The role of ecosystem services in conflicts over potential dam removal – the case of the Mactaquac Dam, Canada

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ABSTRACT

Dams across North America are coming to the end of their planned lifespans. Changing societal values and needs, safety concerns, and high maintenance costs are causing their removal to be increasingly considered. Both constructing and removing dams significantly change river ecology and hydrology, and therefore also the provision of ecosystem services. Such changes affect stakeholders differently, according to their needs, values and perceptions of ecosystem services. Understanding these differential impacts is important to ensure effective and equitable decision making, and as a basis for understanding and resolving any resulting conflict. The aims of this thesis, therefore, were to identify and analyse the social demand for ecosystem services, and analyse the extent to which social demand for ecosystem services underlies stakeholder conflict and how the concept of ecosystem services can be used for its resolution.

A new conceptual framework was developed that linked ecosystem services to stakeholder responses to a decision-making process from a wider range of angles than has been studied to date. The framework focused on social demand for ecosystem services, as opposed to their biophysical provision or economic valuation, as the aspect most directly relevant to stakeholders and the least studied. Frame theory was used to systematically analyse stakeholders' perceptions of the decision and how differences between them contribute to conflict. The strategic implications of how the decision was framed in terms of scale were explored using theory on the politics of scale. Place meanings were used to explore the emotional dimensions of the conflict. Such theories on stakeholder conflict have not been applied to the unique context of dam removal.

The framework was used to explore the case of the Mactaquac Dam on the Saint John River, New Brunswick, Canada. At the time of study, a decision-making process was ongoing to determine whether to rebuild or remove it, triggered by problems in the dam's structure. Study of dam removals to date has been limited to small dams – as a large dam, this was an important test case for other large dams approaching the end of their life.

A qualitative approach was taken to allow an initial exploration of the full range of ecosystem services demanded and how they relate to conflict. Fifty stakeholders, selected using non-proportional quota sampling, participated across two research phases. They represented a range of interests and were located both up and downstream of the dam. In the first phase, semi-structured interviews were used to explore how stakeholders used the river and their opinions

on the future of the dam. In the second phase, participatory mapping was used to reveal the spatial distribution of ecosystem service demand and place meanings.

Stakeholders demanded a range of ecosystem services in all categories of the Millennium Ecosystem Assessment (2005). Although there were few differences in the services demanded by those who preferred to retain the dam and those who preferred to remove it, there were clear differences in their uses of the same services and their spatial distribution. The combination of interviews and participatory mapping to elicit ecosystem service demand allowed potential conflicts of interest to be revealed in ways that would not have been possible using alternative quantitative approaches. Furthermore, participatory mapping was used for the first time to test whether stakeholders could map ecosystem services under future scenarios. Although few individuals could map the locations of ecosystem service change if the dam were removed, the maps served as useful prompts to uncover perceptions of change and its causes.

Stakeholders' interactions with the river through ecosystem services informed how they framed its current state and the decision-making process. Their frames showed loss aversion, as they were less willing to experience a loss than to give up a potential gain. Those in favour of removal framed the decision using spatial and temporal scales differently to those against, in ways that deemed certain arguments and stakeholders as being relevant to the decision and others irrelevant. The temporal scale was newly revealed as important in scale framing in this context. Stakeholders held numerous intangible place meanings, suggesting a strong connection to specific locations in and around the river, many of which were shared between the two groups and were linked to the biophysical characteristics of the river.

Overall, the study found that a range of ecosystem services were highly important locally and would be affected differently if the dam were removed. Theories of stakeholder conflict revealed that the differing demand for services contributed to conflict development, but also suggested opportunities for its resolution. There was widespread agreement about the importance of ecosystem protection and many shared place meanings. Participatory approaches centred around ecological protection and shared place meanings have the potential to allow stakeholders to be heard, build trust, and potentially resolve conflict.

RESUME

Plusieurs barrages nord-américains touchent à la fin de leur vie opérationnelle prévue. L'évolution des valeurs et besoins sociétaux, des préoccupations de sécurité, ainsi que les coûts de maintenance élevés encourage certains à préconiser le démantèlement de tels barrages. La construction et le démantèlement de barrages modifient à la fois l'écologie et l'hydrologie d'une rivière, et donc la prestation de services écosystémiques. De tels changements affectent chaque intervenant différemment selon ses besoins, valeurs et perceptions des services écosystémiques. Il est donc de mise de comprendre ces différents effets si l'on préconise une prise de décisions efficace et équitable, soutenu par une compréhension et une résolution de tout conflit. Les objectifs de cette thèse furent donc d'identifier et d'analyser la demande sociale pour les services écosystémiques, et d'analyser en quelle mesure cette demande sociale pour les services écosystémiques sous-tend les conflits entre intervenants, et en quelle mesure le concept de service écosystémique peut servir à leur résolution.

Un nouveau cadre conceptuel d'une perspective plus large qu'utilisée auparavant fut développé, liant les services écosystémiques aux réponses des intervenants à un processus de prise de décision. Plutôt que l'apport biophysique ou l'évaluation économique des services écosystémiques, le cadre fut axé sur la demande sociale pour ces services, soit l'aspect le plus directement pertinent pour les intervenants, mais le moins étudié. Une théorie de l'encadrement permit une analyse systématique à la fois des perceptions des intervenants quant à leur décision et de leur contribution au conflit. Une exploration des implications stratégiques du cadrage de la décision au niveau de son échelle se fit dans le contexte des théories de la politique d'échelle. Les mérites donnés aux lieux permirent d'étudier les dimensions émotionnelles du conflit. Les théories de conflits entre intervenants n'ont, jusqu'à présent, jamais été appliquées dans le contexte du démantèlement de barrages.

Ce cadre servit à sonder le cas du barrage Mactaquac sur le fleuve Saint-Jean au Nouveau-Brunswick, Canada. Lors de l'étude, un processus décisionnel, à savoir si le barrage serait rebâti ou démantelé, déclenché par des problèmes structuraux du barrage, était en cours. Jusqu'à présent l'étude du démantèlement des barrages s'est vue limitée aux petits barrages — celui-ci étant un grand barrage, il représenta un important cas type vu le grand nombre de grands barrages approchant la fin de leur vie opérationnelle.

Une approche qualitative offre un survol initial de l'étendue complète des services écosystémiques en demande et de leur rapport au conflit. Sélectionnés par échantillonnage non-

probabiliste par quota, 50 intervenants participèrent aux deux phases de recherche. Issus d'en amont et d'en aval du barrage, ils étaient représentatifs d'un vaste éventail d'intérêts. Dans un premier volet, des entrevues semi-structurées servirent à étudier les utilisations de la rivière des intervenants, ainsi que leurs opinions quant à l'avenir du barrage. Dans un second volet, une cartographie participative servit à révéler la répartition spatiale des demandes en services écosystémiques et les mérites des lieux.

Les intervenants ont exigé une large gamme de services écosystémiques dans toutes les catégories énumérées dans l'Évaluation des écosystèmes pour le millénaire (2005). Quoiqu'il n'y eût que très peu de différences dans les services demandés par ceux voulant garder le barrage et ceux préférant son démantèlement, des différences marquantes existaient entre leurs utilisations de ces services et la répartition spatiale de ceux-ci. La combinaison des entrevues et d'une cartographie participative afin de motiver une demande en services écosystémiques, permit de révéler les conflits d'intérêt éventuels d'une manière qui n'aurait pas été possible avec d'autres démarches quantitatives. L'habileté des intervenants à cartographier les services écosystémiques sous divers scénarios éventuels fut testée ici pour la première fois. Peu d'intervenants s'avéraient capables d'identifier les lieux éventuels des services écosystémiques et pourtant le processus révéla les perceptions du changement potentiel et de ses causes.

Grâce aux informations tirées de leurs interactions avec la rivière par l'entremise des services écosystémiques, les intervenants ont pu encadrer son état présent et le processus de prise de décisions. Ces encadrements ont exposé une aversion aux pertes, c'est-à-dire que ces individus étaient moins disposés à subir une perte que de renoncer à un gain éventuel. Employant différemment les échelles spatio-temporelles pour encadrer leurs décisions, les deux groupes divergèrent dans leur inclusion/exclusion d'arguments — selon une perception de leur validité — dans le processus de prise de décision, et, de plus, considérèrent certains groupes d'individus comme étant non pertinents à la décision. Dans ce contexte, l'échelle temporelle s'avéra importante dans le cadrage de l'échelle. Les intervenants tenaient à plusieurs valeurs intangibles données aux lieux, suggérant un fort lien à certains endroits dans ou près de la rivière, dont plusieurs étaient partagées par les deux groupes.

Globalement, la présente étude démontra qu'un éventail de services écosystémiques était très important à l'échelle locale, et le démantèlement du barrage affecterait la qualité et la nature des services. Des théories de conflits entre intervenants ont souligné à la fois le fait que des demandes de service divergentes contribuèrent au développement du conflit, mais aussi des

possibilités de le régler. L'analyse souligna un large consensus quant à la protection des écosystèmes et révéla les nombreuses valeurs communes aux lieux. Des approches participatives centrées sur la protection écologique et des mérites des lieux en commun peuvent permettre aux intervenants de s'exprimer, d'instaurer la confiance, et de résoudre des conflits.

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FORMAT OF THESIS

The thesis must include the following:

(a) A table of contents;

(b) An abstract in English and French;

(c) An introduction which clearly states the rational and objectives of the research;

(d) A comprehensive review of the literature (in addition to that covered in the introduction to each paper);

(e) A final conclusion and summary;

1. As manuscripts for publication are frequently very concise documents, where appropriate, additional material must be provided (e.g. in appendices) in sufficient detail to allow a clear and precise judgment to be made of the importance and originality of the research reported in the thesis.

2. In general, when co-authored papers are included in a thesis the candidate must have made a substantial contribution to all papers included in the thesis. In addition, the candidate is required to make an explicit statement in the thesis as to who contributed to such work and to what extent. This statement should appear in a single section entitled "Contributions of Authors" as a preface to the thesis. The supervisor must attest to the accuracy of this statement at the doctoral oral defense. Since the task of the examiners is made more difficult in these cases, it is in the candidate's interest to clearly specify the responsibilities of all the authors of the “coauthored papers”.

CONTRIBUTIONS OF AUTHORS

The chapters presented in this thesis were prepared for publication in peer-reviewed journals as well as for presentation at scientific conferences. The author of the thesis was responsible for the conceptual and methodological development of the project, data collection and analysis, and production of manuscripts for publication. Dr Jan Adamowski, the thesis supervisor, provided technical guidance on the development of the project as a whole and of each paper, and was responsible for reviewing and editing the manuscripts. Kimberly John, an MSc student in Integrated Water Resources Management from 2015 – 2016, assisted with data processing and analysis for two papers. She contributed specifically to transcribing and coding interviews, digitising maps, and developing a GIS database.

Publications and presentations related to the thesis

A. Parts of this thesis have been published in peer-reviewed journals as follows:

Reilly, K.H. and Adamowski, J.F., 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.

Reilly K.H. and Adamowski, J.F., 2017. Spatial and temporal scale framing of a decision on the future of the Mactaquac Dam in New Brunswick, Canada. Ecology and Society, 22(3): 21.

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Reilly, K.H., Adamowski, J.F., John, K. The role of place meanings in opposition to water-related infrastructure projects – the case of the Mactaquac Dam, New Brunswick, Canada. Submitted to Ecology and Society.

B. Parts of this thesis have been presented at scientific conferences as follows:

Reilly, K.H. and Adamowski, J.F., 2014. Understanding disputes around environmental flows: The role of ecosystem services. Annual Meeting of the American Society of Agricultural and Biological Engineers/Canadian Society for Bioengineering, Montreal, July 13 – 16, 2014.

Reilly, K.H. and Adamowski, J.F., 2015. Perceptions of environmental flows and ecological restoration: A document analysis. 22nd Canadian Hydrotechnical Conference, Canadian Society of Civil Engineers, Montreal, April 29 – May 2, 2015.

Reilly, K.H. and Adamowski, J.F., 2016. How stakeholders frame dam removal: The role of current and anticipated ecosystem service use. Poster presentation, European Geosciences Union General Assembly, Vienna, April 17 – 22 2016.

Reilly, K.H. and Adamowski, J.F., 2016. Social uses of ecosystem services in the context of dam removal. 69th National Conference of the Canadian Water Resources Association, Montreal, May 25 – 27, 2016.

Reilly, K.H., Adamowski, J.F., John, K., 2017. The spatial distribution of ecosystem services around a dammed river reach and its contribution to conflict over possible removal of the dam. Poster presentation, Canadian Society for Ecological Economics and Economics for the Anthropocene Partnership joint conference, Montreal, October 19 – 22 2017.

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LIST OF ABBREVIATIONS

ATV	All-terrain vehicle
CAD	Canadian dollar
GDP	Gross domestic product
GIS	Geographic information system
IWRM	Integrated water resources management
MA	Millennium Ecosystem Assessment
NB Power	New Brunswick Power
NGO	Non-governmental organisation
OECD	Organisation for Economic Cooperation and Development
RBC	Royal Bank of Canada
WCD	World Commission on Dams

1. INTRODUCTION

1.1. General introduction

Freshwater ecosystems are among the most threatened ecosystems on earth (Millennium Ecosystem Assessment (MA) 2005a, Carpenter et al. 2011). Both freshwater habitat and species are being lost faster than for any other ecosystem type (MA 2005a) and a more recent assessment classified the habitat supported by 65% of global river discharge as being under moderate to high threat from human activities (Vörösmarty et al. 2010). Global climate change and population growth are continuing to exert significant pressures on freshwater ecosystems, as river flow is regulated to generate hydropower, secure water supplies, and reduce water-related disaster risk (Nilsson and Berggren 2000, Vörösmarty 2000, Kingsford 2011).

