that the two groups' reference points were different based on their interpretation of the current state, particularly whether it was positive or negative. This is similar to a conflict around the restoration of a river flowing into Lake Erie. Local residents perceived the environmental quality of the river to be good, while experts deemed it to be degraded. Attempts to improve the river's water quality faced opposition from residents who framed the interventions as creating only losses for them through increased costs rather than as improving the quality of the river (Kaufman and Momen 2003). Furthermore, the retainers, who framed removal as a loss for the social, economic, and ecological conditions of the area, as well as for their own use of ecosystem services, adhered much more strongly to their positions than removers who framed it as a gain. This reflects, and may be explained by, the loss aversion component of prospect theory—people are less willing to experience a potential loss than to give up a potential gain (Kahneman and Tversky 1979, Brewer and Kramer 1986, Levin et al. 1998). Similarly, the removers were more willing to give up any improvements that they would get from removal, if removal would also result in losses, such as in the province's ability to meet its energy needs or in flood control.

Using frame theory allowed us to reveal the assumptions and biases that contributed to perceptions of losses and gains (Lewicki 2003, Shmueli et al. 2006, Dewulf et al. 2009). For example, frame A (social and economic stability should be prioritized) assumes that the change in biophysical conditions would negatively affect the activities that small businesses in the tourism industry rely on. Similarly, frame C assumes that restoring salmon populations would deliver economic benefits. Uncovering these assumptions means that impact assessments of such decisions can focus on testing their validity, such as how many tourists would be deterred from visiting the undammed river and how many would be attracted. It also means that education campaigns can target faulty assumptions or incorrect knowledge, such as ecological responses to removal (Hart et al. 2002).

By analyzing how each group made sense of the decision, we were also able to determine their ultimate goal for the decision by analyzing what was most important to people when they discussed their reasoning for their position (Putnam et al. 2003). Specifically, retainers aimed for stability, while removers aimed for trying to improve the status quo by taking opportunities. The former position is particularly interesting since many of the interviewees had not experienced the construction of the dam personally but still wanted to avoid a similar disruption (Keilty et al. 2016). Understanding these ultimate goals can then help inform practical mitigation measures that can attempt to balance the need for stability with the need for improvement and opportunity-taking (Asah et al. 2012*a*). The suggestions of the participants in the neutral/undecided group would be particularly useful here. For example, to mitigate the ecological effects of a rebuilt dam, a fish ladder should be installed and regulations should be introduced to ensure that releases from the dam are closer to the natural flow regime. If the dam were removed, proactive, science-led restoration measures should be taken, such as vegetation planting. Similarly, incentives to improve energy efficiency or for local power generation, such as residential solar panels, should be put in place.

These mitigating actions are therefore a potential strategy for conflict resolution, which is one of the primary aims of understanding frames (Putnam et al. 2003, Shmueli et al. 2006). Another common strategy is to identify either points of convergence between frames or to induce parties to change the frames they use (Putnam et al. 2003, Asah et al. 2012*a*, Emery et al. 2013). In this case, the agreement between groups on the nonuse values of ecosystems could form the basis of collaborative actions to address environmental problems more generally. Such collaborative processes can help disputants change their view of the other party and prevent the conflict from escalating (Lewicki 2003, Putnam et al. 2003, Shmueli et al. 2014). Similarly, points of convergence, such as the need for environmentally friendly power generation, could be a driver for developing alternative or hybrid solutions to meet common needs. One participant suggested that hydropower generated from a free-flowing river could be one such solution.

Lastly, we found that the frames used depended on a person's position on the dam's future but were not affected by interest groups as broadly defined in Table 2 (Brummans et al. 2008). This suggests that for interest to be a reliable proxy for a person's frame, the categories of interest must be sufficiently narrowly defined, and potentially combined with location (in this case, upstream or downstream of the dam).

CONCLUSIONS

This study revealed the frames of a decision about whether to retain or remove a dam coming to the end of its life and how those frames linked to stakeholders' use of ecosystem services. We found extensive use of ecosystem services among study participants, with those who preferred to retain the dam and those who preferred to remove it using the same types of ecosystem services in very different ways. Retainers generally thought they would lose their benefits from ecosystem services if the dam were removed, while removers thought they would gain in services. As the retainers adhered more strongly to their position, these findings support the loss-aversion tenet of prospect theory. We found that the uses of ecosystem services then informed their frames of the decision. Retainers wanted to avoid losses by prioritizing social and economic stability, and arguing for protection of the current ecosystem. Removers used services that they thought would benefit from removing the dam, and therefore argued that removal was an opportunity that should be taken. Therefore, ecosystem service use appears to be a relevant source of frames of dam removals, and potentially other river restoration activities. Using frame theory to explore stakeholders' opinions about the dam's future allowed their assumptions, biases, and the issues they focused on and excluded to be revealed. This information is useful for informing impact assessments, education campaigns, and conflict resolution for such decisions.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/9045

Acknowledgments:

We thank the Social Sciences and Humanities Research Council of Canada for funding this project through a grant held by Jan Adamowski. We are sincerely grateful to all interviewees for their time and willingness to participate in the research, as well as several colleagues who assisted with reviewing and proofreading the manuscript.