At the same time, societal awareness of human dependence on ecosystems, and of the consequences of human activity on those ecosystems, has only grown since the MA (2005a) was published. The concept of ecosystem services, broadly defined as the benefits humans receive from ecosystems (MA 2005a), has evolved from being a metaphor used to raise awareness of this dependency (Norgaard 2010) to a tool for incorporating the value of ecosystems into decision making (Daily et al. 2009, de Groot et al. 2010, Guerry et al. 2015). For example, led by guidance from international bodies such as the Organisation for Economic Cooperation and Development (OECD 2008), ecosystem services are increasingly incorporated into environmental impact assessments and other decision making processes. The value of an ecosystem services approach is in assessing the trade-offs within a socio-ecological system and in communicating more effectively with stakeholders (de Groot et al. 2010, Baker et al. 2013).

However, despite widespread recognition of the importance of ecosystems for human wellbeing, and a proliferation of tools to assess ecosystem services and the impacts of decisions, degradation of freshwater ecosystems continues (Tallis et al. 2008, de Groot et al. 2010, Nahlik et al. 2012). There are several reasons for this, including confusion in the definition and conceptualisation of ecosystem services (Nahlik et al. 2012), a focus on monetary valuation that fails to capture all values of ecosystem services (Kumar and Kumar 2008), and gaps in knowledge of how managing for ecosystem services affects biodiversity (Harrison et al. 2014). A more fundamental difficulty in incorporating multiple ecosystem services into decision making is the trade-offs between them (Goldstein et al. 2012, Howe et al. 2014). Any given ecosystem provides multiple services across some or all of the categories of services identified in the MA (2005) – provisioning, regulating, cultural and supporting

services – and decisions that maximise all services are rare (Rodríguez et al. 2006, Bennett et al. 2009). For example, decisions that aim to increase a provisioning service, such as hydropower or water supply, often require trade-offs in provision of regulating and cultural services (Raudsepp-Hearne et al. 2010). Therefore, effective decision making must take account of the value of all ecosystem services and natural capital, and understand its implications in terms of trade-offs (Goldstein et al. 2012).

A further complication in assessing the trade-offs in provision of multiple ecosystem services is their spatial and scale dependence (Hein et al. 2006, de Groot et al. 2010, King et al. 2015). The ecological processes that provide services operate at different scales and levels (Levin 1992). For example, fish feeding occurs in a localised spatial area, whereas fish migration operates on a higher level on the spatial scale (Sayre and Di Vittorio 2009). Furthermore, stakeholders acting at different levels have been found to value the same set of services differently. For example, ecosystem services provided by a wetland in the Netherlands related to fisheries, recreation and reed cutting were of highest value at local level, whereas the services related to nature conservation were of highest value at national level (Hein et al. 2006). Therefore, changes in service provision may cause stakeholders at some levels to lose out to the benefit of those at other levels. This is well illustrated by the case of Owen's Lake near Los Angeles, California. Local farmers were effectively managing the lake to maintain their water supply for irrigation. However, decision-makers at a larger spatial scale decided to withdraw large volumes of water from the river fed by Owen's Lake to supply Los Angeles with drinking water. Eventually, the lake was drained completely (Bates et al. 1993, Blomquist and Schlager 2005). Similarly, the provision and demand of services may be shifted to different locations in space and time, such as preserving services for future generations (Chan et al. 2007).

When incorporating ecosystem services into decision making, it is important to consider not only their biophysical provision and economic value, but also how they are valued socially (Cowling et al. 2008, Bennett et al. 2009, de Groot et al. 2010). Some researchers argue that these factors should not be assessed separately, but rather considered as part of a social-ecological system that explicitly acknowledges the role of social factors in ecosystem service production. For example, land management, including farming and forest management, changes the biophysical production of ecosystem services (Reyers et al. 2013). While the various dimensions of ecosystem services are clearly interlinked, it is helpful to assess their biophysical provision, social demand and economic value separately, to ensure that none are neglected.

Several terms are used to describe how society benefits from ecosystem services (Wolff et al. 2015), including social value, both monetary and non-monetary (Klain and Chan 2012, Kati and Jari 2016), use, consumption, demand (Yahdjian et al. 2015), and benefits (Cowling et al. 2008). Here the terms benefits from and demand for ecosystem services are used interchangeably to refer to the range of ways in which society and individuals are supported by ecosystem services. Both terms incorporate social values, perceptions and needs for ecosystem services.

In a given context of biophysical provision, ecosystem services are demanded and can be accessed very differently between individuals and different groups of people (Fagerholm et al. 2012, Hamann et al. 2015). How these services are perceived and valued can vary between individuals based on their interest(s) (Casado-Arzuaga et al. 2013), level of scientific knowledge/expertise (Lamarque et al. 2011, Martín-López et al. 2012), degree of familiarity with the location (Fagerholm et al. 2012), experiences in the area (Lamarque et al. 2011), and several other factors. (Darvill and Lindo 2014, García-Nieto et al. 2015).

Stakeholders' preferences for a wide range of services also vary according to social and cultural context (Wolff et al. 2015). The direct use of provisioning services is typically more important where nature is highly important spiritually and culturally, and in areas of high poverty and restricted access to market economies (Hamann et al. 2015). Cultural services tend to be valued more in developed economies (Milcu et al. 2013), or in heritage sites and areas protected for nature conservation (Wolff et al. 2015). This variation makes social assessment of ecosystem services challenging and context specific (Cowling et al. 2008). The provision and use of ecosystem services in the context of a dammed river environment particularly deserves further study (Auerbach et al. 2014, Darvill and Lindo 2014, Brummer et al. 2017).

Studying the variation in ecosystem service use between individuals and social groups, including those separated in space and time, is particularly important during decision making that changes the trade-offs in biophysical production and social demand (Chan et al. 2007). When these impacts affect individuals and social groups differently, conflict between them can occur (Chan et al. 2007, Martín-López et al. 2012, King et al. 2015). Conflict is 'the fundamental and underlying incompatibilities that divide parties' (Lewicki 2003 p. 37). These incompatibilities can be objective or perceived and subjective (Bruckmeier 2005), and are based in different interests or uses, needs, priorities and values (Schmidtz 2000, Nie 2003, Sidaway 2005). For example, conflict arose over ecological restoration of the Lower Kishon

River Basin, Israel, despite all parties being supportive of restoration. Governmental authorities prioritised restoration of the river, and their proposal would have transferred pollution to the sea. This was against the needs of fishermen, who would have been negatively affected by the marine pollution, and the priorities of environmentalists who wanted the pollution to be reduced, not displaced (Shmueli 2008). Therefore, conflicts must be analysed at the level of interests, uses, needs, priorities or values, rather than positions, in order to be understood and resolved or managed (Sidaway 2005, Redpath et al. 2013).

There are numerous conceptualisations of the causes of conflicts over decision making for the environment and natural resources, including ecosystem services, and of how the related disputes escalate into intractability (Lewicki 2003, Nie 2003, Brummans et al. 2008). These drivers of conflict can be broadly categorised into the issues at hand, i.e. what is at stake, the decision-making process, and the characteristics of the actors involved and the relationships between them (Nie 2003, Sidaway 2005, Dewulf et al. 2009). In a conflict, there can be any combination of these drivers at play, and what can appear to be a simple conflict over the distribution of resources can incorporate many other dimensions as well (Bruckmeier 2005). Understanding how these various drivers operate in a given conflict is critical for its successful resolution or management (Nie 2003, Redpath et al. 2013).

Here the focus is on the category of what is at stake, to understand the extent to which the incompatibilities dividing stakeholders are based in ecosystem services, which link the biophysical changes at the heart of a decision-making process to social responses. Within this category, there are again numerous theories that describe how incompatibilities in interests, uses, needs, priorities or values around the issue at stake can arise. Frame theory suggests that stakeholders can come to different understandings of the same problem, based on their prior experiences and interests (Lewicki 2003). In particular, prospect theory posits that people cannot make rational choices because they are influenced by biases, risk aversion, and loss aversion in how they frame a decision (Kahneman and Tversky 1979, Schluter et al. 2017). Other researchers highlight the role of emotions in response to threats to deeply-held values (Buijs and Lawrence 2013, Sandström et al. 2013). In environmental conflicts, emotional responses to a decision are often expressed in terms of attachments to places that would be affected by a decision or management change (Williams et al. 1992, Devine-Wright 2009, Buijs and Lawrence 2013).

The role of demand for ecosystem services in driving incompatibilities between stakeholders in decision-making processes is explored here using these various theories. This approach allows understanding of environmental and natural resource conflict, and therefore strategies for managing and resolving it, to be refined. Specifically, the lens of ecosystem services has the potential to allow drivers of conflict to be distinguished based on their relation to biophysical change, which allows conflict resolution strategies to be similarly distinguished. For example, compensating lost biophysical (ecosystem) features elsewhere is unlikely to be successful if the conflict is also being driven by attachments to place. Therefore, this research contributes to the literature on each of the theories used, frame theory, politics of scale, and sense of place, by applying them to a novel context and developing them accordingly. It similarly contributes to the literature on conflicts over ecosystem services by exploring the range of dimensions in which they can arise.

1.2. Introduction to the case

To illustrate how these theories can apply to conflicts over ecosystem services, the case of the Mactaquac Dam, a large hydropower dam on the Saint John River, New Brunswick, Canada, is used. The focus is on a decision-making process regarding whether it should be rebuilt, maintained without hydropower generation, or removed, precipitated by major structural problems (New Brunswick (NB) Power 2016a). The dam is one of the largest ever considered for removal (Stantec 2015). Its owners, NB Power, part-funded a major hydrological and ecological study (Canadian Rivers Institute 2013) to inform a review of the environmental impacts of the three options (Stantec 2015) and monitor the impacts of the chosen option. A much smaller assessment of their social impacts was also funded (Dillon Consulting 2015) following stakeholder feedback on the initial terms of reference for the assessments. The assessments were not driven by regulatory requirements, but were instead intended to inform the decision and facilitate any eventual provincial or federal environmental impact assessment of the selected option (Stantec 2015). A stakeholder consultation process took place following publication of the assessments from September 2015 to May 2016 (NATIONAL and CRA 2016), as well as a separate consultation with Maliseet First Nations.

The dam was constructed in the 1960s to power New Brunswick's economic development and drive regional modernisation (Kenny and Secord 2010). At the time, there was widespread local opposition to its construction, linked to concerns about destruction of natural beauty, impacts on the Atlantic salmon fishery, and loss of settler and aboriginal cultural heritage (Kenny and Secord 2010, Bourgoin 2013). Land owners were particularly concerned about

expropriations of property and valuable fertile farmland to make way for the reservoir upstream of the dam (Si 1993, Kenny and Secord 2010, Bourgoin 2013). Since then, many in the area have adapted to the presence of the reservoir, and value many ecosystem services, particularly recreation, in the area (Keilty et al. 2016), while others lament the hydrological, ecological and social damage caused by the dam.

This case represents both an important and a unique context for this research. Dams, particularly large dams, are widely recognised as one of the major threats to freshwater biodiversity, due to fragmentation of river systems and changes to river flow (Nilsson and Berggren 2000, Vörösmarty 2000, MA 2005b, Poff and Zimmerman 2010), but provide very useful functions for human society (World Commission on Dams (WCD) 2000). The growing recognition of the value of that biodiversity and of the ecosystem services that free flowing rivers provide has triggered increasing interest in removing non-functional or unsafe dams (Brismar 2002, Hart et al. 2002, Auerbach et al. 2014, O'Connor et al. 2015).

For effective decision-making on the future of such dams, a thorough ecosystem services assessment of the status quo and how that would be anticipated to change on removal is needed (Brismar 2002, Brummer et al. 2017). Social demand for ecosystem services in dammed river environments are the subject of a small body of literature (Auerbach et al. 2014, Darvill and Lindo 2014, Fox et al. 2016, Brummer et al. 2017), but a greater understanding of how these benefits vary between stakeholders is needed. Furthermore, the majority of dams removed to date are small (Fox et al. 2017), and how removal of large dams affects the social benefits from ecosystem services deserves further study.

The dams that have been considered for removal to date are often the source of considerable social conflict (Fox et al. 2016, 2017). Recent studies have identified several dimensions to these conflicts, including concerns about loss of recreational options and cultural heritage, perceptions that removal would leave only large mud flats, fear of reduced property values, and institutional arrangements (Born et al. 1998, Lejon et al. 2009, Jorgensen and Renofalt 2012, Fox et al. 2016, 2017, Brummer et al. 2017). However, the majority of these studies again focus on removals of small dams, of which the effects are of a different order of magnitude than large dams. Thus, understanding the conflict around the Mactaquac Dam provides useful lessons for upcoming decisions on other large hydropower dams, which will be increasingly common in the near future in North America.

By the time of writing this thesis, the decision had been taken to upgrade maintenance and install a fish ladder in order that the Mactaquac Dam could be retained to the end of its planned lifespan in 2068 (NB Power 2016b). The research conducted in the earlier phases of this project contributed to informing the decision maker about stakeholders' concerns, and the later phases can contribute to post-decision conflict management.

1.3. Research aims and objectives

This research draws on literature on ecosystem services and on various theories of stakeholder conflict to analyse how predicted biophysical changes to an ecosystem affect social benefits from ecosystem services and sense of place, and contribute to conflict between stakeholders. It focuses on the ecological and hydrological changes that would be caused by removal of a large dam, which is an emerging issue as more large dams in North America come to the end of their planned lifespans.

The principal aims of this research, therefore, were to:

1. Identify and analyse the social demand for ecosystem services in and around a dammed river environment.
2. Analyse the extent to which social demand for ecosystem services underlies stakeholder conflict and identify how the concept of ecosystem services can be used for its resolution.

To address the aim of the research, several specific objectives were defined to explore its two main components – social demand for ecosystem services and stakeholder conflicts:

1. Social demand for ecosystem services in and around a dammed river environment
    a) To identify the range of ecosystem services from which stakeholders benefit in and around the dammed river, and how they vary between stakeholders.
    b) To identify spatial patterns in the distribution of the ecosystem services that are socially demanded, particularly in relation to the location of the dam, and how they vary between stakeholders.
    c) To determine if stakeholders are able to map the spatial distribution of the ecosystem services from which they benefit.
    d) To determine if stakeholders can map the spatial distribution of ecosystem services that they anticipate benefitting from under various future scenarios and to identify stakeholders' perceptions of the causal mechanisms for a change in the spatial distribution of ecosystem services under different scenarios.

2. Sources of stakeholder conflict around a potential dam removal
    a) To explore the divergence in opinions on the future of the dam between stakeholders with different interests and locations in relation to the dam.
    b) To explore the variation between stakeholder groups in how the problem at the centre of the conflict is framed, and how those frames relate to social demand for ecosystem services, in order to investigate the role of diverging experiences and interests in the conflict.
    c) To develop a conceptual framework for analysing how the problem at the centre of the conflict is framed using spatial and temporal scales, and how these scale frames match and mismatch between stakeholders.
    d) To assess the role of scale framing in exacerbating the conflict around the future of the dam.
    e) To identify the place meanings in and around the dammed river and how they relate to the biophysical environment that is affected by the dam.
    f) To explore the role of place meanings, and, therefore, emotion in the conflict around the dam.

1.4. Thesis outline

The objectives outlined above are addressed in the four manuscripts presented in this thesis.

First, the literature on integrated water resources management and dam removal, social demand for ecosystem services, stakeholder conflicts around ecosystem services, frame theory and sense of place is reviewed in chapter 2. In addition, the case studied in this research is discussed.

To provide a basis for the research by establishing both how and where ecosystem services are socially demanded, the first manuscript, in chapter 3 presents the spatial distribution of ecosystem service benefits elicited through participatory mapping. The mapping methodology is then extended to test stakeholders' ability to map services under future scenarios. This manuscript therefore addresses objectives 1(a), 1 (b), 1(c) and 1(d). To further explore differences in ecosystem service benefits and how they relate to how the conflict is framed, the second manuscript (chapter 4) address objectives 1(a), 2(a) and 2(b). The third manuscript in chapter 5 continues to explore frames of the conflict, specifically scale frames, to address objectives 2(c) and 2(d). The final manuscript (chapter 6) then explores the role of place meanings in the conflict to address objectives 2(e) and 2(f).

Finally, chapter 7 draws conclusions from the research as a whole and from each individual manuscript. The main contributions to knowledge are identified, as well as limitations of the study and suggestions for further research.

2. LITERATURE REVIEW

2.1. Integrated water resources management and dams – framing the literature review

Water resources are increasingly managed using the framework of integrated water resources management (IWRM), the implementation of which is required by the Sustainable Development Goals by 2030 (target 6.5) (United Nations 2015). The definition of IWRM that is typically used comes from the Global Water Partnership (GWP 2000): '*a process which promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems*'.

The major elements in the concept include a systems or holistic approach to water management that integrates the key relationships and variables (Mitchell 2005), planning at river basin level (Hooper 2003), management of trade-offs, and stakeholder participation (Medema et al. 2008) in an attempt to balance environmental, economic and social needs for water.

There is a recognised implementation gap between the ideals of IWRM and its effects on water management in practice (Cook and Spray 2012, Giordano and Shah 2014), but engaging with the critiques of IWRM (Biswas 2004, Medema et al. 2008, Cook and Spray 2012, Giordano and Shah 2014) is beyond the scope of this thesis. It suffices to note here that modern decision-making for water resources increasingly takes place within an IWRM framework.

One of the fundamental challenges for IWRM implementation is reconciling the economic and social advantages of damming rivers with the need to maintain the naturally variable flow regimes on which aquatic ecosystems rely (Poff et al. 1997, Poff and Zimmerman 2010). Dams have provided many benefits for society, including renewable energy, flood control and water storage, and have made important contributions to societal development (World Commission on Dams (WCD) 2000). However, this has been at the cost of river ecosystems and, in many cases, local communities (WCD 2000, Dudgeon et al. 2006, McDonald-Wilmsen and Webber 2010). It is partly in recognition of these environmental and social impacts, and partly due to declining need for the benefits they provide, and emerging safety issues and maintenance costs, that removing ageing dams is increasingly considered (Doyle et al. 2003, 2008, O'Connor et al. 2015, Tonitto and Riha 2016).

Ecological responses to dam removal vary in time and space (Hart et al. 2002, Stanley and Doyle 2003, Pearson et al. 2011). Initial responses post-removal include lower water levels in

the reservoir, increased sediment transport, increased species migration and biotic exchange, return of the natural flow regime and water temperature, a shift in species assemblages, and plant colonisation of exposed land. Over time, the natural river channel re-establishes and sediment transport returns to its natural regime, and plant succession occurs on the exposed land (Hart et al. 2002, Pearson et al. 2011, Magilligan et al. 2016). Dam removal provokes a range of social concerns, both positive and negative, which can include fears about property values, recreational access, aesthetics, cultural heritage, wildlife habitat and employment (Born et al. 1998, Lejon et al. 2009, Fox et al. 2016, 2017, Tonitto and Riha 2016). To some extent, these concerns mirror support of and opposition to dam construction. The concept of ecosystem services provides a useful framework to link and assess the social and ecological impacts of dam removals.

Stakeholder participation is a critical component of decision-making around ageing dams and their potential removal (Reed 2008, Wohl et al. 2015, Tonitto and Riha 2016). A stakeholder can be defined as an individual or organisation that affects or is affected by a decision (Freeman 1984), which in the case of a hydropower dam could include the energy company, energy users, upstream residents, downstream residents, watershed organisations, recreationalists, and environmentalists, amongst others. There are several arguments put forward in favour of stakeholder participation in decision making, from the normative, that individuals have a right to shape the decisions that affect their lives, to the pragmatic, that participation improves the quality of decision making and implementation (Reed 2008).

Stakeholder participation is also promoted as a vehicle of conflict resolution (Beierle and Konisky 2000, Reed 2008). Participatory processes that allow people to have their views heard or bring different stakeholders together have the potential to reduce conflict by building trust between individuals, allowing them to see the legitimacy of others' views, and therefore transform formerly adversarial relationships (Beierle and Konisky 2000, Reed 2008). For example, an assessment of participatory environmental planning around the North American Great Lakes found that the majority of participatory processes assessed were effective at resolving conflicts by providing a forum for people's points of view to be listened to and respected. However, in the minority of cases, participatory processes escalated the conflict by reinforcing divisions between stakeholders and polarising their positions (Beierle and Konisky 2000). Selecting the most appropriate approach for conflict resolution, whether based in participatory processes or using other tools, requires an understanding of the context and dynamics of the conflict (Sidaway 2005, Rauschmayer and Wittmer 2006).

It is especially important to get stakeholder participation right in decision-making around ageing dams and their potential removal. These decisions frequently become a focus point for a dynamic constellation of concerns, interests, values and needs in relation to both the positive and negative impacts of dams, which can result in conflict amongst stakeholders (Lejon et al. 2009, Fox et al. 2016, 2017, Brummer et al. 2017). Dams fulfil a range of functions in a region or landscape, including providing reliable energy or water supplies, reservoir-based recreation, and cultural heritage (Lejon et al. 2009, Jorgensen and Renofalt 2012, Fox et al. 2016). They also have a history of negative impacts on local people and ecosystems. The trauma of their construction can still be in living memory (Sherren et al. 2016, 2017) and the ecological damage, including decline of migratory fish and change to flow regimes, persists and may still be regretted by many (Gosnell and Kelly 2010, Jorgensen and Renofalt 2012, Brummer et al. 2017). Discerning which of these factors are of local importance in a particular conflict and how they affect parties differently is crucial if conflict resolution is to have a chance of success (Sidaway 2005).

The following sections discuss the literature necessary for understanding a conflict around the potential removal of a large dam, with interlinked social and ecological implications, through social assessment of ecosystem services. The conceptual framework for this research (Figure 2.1Figure 2.1) was developed through an iterative process of reviewing the literature and analysing the data collected in this study. First, the concept of ecosystem services is discussed, particularly the role of social demand for services and how it differs between individuals. Next, the literature on conflicts around ecosystem services is discussed, including the various drivers of conflict and tools for resolution. Perceptions of change to ecosystem services are frequently a driver of similar conflicts (Lejon et al. 2009, Jorgensen and Renofalt 2012, Brummer et al. 2017) – frame theory is presented as a means to understand those perceptions and their consequences for conflict. Lastly, the role of place is emphasised (Fox et al. 2017), and so theory on the sense of place is discussed in the final section of the literature review.

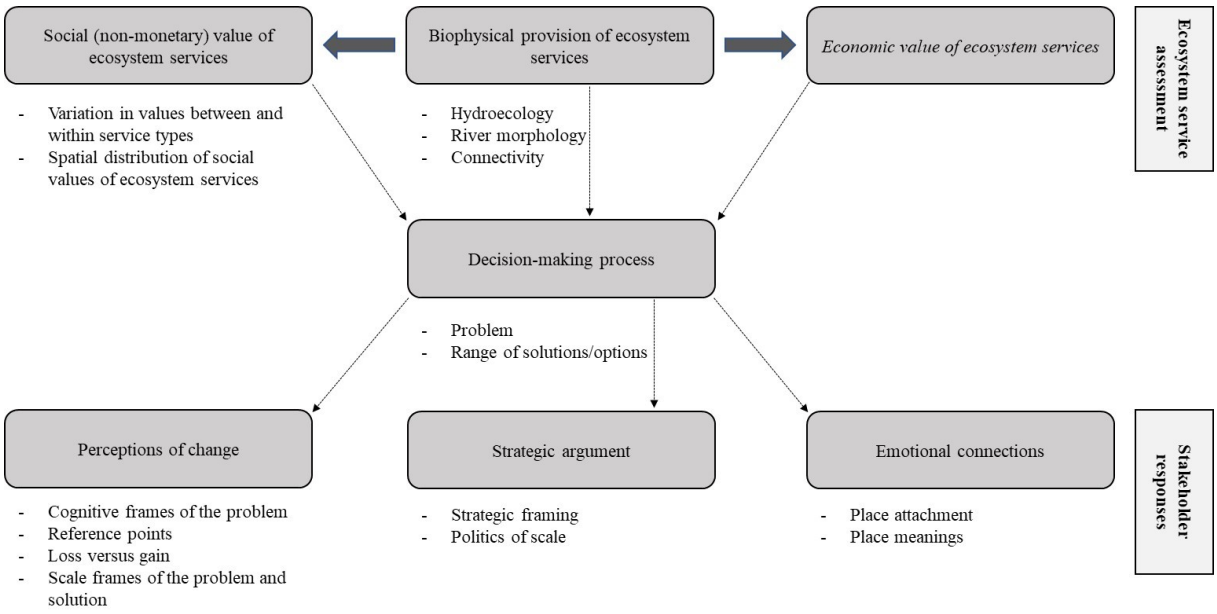


Figure 2.1. Conceptual framework guiding the literature review structure.

2.2. Social demand for ecosystem services

2.2.1. Defining ecosystem services

Integrated water resources management requires balancing the needs of society, the economy and ecosystems for water. To understand the trade-offs inherent in that balance, the interlinkages between the three needs, in terms of how functioning ecosystems support society and the economy, must be understood (Granek et al. 2010). The concept of ecosystem services provides a useful framework to assess and communicate these interlinkages (Liu et al. 2013).

The idea of the natural world being of value for human society has been incorporated into the scientific literature since the 1960s, when Helliwell (1969) discussed the monetary value of wildlife resources for production, potential production, education and recreation. Human-ecosystem relationships have since been captured in this literature by an evolving series of terms (Gómez-Baggethun et al. 2010, Costanza et al. 2017), from 'nature's services' (Westman 1977), then 'ecosystem services' (Ehrlich and Ehrlich 1981), to, most recently, 'nature's contributions to people', developed as part of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Díaz et al. 2018). The latter has been criticised on the one hand for its replacement of 'ecosystems' with 'nature' and on the other for its implication of a uni-directional flow from the natural world to human society. Peterson et al. (2018) argued that the term 'nature' disregards the ecosystems shaped by human activity, such as agricultural and urban ecosystems, that cover a large proportion of the land surface. The uni-directionality

of the ‘nature’s contributions to people’ concept similarly misrepresents the many ecosystem services that are co-created by ecological processes and functions and the social system, which provides the infrastructure and equipment, human capital and social norms and institutions necessary to produce an ecosystem service (Peterson et al. 2018). Given that this research focuses on a dammed river, an ecosystem that has been highly modified by human activities, and that many of the services demanded are co-created between ecological and social systems, the term ‘ecosystem services’ is retained here. Furthermore, efforts are increasing to incorporate ecosystem services into decision making, such as social and environmental impact assessments, and therefore it is more useful to continue with the same terminology used there.

Ecosystem services are defined by the Millennium Ecosystem Assessment (MA) (2005) as ‘the benefits provided by ecosystems’. This definition was purposefully intended to be general, and therefore has spawned a variety of interpretations in making it operational (Fisher et al. 2008, Costanza et al. 2017). The resulting conceptualisations and uses of the term have been variously criticised for undermining environmental accounting (Boyd and Banzhaf 2007), contributing to the commodification of nature (Kosoy and Corbera 2010), excluding services that cannot be valued monetarily (Chan et al. 2012b), neglecting cultural ecosystem services (Daniel et al. 2012), failing to acknowledge their context and cultural specificity (Díaz et al. 2018), and many others. While several alternative definitions have been proposed to address these criticisms, the original MA (2005) definition is used in this thesis due to its wide use and flexibility to incorporate a wide range of benefits. A more precise operational definition that allows for economic accounting or identification of the ecological pathways by which an ecosystem provides a particular service was not needed for this study based on stakeholders’ perceptions of their relationships with ecosystems.

How ecosystems generate a benefit for society is a further, and important, source of contention. The basic conceptualisation is that ecological structures and processes, such as photosynthesis and nutrient cycling, benefit people in some way, i.e. producing an ecosystem service (de Groot et al. 2002, Costanza et al. 2017). Various terminologies and intermediary steps between an ecological structure or process and a benefit to humans have been proposed within this basic conceptualisation (Jax 2005, Fisher et al. 2009, Maes et al. 2012, Potschin and Haines-Young 2017). Gaps in knowledge of the ecological and social processes that produce services, and how they interrelate, hinder efforts to define pathways between ecosystems and social wellbeing (Bennett 2017, Costanza et al. 2017).