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Appendix 1. Codebook for ecosystem services.

Code	Description	Example quote
Aesthetic value	Appreciation of aesthetics of place - both visual aesthetics and smell. Positive general descriptions of aesthetics ('pretty', 'beautiful'), photogenic places, good views, and factors that contribute to positive aesthetics (running water, open spaces, etc.). Aesthetics given as a reason for people to visit the area and stay there.	'Oh it's such a beautiful spot. Like, it's amazing.'
Bequest value	Ecosystem valued for the long-term future, including both specific ecosystem components and the ecosystem in general.	'Think beyond the four-year term and just think objectively about what's the best decision for the future.'
Boating	Enjoyment of various types of boating (either independently of fishing or for fishing), including the infrastructure needed for boating (marinas, etc.).	'I use the water there every day almost. I took my son out for a boat drive last night.'
Camping	Camping near the river.	'I think people like the fact that it's a province that has a lot of open areas, so for camping... And you can camp by the river.'
Disease regulation	Likelihood of disease transmission, such as disease risk from mosquitoes, affected by ecosystem characteristics.	'There would be mosquitoes and disease [if it were removed].'
Fishing	Recreational fishing of any type, including the infrastructure needed for fishing (marinas used for tournaments, etc.).	'The fishing in the Mactaquac headpond is superb. It's equal to any large lake in Ontario.'
Flood regulation	Flood regulation from ecosystem processes. Role of the dam in flood regulation excluded.	'I just know that in other areas you restore a natural river, a river to its natural flow, you will have an impact that is positive on flooding.'

Food provision	Gathering plants and animals for food, including fish and fiddleheads. Fishing purely for recreation excluded.	‘We have unique foods that you can’t find in other areas, like our blueberries, our fiddleheads, our salmon.'
Hydropower	Generating power from running water (viewed positively).	‘It would be a shame to not have a power dam on a river as large as this, creating electricity that’s renewable as long as this river runs.'
Movement/access	Using the ecosystem (standing water) to travel around the area and to get to particular places.	‘The headpond’s backed up past Woodstock, so you can travel a really long ways too.'
Non-use value	Value attributed to components of the ecosystem, including the ecosystem in general and particular species, despite not being directly used, including general support for environmental management or restoration.	‘I like things to be left the way they’re supposed to be. I get concerned when I see our environment manipulated.'
Place attachment	Emotional attachments to specific places, including the factors that led people to move to the area and stay there.	‘The river is important to those of us who live along it, to New Brunswickers and to Canadians.'
Pollution dilution	Dilution of aquatic pollutants, both in terms of the volume of water and the positioning of specific outfalls.	‘And this river is polluted. Can you imagine if there was only a quarter of it?'
Recreation - other	Enjoyment of recreation not otherwise in a category, including swimming and walking.	‘Not for boating but for walks. There’s nice trails along the river obviously.'
Relaxation	Feeling of relaxation from ecosystem components, whether in combination with one of other activities (e.g. fishing) or not.	‘It rocks you to sleep, the feel of the water.'

Social connections	Social connections facilitated by the ecosystem or one of other activities (e.g. fishing)	‘We will go out the odd Saturday and Sunday afternoon if it’s nice and they want to get together.'
Soil fertility	Fertile soil valued for supporting farming or other activities.	‘I suspect that soil and the silt will be very rich in nutrients, and maybe other things.'
Water filtration	Filtration of water through soil, rocks and wetlands to remove pollutants.	‘There is some influence to [the groundwater] from the river. It’s a percentage but it goes through a lot of rock, or a lot of sandstone and sand before it gets to [the] big wells.'
Water supply	River used for public or private water supply.	‘We have a pulp mill [AV Nackawic] that relies heavily on the water level the way it is right now. They have an intake for industrial water.'
Wildlife watching	Enjoyment from watching wildlife.	‘It’s really important in our old age. We enjoy the animals.'