For this research, it suffices to distinguish the ecological production, social (and cultural) demand and economic valuation of ecosystem services (de Groot et al. 2002, MA 2005a, Cowling et al. 2008). The focus here is on social demand and its variation between stakeholders and individuals, in order to explore how such variation contributes to conflict over the distribution of the costs and benefits of ecosystem services (Costanza et al. 2017).

In its early scientific use, the ecosystem services concept was used as a metaphor that made explicit society's reliance on the structure and functioning of ecosystems to argue for ecosystem protection and restoration (Brauman et al. 2007, Fisher et al. 2008, Daily et al. 2009, Redford and Adams 2009, Norgaard 2010). Since then, attention has increasingly been focused on implementation of the concept to benefit human society while safeguarding nature and biodiversity. This implementation has taken several forms, notably including mainstreaming ecosystem services into land and water management (Cowling et al. 2008, Hauck et al. 2013, Liu et al. 2013), payment for ecosystem services schemes (Redford and Adams 2009, Farley and Costanza 2010), and incorporation into decision making for extractive and infrastructure projects, including impact assessments (Baker et al. 2013, Karjalainen et al. 2013).

Mainstreaming ecosystem services in decision making is an attractive proposition. For conservation or ecological management projects, it implies that improving or safeguarding ecosystems can also provide benefits for humans (Tallis et al. 2008). Assessing the trade-offs of a decision through the framework of ecosystem services allows ecological and social impacts to be discussed in the same terms, and highlights the economic value of functioning ecosystems (Costanza et al. 1997, Granek et al. 2010, Baker et al. 2013). This assessment also identifies the beneficiaries of ecosystem services (Cowling et al. 2008), and which social groups will be positively and negatively affected (King et al. 2015). Lastly, it provides a useful entry point for participatory decision making, by demonstrating how biophysical changes to an ecosystem are relevant to people's lives in a way that is easy for stakeholders to grasp (Palomo et al. 2011, Baker et al. 2013, Karjalainen et al. 2013).

However, it is challenging to ensure that the benefits of decisions or projects that incorporate ecosystem services are realised in practice (de Groot et al. 2010). To understand how the biophysical changes caused by a project affect ecosystem services, it must first be understood how those changes affect the structure of the ecosystem and its processes, and how those in turn affect service provision. However, these relationships are complex and the pathways are not well understood (Kremen 2005, de Groot et al. 2010). Individual species vary in their

contribution to the ecosystem functioning that provides ecosystem services (Bullock et al. 2011) and biophysical changes are likely to increase provision of some services and decrease others (Rodríguez et al. 2006, Bennett et al. 2009, Raudsepp-Hearne et al. 2010). For example, a study of an agricultural landscape in Quebec, Canada, found trade-offs between provisioning services and regulating and cultural services (Raudsepp-Hearne et al. 2010), meaning that decisions that increase the former come at the cost of the latter two service types. Further consideration of the ecology of ecosystem services and trade-offs in their biophysical provision is outside the scope of this thesis.

A second major challenge, the focus of this thesis, is in assessing how changes to the biophysical provision of ecosystem services affect the beneficiaries (Cowling et al. 2008). This assessment of social demand for ecosystem services receives less attention than biophysical provision or economic valuation (Cowling et al. 2008, Daniel et al. 2012, Plieninger et al. 2013). It requires different and time consuming assessment methods (Cowling et al. 2008, Plieninger et al. 2013), must take account of variation between individuals and social groups (Martín-López et al. 2012), and focuses to a large extent on cultural services, which are often considered subjective (Daniel et al. 2012). However, it is important to understand in order to gain a more complete picture of how ecosystems support human wellbeing, to identify trade-offs between different groups, and assess the potential for conflict (Fagerholm et al. 2012, Martín-López et al. 2012, Milcu et al. 2013, Plieninger et al. 2013, King et al. 2015).

2.2.2. Assessing social demand for ecosystem services

To discuss the varying ways in which individuals and stakeholders can demand ecosystem services, and how that demand can be measured, it is first necessary to outline the definitions of social demand used in the literature (Wolff et al. 2015). In some cases, demand is defined in the economic sense, as in the direct use or consumption of a service or ecosystem good, such as fish for example (Burkhard et al. 2012, Wolff et al. 2015). Here demand is instead defined broadly in terms of stakeholders' desires, preferences and values for services, whether or not they are directly consumed (Kumar and Kumar 2008, Martín-López et al. 2012, Plieninger et al. 2013, King et al. 2015, Wolff et al. 2015, Kati and Jari 2016). This definition incorporates the ability to access a service, preferences around its location and its biophysical characteristics, and social-cultural values (Wolff et al. 2015). It also includes the level of service provision needed to achieve a socially-desirable condition, such as reduced flood risk (Villamagna et al. 2013). Social demand is distinct from economic values of ecosystem services in that its assessment does not use monetary valuation techniques and hence incorporates the many

intangible services that are important to people (Chan et al. 2012a, Santos-Martín et al. 2016). As noted previously, social demand for and benefits from ecosystem services are used interchangeably in this thesis to incorporate stakeholders' values, perceptions and needs.

A variety of methods are used to assess or elicit social demand for ecosystem services (de Groot et al. 2010, Wolff et al. 2015). It can be measured indirectly through indicators such as numbers of recreational users or geotagged photos (Nahuelhual et al. 2013, Martínez Pastur et al. 2015). Alternatively, information on perceptions, values and knowledge can be obtained directly from stakeholders (Martín-López et al. 2012, Klain and Chan 2012, Plieninger et al. 2013, Palomo et al. 2014, García-Nieto et al. 2015). The latter approach has the advantage of accounting for the local social and cultural context and incorporating a diverse range of values that are not easily categorised (Chan et al. 2012b). Direct elicitation can be carried out through surveys to cover a large sample of stakeholders (Martín-López et al. 2012, Casado-Arzuaga et al. 2013), interviews for a more in-depth investigation of a smaller sample (Lamarque et al. 2011, Asah et al. 2014, Gould et al. 2015), and participatory mapping, to include the spatial distribution of ecosystem services (Raymond et al. 2009, Fagerholm et al. 2012, Plieninger et al. 2013, Brown and Fagerholm 2014, García-Nieto et al. 2015). Several other methods are also possible, including assessing willingness to invest time, focus groups, Q methodology and others (Santos-Martín et al. 2016).

The many methods to elicit social demand for ecosystem services share similar fundamental assumptions, namely that social demand is both individually specific and shaped by the social and cultural context; that it is affected by numerous other contextual factors including ecology, history and politics; and that its elicitation is based on the interpretation of communication between people (Chan et al. 2012a, Kenter et al. 2015, Santos-Martín et al. 2016). The data collected using these methods can be quantitative or qualitative, depending on the method and the purpose of the assessment. Qualitative data allows an in-depth and nuanced exploration of a small number of participants, whereas quantitative data allows generalisation to larger populations (Miles et al. 2013). Furthermore, data can be collected from individuals, to identify individually-held, albeit socially and culturally shaped, demand or from groups, to identify shared demand (Kenter et al. 2015, Santos-Martín et al. 2016).

In this study, a combination of interviews and interview-based participatory mapping was used to capture spatial and non-spatial variation between individuals in their social demand for ecosystem services. These interpretive methods were chosen because their combination is

considered suitable to elicit all non-economic values for ecosystem services, particularly intangible values, and to account for the spatial distribution of services (Santos-Martín et al. 2016). The use of interviews implies the collection of qualitative data. In this case, qualitative data was critical for uncovering the details in differences between individuals' social demand for ecosystem services and position in a conflict situation. A qualitative approach also allows individuals to offer information beyond that deemed important by the researcher. The interviews were conducted individually, which also allowed the differences between individuals' perceptions and values to be uncovered. Group-based methods were not used due to the risk in this particular context that opinions contrary to the majority position would not be voiced due to fear of social repercussions (Keilty et al. 2016, Sherren et al. 2016).

Previous studies using a range of these methods have found that demand for ecosystem services varies between individuals based on their knowledge and education, location, interests, time spent in the area, and experiences (Lamarque et al. 2011, Fagerholm et al. 2012, Martín-López et al. 2012, Casado-Arzuaga et al. 2013, Darvill and Lindo 2014, García-Nieto et al. 2015). For example, Martín-López et al. (2012) found that rural participants most often discussed recreational hunting and provisioning services, whereas urban people mentioned regulating services and a range of other cultural services. In a participatory mapping study of ecosystem services, Fagerholm et al. (2012) found that individuals who had lived longer in the area mapped more services than those who had spent less time there. Ecosystem services demand also varies culturally and socially (Chan et al. 2012a, 2012b). For example, indigenous people often have different value systems that determine ecosystem services demand (Chan et al. 2012b). Therefore, demand should be elicited in a particular context and take account of the variation between individuals, which has the potential to contribute to conflict (Kovács et al. 2014, King et al. 2015).

2.3. Stakeholder conflicts and ecosystem services

Conflict amongst stakeholders over resource and ecosystem management is pervasive. Integrated water resources management provides a framework for managing and resolving it through recognising and balancing trade-offs and through stakeholder participation (Saravanan et al. 2009). As previously mentioned, Lewicki (2003 p. 37) is followed here in defining conflict as 'the fundamental and underlying incompatibilities that divide parties'. In Lewicki's conceptualisation, episodes of dispute arise as a response to specific issues and events due to the underlying conflict, defined by the stakeholders' existing incompatibilities. Other definitions make a similar distinction, but label the incompatibilities as 'disagreements' or

clashes of opinions, and the episodes in which a party takes action as 'conflicts' (White et al. 2009, Redpath et al. 2013). Regardless of the terminology used, in this thesis a sub-section of the underlying incompatibilities is explored that relates to ecosystem services, and is referred to as a conflict. In this thesis, a low-level conflict is the focus, characterised by some organising by stakeholders at local level, but with no large protests or violent conflict (Kröger 2013)

The dynamics and resolution of conflict have been studied in relation to natural resources management (Bennett et al. 2001, Nie 2003), land use (Nash et al. 2010, Brown and Raymond 2014), forests (Buijs and Lawrence 2013, Sandström et al. 2013), nature conservation (Redpath et al. 2013), and biodiversity (White et al. 2009, Young et al. 2010), as well as in relation to environmental issues more generally (Lewicki 2003). These literatures are all drawn on, as relevant, because dam removal conflicts can be conceptualised as being over natural resource management (i.e. water), river restoration, or biodiversity, which underlies provision of ecosystem services (Harrison et al. 2014).

These types of conflicts are particularly challenging to resolve because they are both ecologically and socially complex (Wittmer et al. 2006). Conflict is often triggered by a proposal to change some component of an ecosystem, by changing its management or through a development project, for example. The complexity of ecosystems is such that the ecological consequences of a decision are difficult to predict over the relevant spatial and temporal scales (Wittmer et al. 2006, Paavola and Hubacek 2013). The social complexity arises when the full range of parties that could have a claim in the conflict are considered – entities affected by a proposed change in management include people located far from the site of the conflict, future generations and non-human nature (Lidskog 2005, Wittmer et al. 2006). Therefore, conflicts have to be managed in a context characterised by scientific uncertainty and a multitude of needs, interests and values (Brugnach et al. 2008).

Several approaches have been used in the literature to study the drivers and management of conflict over resources or ecosystems, from a range of disciplinary starting points, including psychology, sociology, politics and economics (Bennett et al. 2001, Sandström et al. 2013). The high-level approach focuses on the structural and functional drivers of conflict, including economic development, governance regimes and international policy (Ravikumar et al. 2013, Sandström et al. 2013). A second approach addresses the role of institutional change or failure in development of conflict (Bennett et al. 2001, Sandström et al. 2013, Sténs and Sandström 2013, Fox et al. 2017). Such institutions can include regulation, markets, and cultural norms.

For example, Bennett et al. (2001a) found that failure to enforce fishery regulations contributed to conflict between different groups of fishermen in Bangladesh and Ghana. Lastly, conflicts can be analysed at the level of the stakeholders involved in the conflict, which can take the form of competing interests, values, perceptions and emotions (Sidaway 2005, Sandström et al. 2013). This thesis takes the latter approach as variation in ecosystem service demand and uneven impacts on service provision as a result of a decision will contribute to conflict at the level of individual stakeholders. Furthermore, understanding these individual-level incompatibilities provides the foundation for effective participatory decision making (Sandström et al. 2013), as called for by IWRM. It is acknowledged, however, that a full understanding of the conflict studied here would require the institutional and structural-functional context to be incorporated as well.

To understand conflict at the level of the stakeholders involved and how it can be best managed, it is useful to differentiate the dimensions in which incompatibilities between stakeholders can exist (Table 2.1). In addition to these dimensions, conflicts can become highly emotional, due to strong connections to place or other features of the resource or ecosystem, which can exacerbate incompatibilities in other dimensions and contribute to conflict escalation (Buijs and Lawrence 2013, Yasmi et al. 2013). In practice, conflicts are multidimensional, and there are few cases where a singular cause can be identified (Sidaway 2005, Young et al. 2010). Nevertheless, a differentiation of those dimensions is useful as a framework for analysis of cases or comparison between cases (Bennett et al. 2001).

Table 2.1 Common typologies of stakeholder conflict in environmental fields.

Category	Conflict type	Description	Indicated approach for management/resolution	Reference
Issue	Conflicting positions	Positions are a stance taken in a conflict, e.g. being for or against something, demands/solutions.	Difficult to resolve at the level of positions – aim to shift to consideration of interests or values, which allows more space for common ground.	Sidaway 2005
Issue	Conflicting concerns	Concerns here refer to needs or fears of the satisfaction of needs.	Attempt to decrease fears and increase met needs.	Sidaway 2005
Issue	Conflicting interests	Interests refer to the goals and desires of the parties.	Shift parties to consider interests rather than positions, attempt to find common ground.	Nie 2003, Sidaway 2005
Issue	Conflicting values and beliefs	Values are closely linked to beliefs and have a normative dimension – the way things should be.	Values generally cannot be changed – attempt to change priority of values instead.	Sidaway 2005

Category	Conflict type	Description	Indicated approach for management/resolution	Reference
Issue	Diverging perceptions or frames	Insufficient information, incorrect interpretation or assessment of information.	Provide better information, correct biases.	Sidaway 2005, Sandström et al. 2013
Relationships	Poor relationships between parties	In-group/out-group effects, characterisation, poor communication, power imbalances, trust.	Participatory processes to build trust.	Sidaway 2005, Dewulf et al. 2009
Processes	Perceived appropriateness and fairness of decision-making processes	Processes by which decisions are made.	Attempt to shift from adversarial to collaborative decision making.	Nie 2003, Sidaway 2005, Dewulf et al. 2009

Effective resolution or management of a conflict depends on its drivers (Table 2.1). In general, however, participatory or collaborative processes for planning, decision making and resource management are promoted as a vehicle for building consensus and/or resolving conflict (Beierle and Konisky 2000, Rauschmayer and Wittmer 2006, van de Kerkhof 2006, Voinov and Bousquet 2010, Zachrisson and Beland Lindahl 2013). Possible approaches include participatory modelling, consensus building conferences, multi-criteria analysis, role play games, and many others, as well as formal negotiations and mediation (Messner et al. 2006, Rauschmayer and Wittmer 2006, Voinov and Bousquet 2010). The intended outcome of these interventions can range from providing information, reframing, and finding common ground, to transforming adversarial relationships (Kaufman and Smith 1999, Gray 2004, Shmueli et al. 2006, Reed 2008). However, some researchers argue that conflict can have positive effects, including bringing to light stakeholders' needs, opening an opportunity for local people to participate in resource management, stimulating learning, and ultimately improving social relations (Coser 1956, Castro and Nielsen 2001, Yasmi et al. 2009, 2013). Therefore, resolution should not necessarily be the goal of these approaches, but rather conflict should be managed constructively such that its positive effects can be realised (Sandström et al. 2013).

Given the ecological and social complexity of ecosystem-related conflicts, it is useful to explore in more detail how interests, needs, values, and perceptions or misunderstandings (Table 2.1) can diverge between stakeholders involved in the conflict, and how they relate to the ecology in question. Identifying the social and ecological components of the conflict can indicate the extent to which it can be resolved with better ecological information or with conflict resolution processes (Jorgensen and Renofalt 2012). The ecosystem services framework has been used to explore the interlinkages between those social and ecological components in conflicts over water resources management in a small body of literature,

primarily to explore diverging interests (Jacobs and Buijs 2011, Jorgensen and Renofalt 2012, Darvill and Lindo 2016, Brummer et al. 2017). In this thesis, that framework is used in combination with a range of theories of conflict to explore those divergences from a wider range of angles than has been done to date. The following sections explore theories of conflict between individuals that can be linked to ecosystem services, including frame theory, politics of scale and sense of place.

2.4. Frame theory

Frame theory is used in a wide range of disciplines, including psychology (Levin et al. 1998), sociology (Benford and Snow 2000), media and communication studies (Matthes 2009), conflict studies (Drake and Donohue 1996), and environmental/natural resource conflicts (Lewicki 2003, Brummans et al. 2008, Isendahl et al. 2009, Jacobs and Buijs 2011, Dewulf et al. 2011, Juerges and Newig 2015) to understand people's perceptions of external events, and the consequences of those perceptions. In this context, then, the term 'frame' describes how a person interprets or makes sense of a particular event (Lewicki 2003). It provides a useful approach for systematically identifying the sources of perceptions of a situation and how they differ between individuals (Lewicki 2003). The focus here is on the literature on frames of environmental/natural resource conflicts, since this field is most closely aligned to the context for the research.

2.4.1. Approaches to studying frames

The range of fields in which frames have been analysed reflects a diversity of ontological, theoretical and methodological approaches, even within the literature on environmental conflicts (Dewulf et al. 2009, Cornelissen and Werner 2014). Dewulf et al. (2009) separated these approaches into two main paradigms: the study of interactional frames and of cognitive frames. The definition of what a frame is, how it arises and changes, and how it affects conflict situations, differs between the two. A cognitive frame is an individual's interpretation of external reality that arises from their previous experiences and knowledge. Interactional frames are a co-constructed interpretation of reality negotiated between individuals (Dewulf et al. 2009). For this study the concept of cognitive framing is used, since it allows an accurate understanding of stakeholders involved in a conflict and allows frames to be easily compared between individuals to identify where they diverge (Dewulf et al. 2009, Asah et al. 2012b).

The concept of cognitive frames has its basis in psychology, specifically Bartlett's (1932) theory of reconstructive memory. Based on psychological experiments, Bartlett theorised that

memories are reconstructions of past experiences and knowledge that influence how a situation in the present is understood. In interpreting new information, a person fits it into the context of their existing thoughts and knowledge. From this basis in psychology, the concept was further refined by being used in the field of artificial intelligence. Minsky (1974) first used the term 'frame' to describe responses to a situation and what might occur next. The process of selecting a frame to determine one's actions in response to a situation was described as: '*when one encounters a new situation (or makes a substantial change in one's view of the present problem) one selects from memory a structure called a frame. This is a remembered framework to be adapted to fit reality by changing details as necessary*' (Minsky, 1974, p. 211). The conceptualisation of cognitive frames in the context of environmental conflicts arose from here (Dewulf et al. 2009, Asah et al. 2012b).

There are several assumptions about how an event or situation is interpreted in the concept of cognitive frames. It assumes firstly that an external event occurs, which is then represented in a person's mind; this representation is termed a frame. Frames are persistent structures of past experiences that are stored in memory. Thus, the process of interpreting a current event involves selecting the frame from an existing set stored in memory that best applies to the event in question. The processing of new information, knowledge or experiences changes a person's set of frames (Dewulf et al. 2009).

2.4.2. The role of frames in conflict

Studying cognitive frames is a means of understanding the dynamics of a conflict, for example over a decision related to environmental or natural resource management. The theory of cognitive frames posits that the frames by which people interpret the world are biased and do not thus represent an accurate view of an event (Tversky and Kahneman 1981, Dewulf et al. 2009). This allows very different interpretations to arise between different people affected by or involved in the event at hand. According to frame theory, conflict occurs between individuals and groups due to differences in these interpretations of external reality (Lewicki 2003, Gray 2004). Furthermore, individuals' cognitive frames can be further reinforced through interaction with others, and can be used strategically to persuade or to promote a particular point of view (Gray and Putnam 2003, Dewulf et al. 2004, Shmueli et al. 2006).

There are several aspects of reality that can be framed in a conflict situation, which Dewulf et al. (2009) differentiated into issues, identity and relationships, and processes. The issues at the centre of the conflict include what the problem is and how it should be best resolved, and are

frequently subject to framing (Bardwell 1991, Dewulf et al. 2009, Asah et al. 2012a, 2012b). Problem frames incorporate various assumptions and preconceptions, in terms of which aspects of the situation are focused on, and to whom and what the blame for the problem is attributed (Bardwell 1991). Diverging definitions of the problem restrict the range of acceptable solutions and can result in intractable differences between stakeholders' positions in the conflict (Bardwell 1991, Gray 2004). For example, (Asah et al. 2012b) analysed a conflict around all-terrain vehicle (ATV) use in public lands in the United States. Stakeholders variously framed the problem as one of ineffective management and poor enforcement of penalties for ATV use, of a minority of badly-behaving users, and of unclear signs for where ATV use is permitted (Asah et al. 2012b). Each of these interpretations of the problem suggests a different solution.

Conflict can be intensified by how the parties involved frame their own identity in relation to it. When a management decision is seen to be contrary to a person's core identity, opposition to the decision is strengthened (Lewicki 2003, Gray 2004, Brummans et al. 2008). For example, a conflict over management of a national park in the United States worsened when local residents felt the establishment of the park threatened their identity linked to mining and logging (Gray 2004). Identity frames also serve to highlight a person's connections to others and assert their membership of a group of similar individuals. In defining a group identity, it has to be differentiated from others, which can involve negative characterisation of those who are not members of a group (Wondolleck et al. 2003). This can create in-group/out-group effects, in which members of the in-group are trusted, while those of the out-group are perceived as having malicious intentions (Tajfel et al. 1971, Cheng and Daniels 2005). The result can be that parties become polarised to the extent that the conflict becomes 'us versus them' (Wondolleck et al. 2003).

Lastly, parties can diverge in their perceptions of the processes by which the decision should be made and the conflict resolved (Dewulf et al. 2009). For example, individuals can hold different preferences for decision making over environmental management, including preferring to delegate it to experts, leaving management to individuals without societal restrictions, or for decision making to be a collaborative or democratic process (Peterson 2005, Brummans et al. 2008). A similar range of preferences for conflict resolution can be identified, including collaborative negotiation, neutral mediation, or litigation (Keltner 1994, Lewicki 2003, Brummans et al. 2008). These frames of the process are often linked to how participants frame the issues and identities involved in a conflict (Brummans et al. 2008).

Understanding how stakeholders frame the event at the centre of a conflict enables their positions and the key aspects of the situation to be identified (Bardwell 1991, Shmueli and Ben-Gal 2003, Asah et al. 2012b). Awareness of the cognitive frames held by stakeholders can facilitate effective mediation in the conflict, with the intention of achieving frame convergence and can identify common ground that forms the basis of reframing (Lewicki 2003, Shmueli and Ben-Gal 2003, Asah et al. 2012b). For example, Kaufman and Gray (2003) found that presenting the results of a frame analysis of two environmental conflicts (over management of a national park and management of a river) to the stakeholders facilitated stakeholder interactions and built understanding. They concluded that frame analysis and subsequent feedback had the potential to enhance the success of other conflict resolution techniques. In reframing their perception of an event with a mediator, parties can incorporate others' views in their frames and resolution is more likely (Gray 2004).

2.4.3. Scale frames and the politics of scale

Frames of the issues at the centre of a conflict often incorporate defining the boundaries of the problem and solution on particular scales or levels, a process known as 'scale framing' (van Lieshout et al. 2011). Scales are '*the spatial, temporal, quantitative or analytical dimensions used to describe a phenomenon*' (Gibson et al. 2000, van Lieshout et al. 2012:164). There are numerous scales of relevance to environmental problems, including hydrological scales, administrative scales, and the temporal scale (Cash et al. 2006). Each of these scales can be divided into levels, such as nations, provinces and municipalities on the administrative scale (Gibson et al. 2000, Cash et al. 2006). Scale frames are particularly relevant in environmental decision making that has different implications across levels and scales. For example, the ecological impacts of removing a dam include changes to fish migration and sediment transport in the short term and composition of plant communities in the long term (Hart et al. 2002). Matching the scale and level of a problem's occurrence to the scale and level of its management is therefore of political concern for environmental and water issues (Cash et al. 2006).

Which scales and levels are incorporated into the problem frame affects which solutions become preferable, and therefore how an issue is scale framed has political consequences. They can be used, consciously or unconsciously, to advocate for particular political goals or to change power relations, in a process known as the politics of scale (Delaney and Leitner 1997, McCann 2003, Kurtz 2003, Harrison 2006, Leitner et al. 2008). Scale frames of a problem suggest which issues and stakeholders are legitimate to consider in decision-making, and which are illegitimate. For example, a study of fracking in Pennsylvania found that proponents framed

the benefits of the industry as occurring at a range of levels, from local job provision to cheaper energy across the state. The inclusion of residents across the state made fracking appear more attractive than it would if the benefits were only framed at local level, which could easily be countered by opponents focusing on the local harm caused by pollution (Sica 2015). Scale can thus be manipulated to match the level of a problem and its solution (Kurtz 2003, Juerges and Newig 2015).

Diverging scale frames also have a role in exacerbating conflict between stakeholders. The process of manipulating scales can obscure interests and make problems appear more or less widely shared (Harrison 2006, van Lieshout et al. 2011). The scales and levels on which problems are understood may be different between stakeholders, creating further incompatibilities and intensifying communication difficulties (Termeer et al. 2010, van Lieshout et al. 2011). Therefore, understanding the added scale dimension of stakeholders' frames is important for informing mediation and other reframing attempts (Shmueli et al. 2006, van Lieshout et al. 2011).

While scale frames have been studied in several contexts, including agriculture and renewable energy (Harrison 2006, van Lieshout et al. 2011, 2012, 2014, Juerges and Newig 2015), they have not been studied in relation to water management or dam removal, both contexts that have clear scalar implications. Furthermore, the focus has been on various spatial scales, with only a small number of studies incorporating the temporal scale (McCann 2003, van Lieshout et al. 2011). The concept of scale frames is therefore applied to the new context of dam removal and the temporal scale is addressed, which is of particular importance for issues with varying impacts over time.

2.5. Sense of place

To incorporate the emotional dimension of environmental conflicts (Buijs and Lawrence 2013, Yasmi et al. 2013), the literature on sense of place is used, which describes people's emotional connections to places. This is particularly important for conflicts that occur at local scale over the impacts of decisions that vary spatially, and particularly when the stakeholders in conflict are likely to have strong connections to particular locations (Williams and Stewart 1998). Sense of place is an important concept for many different fields, including social and environmental psychology (Stedman 2002, Manzo 2003, Lewicka 2011), rural sociology (Beckley et al. 2007), human geography (Brown et al. 2002), and natural resources management (Cheng et al. 2003, Davenport and Anderson 2005). Inherent in the study of sense of place is the distinction

between space (or location) and place. According to Tuan's (1977) commonly used definition, '*what begins as undifferentiated space becomes place as we get to know it better and endow it with value'* (page 6). Therefore, the experiences people have in a location, and the events that occur there, give it meaning as a place (Davenport and Anderson 2005, Williams 2008).

The relationships that people have with particular locations, which then become places, have been conceptualised in a variety of ways (Manzo 2003, Trentelman 2009, Lewicka 2011, Masterson et al. 2016). For example, the concepts of sense of place (Davenport and Anderson 2005, Jorgensen and Stedman 2006), place attachment (Lewicka 2011), place identity (Twigger-Ross and Uzzell 1996, Fresque-Baxter and Armitage 2012), place dependence (Jorgensen and Stedman 2001), place meanings (Davenport and Anderson 2005), place satisfaction (Stedman 2003), and rootedness (Hammitt et al. 2006) have all been identified and discussed in the literature. Regardless of how these terms are defined or related to each other, their study generally falls into two distinct approaches (Trentelman 2009, Lewicka 2011, Masterson et al. 2016, Stedman 2016). One approach is primarily quantitative and based in social and environmental psychology. It uses Likert scales to assess the strength and valence of various components of place attachment (Jorgensen and Stedman 2006, Raymond et al. 2010, Devine-Wright 2013) and relates them to other variables, such as attitudes to environmental change (Devine-Wright 2013) or biophysical characteristics of the location (Stedman 2003). The second approach involves a qualitative assessment of place meanings, and is often used by human geographers and natural resource scholars to explore variations in meaning in a given context (Davenport and Anderson 2005, Beckley et al. 2007, Gunderson and Watson 2007, Trentelman 2009). The two approaches can be seen as complementary, with meanings contributing to place attachment (Stedman et al. 2004, Beckley et al. 2007, Stedman 2008, Masterson et al. 2016).

In this research, sense of place is referred to as an overarching concept that encompasses both place attachment and place meaning (Tuan 1977, Rickard and Stedman 2015, Masterson et al. 2016, Stedman 2016). Place attachment involves an appraisal of the importance or quality of a place to which a person has an emotional bond, which is typically positive but can also be negative (Low and Altman 1992, Manzo 2003, Stedman 2016). Place meanings, on the other hand, define the nature of a place for a particular person, i.e. what type of place it is (Stedman 2016). Therefore, fundamentally, place attachment and place meanings can be understood as evaluative and descriptive, respectively (Stedman et al. 2004, Stedman 2008, Jacquet and Stedman 2014, Masterson et al. 2016). The focus here is on place meanings, which have been

somewhat neglected in the study of the implications of sense of place for management of resources or ecosystems. Place meanings are the focus because a range of meanings can be associated with a given location, based on a person or community's individual history, experiences and characteristics. When a change to that location threatens some of those meanings, conflict can arise or be exacerbated (Davenport and Anderson 2005, Beckley et al. 2007, Anderson et al. 2013, Buijs and Lawrence 2013).

A space becomes imbued with meaning through people's interactions with it, and, in general, different modes of interaction can produce different sets of meanings for the same setting. Such modes of interaction could include permanent residence, seasonal residence, tourism, recreation, work and others (Stedman 2002, Kyle et al. 2004, Farnum et al. 2005, Smaldone et al. 2008). For example, a study of residents of a lake in Wisconsin found that permanent lakeshore residents gave the lake meaning as a neighbourly community, while for seasonal residents it had meaning as an escape (Stedman 2002, 2008). Other studies have shown, however, that frequent direct interaction with a place is not needed for it to be given meaning (Gunderson and Watson 2007). A variety of other factors can contribute to meaning, including the biophysical characteristics of a location, an individual's characteristics, and the discourses and expectations of the social context (Jacquet and Stedman 2014, Masterson et al. 2016, Stedman 2016).

There is considerable debate in the literature about whether meanings are individualised, formed through individual interactions with a setting, or whether they are constructed by a social or cultural group (Jacquet and Stedman 2014, Masterson et al. 2016). The social and environmental psychology approach to sense of place emphasises the former – individuals interact with an environment in a way that shapes their attitudes and beliefs about that place and how it should be managed (Jorgensen and Stedman 2001, 2006, Smith et al. 2011). For others, place meanings are the dynamic result of ongoing social interactions in a space. In this view, an individual's initial place meanings are mediated and sustained by interactions with other people (Stokowski 2002). In particular, power and authority can shape place meanings through communications, regulations and cultural norms (Masterson et al. 2016). For example, communications from national park services have been found to influence visitors' place meanings by teaching them what kind of place it is (Rickard and Stedman 2015). The interactions that an individual of a given role, such as an angler or hunter, has with an environment are constrained by social expectations of those roles (Masterson et al. 2016). Here

the view is that place meanings develop through individual experiences that are shaped by social processes (Masterson et al. 2016)

Similarly, there are extensive debates about the role of the characteristics of the biophysical environment in shaping place meanings, particularly those that are socially constructed (Stedman 2003, Trentelman 2009, Lewicka 2011). For some, biophysical characteristics are relatively unimportant to the development of place meanings, since their relevance is itself socially constructed (Greider and Garkovich 1994, Stokowski 2002, Trentelman 2009). However, it is now widely demonstrated that place meanings and attachment arise from a combination of the social and biophysical characteristics of a place (Eisenhauer et al. 2000, Stedman 2003, Davenport and Anderson 2005, Smith et al. 2011, Spartz and Shaw 2011, Kil et al. 2014), and that meanings can change in response to a change in the biophysical environment (Davenport and Anderson 2005).

The biophysical environment contributes to place meanings both directly and indirectly. Its characteristics directly contribute to the type of description a place is given, such that a remote, wild forest can be labelled as wilderness; some researchers refer to this as providing the 'raw material for meanings' (Jacquet and Stedman 2014, Masterson et al. 2016, Stedman 2016). Indirectly, the biophysical environment determines which experiences are possible, from which meanings are then inferred. For example, recreational activities such as hunting are only possible if the requisite species are present (Masterson et al. 2016, Stedman 2016). Therefore, the biophysical environment bounds the individual interpretations and social constructions that give it meaning (Jacquet and Stedman 2014). Ultimately, place meanings, arise from three key components: the biophysical characteristics of a setting, individual interpretations and experiences with it, and social discourses and expectations about a place and behaviours within it (Jacquet and Stedman 2014, Masterson et al. 2016, Stedman 2016).

Place meanings have relevance to decision making in terms of the responses from local stakeholders. Several studies have found both positive and negative relationships between strength of place attachment and degree of acceptance of infrastructure projects that would change a location's characteristics (Vorkinn and Riese 2001, Stedman 2002, Devine-Wright and Howes 2010, Devine-Wright 2011, 2013, Jacquet and Stedman 2014). Whether a project is perceived to fit with prevailing place meanings has been suggested as the factor that determines whether the relationship between place attachment and project acceptance is positive or negative (Stedman 2002, Devine-Wright and Howes 2010, Devine-Wright 2011).

In these studies, the focus has primarily been on the more tangible meanings, including economic, ecological and experiential meanings. The focus here is on intangible meanings, including how a place contributes to personal and community identity, to attempt to account for emotion in the development of conflict over dam removal.

2.6. Context of the Mactaquac Dam conflict

This research focuses on a single case – the decision-making process around the future of the Mactaquac Dam in New Brunswick, Canada. This case was selected for several reasons. There was evidence that ecosystem services, particularly cultural services, were locally very important, as demonstrated by the importance of tourism to the local economy and the proliferation of local water-based recreation groups (Dillon Consulting 2015, Stantec 2015). The decision was also proving to be controversial amongst an engaged set of local stakeholders, as indicated by their attendance at information meetings and the numerous blogs, letters to the editor and editorials that were published about the subject. Therefore, there was ample scope for the conceptual framework (Figure 2.1) to be tested. The dam was one of the largest ever considered for removal to date, and therefore provides an important test case for decisions over similar large dams, while being an extreme case (Gerring 2004) compared to the small dams studied to date (Lejon et al. 2009, Jorgensen and Renofalt 2012, Fox et al. 2016). Lastly, the case was timely – the data was collected during the decision-making process, allowing perceptions to be gathered contemporaneously and enabling the research outcomes to contribute to the process. In this section, the case is introduced in more detail, including the context that is necessary for understanding the conflict over its future.

2.6.1. History of dam construction

The Mactaquac Dam was built on the mainstem of the Saint John River, New Brunswick, Canada, between 1965 and 1968, when it was commissioned as a hydropower dam. In the first half of the 20th century the province was economically depressed, primarily due to the decline of the local timber and shipbuilding industries. Average individual income and unemployment were worse than the Canadian rates at the time, and the province was losing population as young people moved away to find employment (Bourgoin 2013). The provincial government and power company viewed hydropower dams, including but not limited to the Mactaquac Dam, as engines of economic development, by providing a reliable electricity supply to the newly developing mining and paper industries and offering employment (Kenny and Secord 2010, Bourgoin 2013). At the same time, a rural development project was conceived around the construction of the dam, which incorporated the establishment of a provincial park near the

dam site, a historical museum, and a paper and pulp mill (Si 1993, Bourgoin 2013). Ultimately, the project failed in creating lasting employment other than 100 jobs at the mill (Si 1993).

In common with the dominant practices of the time, the decision to construct the dam was made without consultation and with disregard for widespread public opposition (Kenny and Secord 2010, Bourgoin 2013). As noted in section 1.2, opposition centred around a number of concerns, including loss of the salmon fishery, aesthetics of the free-flowing river, graveyards and churches. Some 900-1100 people were relocated to allow for the headpond to be flooded, including an entire community at Jewett's Mill, which was generally considered a traumatic process (Si 1993, Bourgoin 2013). Of those who were not relocated, many were farmers who lost their most fertile and productive land at the valley bottom, which rendered their farms economically unviable.

The Maliseet First Nations were particularly affected – Fort Meductic, a Maliseet cemetery and part of the reserve at Woodstock were flooded by the dam's reservoir. Traditional uses of the river, including canoeing and salmon fishing, have also been affected, and the dam has ruptured the Maliseet people's spiritual connection to the river and physically separated their communities (Tremblay 2016, Sherren et al. 2017). In addition, the dam site is directly adjacent to the Kingsclear First Nation, which therefore was, and continues to be, significantly affected by the construction and operation of the dam. The loss of reserve land at Woodstock was compensated by the Canadian federal government in 2008 for having taken place in contravention of the Indian Act (Bourgoin 2013), but the other impacts remain.

For some residents, the negative effects of the dam's construction and the loss it entailed lingered in negative emotions, community relations and personal health (Si 1993, Keilty et al. 2016). Many of those people, however, felt that the headpond ecosystem had reached a stable state and wanted to avoid further disturbance (Keilty et al. 2016), while others still hoped to remove the dam. For some people, quality of life had improved since the dam was built, as they adapted to its presence and came to value its aesthetics and recreational opportunities (Keilty et al. 2016, Sherren et al. 2016).

2.6.2. The decision-making process

New Brunswick Power announced in 2013 that the dam was unlikely to reach its planned 100-year lifespan due to a structural problem in the concrete electricity generating structures, including the powerhouse and spillway. An alkali-aggregate reaction had already been causing

the concrete to expand since the 1980s, which required regular maintenance to allow electricity generation (New Brunswick (NB) Power 2016a).

The power company commenced a decision-making process for the future of the dam. It was decided that the final option should be operational by 2030, thus the decision-making process started in 2013 to allow time for initial studies and consultations, legally-mandated impact assessments, permitting, and construction (NB Power 2016a). The options initially presented at that point included replacing the affected structures, effectively building a new dam on the other side of the river from present. This option would repower the dam and retain the headpond. The second option was to decommission the concrete structures and retain the earthen dam that formed the headpond. The third option was to remove the dam entirely and return the river to its free flowing state (Stantec 2015). In summer 2016, a fourth option emerged, which essentially entailed upgrading the maintenance and replacing some structures without building a new dam to allow it to meet its planned lifespan (NB Power 2017).

The decision-making process lasted approximately three years, with the final decision being made in late 2016. As mentioned previously, a large-scale hydrological and ecological study of the headpond and river began, and reviews of the environmental and social impacts were commissioned. These reviews were published at the end of summer 2015, which was followed by a stakeholder consultation conducted by an independent consultancy until May 2016 (NATIONAL and CRA 2016). A separate consulting company carried out a separate engagement process with six Maliseet First Nations bands. The power company itself published a discussion paper highlighting the key issues for the decision, which included energy policy, financial considerations, replacement services, risk, and external factors defined as aboriginal, social and environmental considerations (NB Power 2016a).

These considerations were particularly important given the economic, social and regulatory context of the province at the time. New Brunswick has a regulatory requirement to produce 40% of its energy from renewables by 2020 (NB Power 2016a). Therefore, the 12% of the provincial energy demand produced by Mactaquac would have to be replaced by other renewables, such as wind, which do not necessarily provide the same function in the grid as a hydropower dam. The ability to rapidly start up the generating station of hydropower plants like Mactaquac provides operating reserve on the system, meaning generation can be quickly increased in response to changes in demand and repower the rest of the grid if needed (NB Power 2016a, Sherren et al. 2017).

The economic state of the province presented a challenge, whichever option was chosen. All three options were predicted to be very expensive – ranging from 4.3 to 5.6 billion CAD. The project would be paid for by a loan from the provincial government and incremental rate increases for consumers. In the period up to the decision, the provincial government's debt was steadily increasing, predicted to reach 42% of GDP in 2017/2018 (RBC 2017), making such large investments difficult for the province. On the other hand, investment in infrastructure projects was a provincial priority to generate economic activity, provide jobs, and attempt to stem the depopulation, especially of young people, of the province (Government of New Brunswick 2014, 2016, Statistics Canada 2017).

Each of the three options presented a different set of environmental and social impacts. The environmental impacts were reviewed in several categories: atmospheric environment, acoustic environment, surface water, groundwater, aquatic environment, vegetation and wetlands, wildlife and wildlife habitat, economy and employment, human occupancy and resource use, infrastructure and services, transportation, heritage resources, and traditional use of land and resources by Aboriginal persons. Many of the impacts anticipated from retaining the dam would occur at the dam site during construction, including noise and dust production, and disturbance of vegetation. However, the continued presence of the dam would cause current environmental impacts, including blocking the passage of migrating fish, to continue. Some impacts would vary spatially through the affected reach. For example, removal of the dam was expected to decrease risk of ice jam flooding in the upper headpond and increase it in the lower headpond and downstream. Others were anticipated to vary over time. For example, it was thought that removal would create a short-term stress for wildlife but an improvement in wildlife and habitat, particularly wetland habitat, in the long term (Stantec 2015).

The social impact assessment also reviewed impacts on recreational uses; housing, services and infrastructure; community identity; intakes and outfalls; land acquisition; drinking water supply; property values; river access; transportation disruption; and changes to viewsheds, in addition to the social impacts covered in the environmental review. The social impacts of the options that involved retaining the dam were again thought to occur at the dam site and be related to construction impacts. These disturbances would be of particular concern to the Kingsclear First Nation located adjacent to the dam. Impacts of dam removal were identified as including possible changes to recreational use, reconnection to the river for the Kingsclear First Nation, and possible economic and structural changes to communities (Dillon Consulting 2015).

The stakeholder consultation and an independent survey of provincial residents found that the majority preferred to retain the dam in some form, with a minority preferring removal (NATIONAL and CRA 2016, Sherren et al. 2017). Qualitative studies of residents' preferences also found the vast majority wanted to retain the dam (Keilty et al. 2016, Sherren et al. 2016). However, these latter studies only included residents of the lower headpond, which was most changed by construction of the dam, and excluded individuals in the upper headpond and downstream of the dam, who also had a stake in the decision (Keilty et al. 2016). Nevertheless, these findings belie the contentiousness of the decision-making process. There was strong social pressure around the lower headpond in particular to support retention of the dam (Keilty et al. 2016, Sherren et al. 2017). Community meetings were reported to be heated, and letters to the editor were exchanged in the local newspaper. The Maliseet First Nations' preference to remove the dam was given little coverage in the media (Sherren et al. 2017).

Despite the extensive reviews and stakeholder consultation, the decision-making process was criticised for unequal consideration of the options, unbalanced distribution of resources for environmental and social reviews, and lack of transparency. The stakeholder consultation and social impact assessment were deemed to be less rigorous than the study of environmental impacts, and to use poor social science (Sherren et al. 2017). The First Nations engagement process was not conducted publicly, and it was thought by some that their preferred option of dam removal was never seriously considered (Tremblay 2016, Sherren et al. 2017).

Ultimately, NB Power decided in late 2016 to replace some structures, without a full rebuild, and continue maintenance to allow the dam to reach its planned lifespan. The project involves replacing turbines, repairing damaged concrete, and installing fish passage for multiple species (NB Power 2016b). While most residents were deemed 'relieved' at the decision (Sherren et al. 2017), informal follow up with the participants of this study found that those who wanted to remove the dam were strongly disappointed. The decision was made after the fieldwork for this study was conducted but before the completion of this thesis. Nevertheless, the research was useful for the case as a contribution to understanding stakeholders' perspectives during the decision-making process and offering suggestions for conflict management post decision.

REFERENCES

Anderson, N. M., K. J. H. Williams, and R. M. Ford. 2013. Community perceptions of plantation forestry: The association between place meanings and social representations of a contentious rural land use. *Journal of Environmental Psychology* 34:121–136.

Asah, S. T., D. N. Bengston, K. Wendt, and L. Devaney. 2012a. Prognostic framing of stakeholders' subjectivities: A case of all-terrain vehicle management on state public lands. *Environmental Management* 49(1):192–206.

Asah, S. T., D. N. Bengston, K. Wendt, and K. C. Nelson. 2012b. Diagnostic reframing of intractable environmental problems: case of a contested multiparty public land-use conflict. *Journal of Environmental Management* 108:108–19.

Asah, S. T., A. D. Guerry, D. J. Blahna, and J. J. Lawler. 2014. Perception, acquisition and use of ecosystem services: Human behavior, and ecosystem management and policy implications. *Ecosystem Services* 10:180–186.

Auerbach, D. A., D. B. Deisenroth, R. R. McShane, K. E. McCluney, and N. L. Poff. 2014. Beyond the concrete: Accounting for ecosystem services from free-flowing rivers. *Ecosystem Services* 10:1–5.

Baker, J., W. R. Sheate, P. Phillips, and R. Eales. 2013. Ecosystem services in environmental assessment — Help or hindrance ? *Environmental Impact Assessment Review* 40:3–13.

Bardwell, L. V. 1991. Problem-Framing: A perspective on environmental problem-solving. *Environmental Management* 15(5):603–612.

Bartlett, F. 1932. *Remembering: A study in experimental and social psychology*. Cambridge University Press, Cambridge, UK.

Bates, S., D. Getches, L. MacDonnell, and C. Wilkinson. 1993. *Searching out the headwaters: Change and rediscovery in Western water policy.* Island Press, Washington DC.

Beckley, T. M., R. C. Stedman, S. M. Wallace, and M. Ambard. 2007. Snapshots of What Matters Most: Using Resident-Employed Photography to Articulate Attachment to Place. *Society & Natural Resources* 20(10):913–929.

Beierle, T. C., and D. M. Konisky. 2000. Values, conflict, and trust in participatory

environmental planning. *Journal of Policy Analysis and Management* 19(4):587–602.

Benford, R. D., and D. A. Snow. 2000. Framing Processes and Social Movements: An Overview and Assessment. *Annual Review of Sociology* 26:611–639.

Bennett, E. M. 2017. Research Frontiers in Ecosystem Service Science. *Ecosystems* 20(1):31–37.

Bennett, E. M., G. D. Peterson, and L. J. Gordon. 2009. Understanding relationships among multiple ecosystem services. *Ecology Letters* 12(12):1394–1404.

Bennett, E., A. Neiland, E. Anang, P. Bannerman, A. Atiq Rahman, S. Huq, S. Bhuiya, M. Day, M. Fulford-Gardiner, and W. Clerveaux. 2001. Towards a better understanding of conflict management in tropical fisheries: evidence from Ghana, Bangladesh and the Caribbean. *Marine Policy* 25(5):365–376.

Biswas, A. K. 2004. Integrated Water Resources Management : A Reassessment. *Water International* 29(2):248–256.

Blomquist, W., and E. Schlager. 2005. Political Pitfalls of Integrated Watershed Management. *Society & Natural Resources* 18(2):101–117.

Born, S. M., K. D. Genskow, T. L. Filbert, N. Hernandez-Mora, M. L. Keeper, and K. A. White. 1998. Socioeconomic and institutional dimensions of dam removals: The Wisconsin experience. *Environmental Management* 22(3):359–370.

Bourgoin, S. 2013. Disregarded sentiments: Discovering the voices of opposition to the Mactaquac Dam. St Mary's University.

Boyd, J., and S. Banzhaf. 2007. What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics* 63(2–3):616–626.

Brauman, K. a., G. C. Daily, T. K. Duarte, and H. a. Mooney. 2007. The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services. *Annual Review of Environment and Resources* 32(1):67–98.

Brismar, A. 2002. River systems as providers of goods and services: A basis for comparing desired and undesired effects of large dam projects. *Environmental Management* 29(5):598–609.

Brown, G., and N. Fagerholm. 2014. Empirical PPGIS/PGIS mapping of ecosystem services:

A review and evaluation. *Ecosystem Services* 13:119–133.

Brown, G. G., P. Reed, and C. C. Harris. 2002. Testing a place-based theory for environmental evaluation: An Alaska case study. *Applied Geography* 22(1):49–76.

Brown, G., and C. M. Raymond. 2014. Methods for identifying land use conflict potential using participatory mapping. *Landscape and Urban Planning* 122:196–208.

Bruckmeier, K. 2005. Interdisciplinary Conflict Analysis and Conflict Mitigation in Local Resource Management. *Ambio* 34(2):65–73.

Brugnach, M., A. Dewulf, C. Pahl-Wostl, and T. Taillieu. 2008. Toward a Relational Concept of Uncertainty: about Knowing Too Little, Knowing Too Differently, and Accepting Not to Know. *Ecology And Society* 13(2):30.

Brummans, B. H. J. M., L. L. Putnam, B. Gray, R. Hanke, R. J. Lewicki, and C. Wiethoff. 2008. Making sense of intractable multiparty conflict: A study of framing in four environmental disputes. *Communication Monographs* 75(1):25–51.

Brummer, M., B. Rodríguez-Labajos, T. Thanh Nguyen, and D. Jorda-Capdevila. 2017. "They Have Kidnapped Our River": Dam Removal Conflicts in Catalonia and Their Relation to Ecosystem Services Perceptions. *Water Alternatives* 10(3):744–768.

Buijs, A. E., and A. Lawrence. 2013. Emotional conflicts in rational forestry: Towards a research agenda for understanding emotions in environmental conflicts. *Forest Policy and Economics* 33(September 2015):104–111.

Bullock, J. M., J. Aronson, A. C. Newton, R. F. Pywell, and J. M. Rey-Benayas. 2011. Restoration of ecosystem services and biodiversity: conflicts and opportunities. *Trends in Ecology & Evolution* 26(10):541–9.

Burkhard, B., F. Kroll, S. Nedkov, and F. Müller. 2012. Mapping ecosystem service supply, demand and budgets. *Ecological Indicators* 21:17–29.

Canadian Rivers Institute. 2013. Mactaquac Aquatic Ecosystem Study - Study Area. http://canadianriversinstitute.com/research/mactaquac-aquatic-ecosystem-study/study-area/.

Carpenter, S. R., E. H. Stanley, and M. J. Vander Zanden. 2011. State of the World's Freshwater Ecosystems: Physical, Chemical, and Biological Changes. *Annual Review of*

Environment and Resources 36:75–99.

Casado-Arzuaga, I., I. Madariaga, and M. Onaindia. 2013. Perception, demand and user contribution to ecosystem services in the Bilbao Metropolitan Greenbelt. *Journal of Environmental Management* 129:33–43.

Cash, D. W., W. N. Adger, F. Berkes, P. Garden, L. Lebel, and P. Olsson. 2006. Scale and Cross-Scale Dynamics: Governance and Information in a Multilevel World. *Ecology and Society* 11(2):8.

Castro, A. P., and E. Nielsen. 2001. Indigenous People and Co-management: Implications for Conflict Management. *Environmental Science and Policy* 4:229–239.

Chan, K. M. A., A. D. Guerry, P. Balvanera, S. Klain, T. Satterfield, X. Basurto, A. Bostrom, R. Chuenpagdee, R. Gould, B. S. Halpern, J. Levine, B. Norton, M. Ruckelshaus, R. Russell, J. Tam, K. M. A. Chan, A. D. Guerry, P. Balvanera, S. Klain, T. Satterfield, and X. Basurto. 2012a. Where are *Cultural* and *Social* in Ecosystem Services? A Framework for Constructive Engagement. *BioScience* 62(8):744–756.

Chan, K. M. A., T. Satterfield, and J. Goldstein. 2012b. Rethinking ecosystem services to better address and navigate cultural values. *Ecological Economics* 74:8–18.

Chan, K. M. a, R. M. Pringle, J. a I. Ranganathan, C. L. Boggs, Y. L. Chan, P. R. Ehrlich, P. K. Haff, N. E. Heller, K. Al Khafaji, and D. P. Macmynowski. 2007. When Agendas Collide: Human Welfare and Biological Conservation. *Conservation Biology* 21(1):59–68.

Cheng, A. S., and S. E. Daniels. 2005. Getting to "We": Examining the Relationship between Geographic Scale and Ingroup Emergence in Collaborative Watershed Planning. *Research in Human Ecology* 12(1):30–43.

Cheng, A. S., L. E. Kruger, and S. E. Daniels. 2003. "Place" as an Integrating Concept in Natural Resource Politics: Propositions for a Social Science Research Agenda. *Society & Natural Resources* 16(2):87–104.

Cook, B. R., and C. J. Spray. 2012. Ecosystem services and integrated water resource management: different paths to the same end? *Journal of environmental management* 109:93–100.

Cornelissen, J. P., and M. D. Werner. 2014. Putting Framing in Perspective: a Review of

Framing and Frame Analysis Across the Management and Organizational Literature. *The Academy of Management Annals* 8(1):181–235.

Coser, L. 1956. *The Functions of Social Conflict*. The Free Press, New York.

Costanza, R., R. d'Arge, R. De Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, and M. Van Den Belt. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387(6630):253–260.

Costanza, R., R. De Groot, L. Braat, I. Kubiszewski, L. Fioramonti, P. Sutton, S. Farber, and M. Grasso. 2017. Twenty years of ecosystem services: How far have we come and how far do we still need to go ? *Ecosystem Services* 28:1–16.

Cowling, R. M., B. Egoh, A. T. Knight, P. J. O'Farrell, B. Reyers, M. Rouget, D. J. Roux, A. Welz, and A. Wilhelm-Rechman. 2008. An operational model for mainstreaming ecosystem services for implementation. *Proceedings of the National Academy of Sciences of the United States of America* 105(28):9483–9488.

Daily, G. C., S. Polasky, J. Goldstein, P. M. Kareiva, H. a Mooney, L. Pejchar, T. H. Ricketts, J. Salzman, and R. Shallenberger. 2009. Ecosystem services in decision making: time to deliver. *Frontiers in Ecology and the Environment* 7(1):21–28.

Daniel, T. C., A. Muhar, A. Arnberger, O. Aznar, J. W. Boyd, K. M. a Chan, R. Costanza, T. Elmqvist, C. G. Flint, P. H. Gobster, A. Grêt-Regamey, R. Lave, S. Muhar, M. Penker, R. G. Ribe, T. Schauppenlehner, T. Sikor, I. Soloviy, M. Spierenburg, K. Taczanowska, J. Tam, and A. von der Dunk. 2012. Contributions of cultural services to the ecosystem services agenda. *Proceedings of the National Academy of Sciences of the United States of America* 109(23):8812–9.

Darvill, R., and Z. Lindo. 2014. Quantifying and mapping ecosystem service use across stakeholder groups: Implications for conservation with priorities for cultural values. *Ecosystem Services* 13:153–161.

Darvill, R., and Z. Lindo. 2016. The inclusion of stakeholders and cultural ecosystem services in land management trade-off decisions using an ecosystem services approach. *Landscape Ecology* 31(3):533–545.

Davenport, M. A., and D. H. Anderson. 2005. Getting From Sense of Place to Place-Based Management: An Interpretive Investigation of Place Meanings and Perceptions of

Landscape Change. *Society & Natural Resources* 18(7):625–641.

Delaney, D., and H. Leitner. 1997. The political construction of scale. *Political Geography* 16(2):93–97.

Devine-Wright, P. 2009. Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. *Journal of Community & Applied Social Psychology* 19:426–441.

Devine-Wright, P. 2011. Place attachment and public acceptance of renewable energy: A tidal energy case study. *Journal of Environmental Psychology* 31(4):336–343.

Devine-Wright, P. 2013. Explaining "NIMBY" Objections to a Power Line: The Role of Personal, Place Attachment and Project-Related Factors. *Environment and Behavior* 45(6):761–781.

Devine-Wright, P., and Y. Howes. 2010. Disruption to place attachment and the protection of restorative environments: A wind energy case study. *Journal of Environmental Psychology* 30(3):271–280.

Dewulf, A., M. Craps, and G. Dercon. 2004. How Issues Get Framed and Reframed When Different Communities Meet: A Multi-level Analysis of a Collaborative Soil Conservation Initiative in the Ecuadorian Andes. *Journal of Community & Applied Social Psychology* 14:177–192.

Dewulf, A., B. Gray, L. Putnam, R. Lewicki, N. Aarts, R. Bouwen, and C. van Woerkum. 2009. Disentangling approaches to framing in conflict and negotiation research: A meta-paradigmatic perspective. *Human Relations* 62(2):155–193.

Dewulf, A., M. Mancero, G. Cardenas, and D. Sucozhanay. 2011. Fragmentation and connection of frames in collaborative water governance: a case study of river catchment management in Southern Ecuador. *International Review of Administrative Sciences* 77(1):50–75.

Díaz, B. S., U. Pascual, M. Stenseke, B. Martín-lópez, R. T. Watson, Z. Molnár, R. Hill, K. M. A. Chan, I. A. Baste, K. A. Brauman, S. Polasky, A. Church, M. Lonsdale, A. Larigauderie, P. W. Leadley, P. E. Alexander, V. Oudenhoven, F. Van Der Plaat, M. Schröter, S. Lavorel, Y. Aumeeruddy-thomas, E. Bukvareva, K. Davies, S. Demissew, G. Erpul, P. Failler, C. A. Guerra, C. L. Hewitt, H. Keune, S. Lindley, and Y. Shirayama.

2018. Assessing nature's contributions to people. *Science* 359(6373):270–272.

Dillon Consulting. 2015. *Social Impact Comparative Review*.

Doyle, M. W., J. M. Harbor, and E. H. Stanley. 2003. Toward policies and decision-making for dam removal. *Environmental Management* 31(4):453–465.

Doyle, M. W., E. H. Stanley, D. G. Havlick, M. J. Kaiser, G. Steinbach, W. L. Graf, G. E. Galloway, and J. A. Riggsbee. 2008. Environmental science. Aging infrastructure and ecosystem restoration. *Science* 319(5861):286–287.

Drake, L. E., and W. A. Donohue. 1996. Communicative Framing Theory in Conflict Resolution. *Communication Research* 23(3):297–322.

Dudgeon, D., A. H. Arthington, M. O. Gessner, Z.-I. Kawabata, D. J. Knowler, C. Lévêque, R. J. Naiman, A.-H. Prieur-Richard, D. Soto, M. L. J. Stiassny, and C. a Sullivan. 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews of the Cambridge Philosophical Society* 81(2):163–82.

Ehrlich, P. R., and A. H. Ehrlich. 1981. *Extinction: The causes and consequences of the disappearance of species*. Random House, New York.

Eisenhauer, B. W., R. S. Krannich, and D. J. Blahna. 2000. Attachments to Special Places on Public Lands: An Analysis of Activities, Reason for Attachments, and Community Connections. *Society & Natural Resources* 13:421–441.

Fagerholm, N., N. Käyhkö, F. Ndumbaro, and M. Khamis. 2012. Community stakeholders' knowledge in landscape assessments - Mapping indicators for landscape services. *Ecological Indicators* 18:421–433.

Farley, J., and R. Costanza. 2010. Payments for ecosystem services: From local to global. *Ecological Economics* 69(11):2060–2068.

Farnum, J., T. Hall, and L. E. Kruger. 2005. Sense of place in natural resource recreation and tourism: An evaluation and assessment of research findings. *USDA Forest Service - General Technical Report PNW*(660):1–59.

Fisher, B., K. Turner, M. Zylstra, R. Brouwer, R. De Groot, S. Farber, P. Ferraro, R. Green, D. Hadley, J. Harlow, P. Jefferiss, C. Kirkby, P. Morling, S. Mowatt, R. Naidoo, J. Paavola, B. Strassburg, D. Yu, and A. Balmford. 2008. Ecosystem Services and Economic Theory:

Integration for Policy-Relevant Research. *Ecological Applications* 18(8):2050–2067.

Fisher, B., R. K. Turner, and P. Morling. 2009. Defining and classifying ecosystem services for decision making. *Ecological Economics* 68(3):643–653.

Fox, C. A., F. J. Magilligan, and C. S. Sneddon. 2016. "You kill the dam, you are killing a part of me": Dam removal and the environmental politics of river restoration. *Geoforum* 70:93–104.

Fox, F., C. Magilligan, and C. Sneddon. 2017. The Social, Historical , and Institutional Contingencies of Dam Removal. *Environmental Management* 59:982–994.

Freeman, R. E. 1984. *Strategic management: A stakeholder approach*. Pitman, Boston, US.

Fresque-Baxter, J. A., and D. Armitage. 2012. Place identity and climate change adaptation: A synthesis and framework for understanding. *Wiley Interdisciplinary Reviews: Climate Change* 3(3):251–266.

García-Nieto, A. P., C. Quintas-Soriano, M. García-Llorente, I. Palomo, C. Montes, and B. Martín-López. 2015. Collaborative mapping of ecosystem services: The role of stakeholders′ profiles. *Ecosystem Services* 13:141–152.

Gerring, J. 2004. *Case Study Research: Principles and Practices*. Cambrdige University Press, Cambridge, UK.

Gibson, C. C., E. Ostrom, and T. K. Ahn. 2000. The concept of scale and the human dimensions of global change: A survey. *Ecological Economics* 32(2):217–239.

Giordano, M., and T. Shah. 2014. From IWRM back to integrated water resources management. *International Journal of Water Resources Development* 30(3):364–376.

Goldstein, J. H., G. Caldarone, T. K. Duarte, D. Ennaanay, N. Hannahs, G. Mendoza, S. Polasky, S. Wolny, and G. C. Daily. 2012. Integrating ecosystem-service tradeoffs into land-use decisions. *Proceedings of the National Academy of Sciences* 109(19):7565–7570.

Gómez-Baggethun, E., R. de Groot, P. L. Lomas, and C. Montes. 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. *Ecological Economics* 69(6):1209–1218.

Gosnell, H., and E. C. Kelly. 2010. Peace on the river? Social-ecological restoration and large

dam removal in the Klamath basin, USA. *Water Alternatives* 3(2):362–383.

Gould, R. K., S. C. Klain, N. M. Ardoin, T. Satterfield, U. Woodside, N. Hannahs, G. C. Daily, and K. M. Chan. 2015. A protocol for eliciting nonmaterial values through a cultural ecosystem services frame. *Conservation Biology* 29(2):575–586.

Government of New Brunswick. 2014. *New Brunswick Population Growth Strategy 2014-2017*.

Government of New Brunswick. 2016. *The New Brunswick Economic Growth Plan*.

Granek, E. F., S. Polasky, C. V Kappel, D. J. Reed, D. M. Stoms, E. W. Koch, C. J. Kennedy, L. a Cramer, S. D. Hacker, E. B. Barbier, S. Aswani, M. Ruckelshaus, G. M. E. Perillo, B. R. Silliman, N. Muthiga, D. Bael, and E. Wolanski. 2010. Ecosystem services as a common language for coastal ecosystem-based management. *Conservation biology : the journal of the Society for Conservation Biology* 24(1):207–16.

Gray, B. 2004. Strong opposition: Frame-based resistance to collaboration. *Journal of Community & Applied Social Psychology* 14:166–176.

Gray, B., and L. L. Putnam. 2003. Means to what end? Conflict management frames. *Environmental Practice* 5(3):239–246.

Greider, T., and L. Garkovich. 1994. Landscapes: The Social Construction of Nature and the Environment. *Rural Sociology* 59(1):1–24.

de Groot, R. S., R. Alkemade, L. Braat, L. Hein, and L. Willemen. 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological Complexity* 7(3):260–272.

de Groot, R. S., M. A. Wilson, and R. M. J. Boumans. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics* 41:393–408.

Guerry, A. D., S. Polasky, J. Lubchenco, R. Chaplin-kramer, and G. C. Daily. 2015. Natural capital and ecosystem services informing decisions : From promise to practice. *PNAS* 112(24):7348–7355.

Gunderson, K., and A. Watson. 2007. Understanding Place Meanings on the Bitterroot National Forest, Montana. *Society & Natural Resources* 20(8):705–721.

GWP. 2000. *Integrated Water Resources Management. TAC Background Paper No. 4*. Stockholm.

Hamann, M., R. Biggs, and B. Reyers. 2015. Mapping social-ecological systems: Identifying "green-loop" and "red-loop" dynamics based on characteristic bundles of ecosystem service use. *Global Environmental Change* 34:218–226.

Hammitt, W. E., E. a. Backlund, and R. D. Bixler. 2006. Place Bonding for Recreation Places: Conceptual and Empirical Development. *Leisure Studies* 25(1):17–41.

Harrison, J. L. 2006. "Accidents" and invisibilities: Scaled discourse and the naturalization of regulatory neglect in California's pesticide drift conflict. *Political Geography* 25(5):506–529.

Harrison, P. A., P. M. Berry, G. Simpson, J. R. Haslett, M. Blicharska, M. Bucur, R. Dunford, B. Egoh, M. Garcia-Llorente, N. Geamănă, W. Geertsema, E. Lommelen, L. Meiresonne, and F. Turkelboom. 2014. Linkages between biodiversity attributes and ecosystem services: A systematic review. *Ecosystem Services* 9:191–203.

Hart, D. D., T. E. Johnson, K. L. Bushaw-Newton, R. J. Horwitz, A. T. Bednarek, D. F. Charles, D. a Kreeger, and D. J. Velinsky. 2002. Dam removal: Challenges and opportunities for ecological research and river restoration. *Bioscience* 52(8):669–681.

Hauck, J., C. Görg, R. Varjopuro, O. Ratamäki, and K. Jax. 2013. Benefits and limitations of the ecosystem services concept in environmental policy and decision making: Some stakeholder perspectives. *Environmental Science & Policy* 25:13–21.

Hein, L., K. van Koppen, R. S. de Groot, and E. C. van Ierland. 2006. Spatial scales, stakeholders and the valuation of ecosystem services. *Ecological Economics* 57:209–228.

Helliwell, D. R. 1969. Valuation of wildlife resources. *Regional Studies* 3(1):41–47.

Hooper, B. P. 2003. Integrated Water Resources Management and River Basin Governance. *Water Resources Update* 33(1963):207–215.

Howe, C., H. Suich, B. Vira, and G. M. Mace. 2014. Creating win-wins from trade-offs ? Ecosystem services for human well-being : A meta-analysis of ecosystem service trade-offs and synergies in the real world. *Global Environmental Change* 28:263–275.

Isendahl, N., A. Dewulf, M. Brugnach, G. François, S. Möllenkamp, and C. Pahl-Wostl. 2009.

Assessing Framing of Uncertainties in Water Management Practice. *Water Resources Management* 23(15):3191–3205.

Jacobs, M. H., and A. E. Buijs. 2011. Understanding stakeholders' attitudes toward water management interventions: Role of place meanings. *Water Resources Research* 47(1):W01503.

Jacquet, J., and R. Stedman. 2014. The risk of social-psychological disruption as an impact of energy development and environmental change. *Journal of Environmental Planning and Management* 57(9):1285–1304.

Jax, K. 2005. Function and "' functioning '" in ecology: What does it mean? *Oikos* 111(3):641–648.

Jorgensen, B. S., and R. C. Stedman. 2001. Sense of Place As an Attitude: Lakeshore Owners Attitudes Toward Their Properties. *Journal of Environmental Psychology* 21(3):233–248.

Jorgensen, B. S., and R. C. Stedman. 2006. A comparative analysis of predictors of sense of place dimensions: Attachment to, dependence on, and identification with lakeshore properties. *Journal of Environmental Management* 79:316–27.

Jorgensen, D., and B. M. Renofalt. 2012. Damned if you do; damned if you don't: Debates on dam removal in the Swedish media. *Ecology and Society* 18(1):18.

Juerges, N., and J. Newig. 2015. What role for frames in scalar conflicts? *Land Use Policy* 49:426–434.

Kahneman, D., and A. Tversky. 1979. Prospect theory: An analysis of decision under risk. *Econometrica* 47(2):263–292.

Karjalainen, T. P., M. Marttunen, S. Sarkki, and A. M. Rytkönen. 2013. Integrating ecosystem services into environmental impact assessment: An analytic-deliberative approach. *Environmental Impact Assessment Review* 40(1):54–64.

Kati, V., and N. Jari. 2016. Bottom-up thinking-Identifying socio-cultural values of ecosystem services in local blue-green infrastructure planning in Helsinki, Finland. *Land Use Policy* 50:537–547.

Kaufman, S., and B. Gray. 2003. Using retrospective and prospective frame elicitation to evaluate environmental disputes. Pages 1–15*Evaluating Environmental Dispute*

Resolution. Resources for the Future, Washington DC.

Kaufman, S., and J. Smith. 1999. Framing and reframing in land use change conflicts. *Journal of Architectural and Planning Research* 16(2):164.

Keilty, K., T. M. Beckley, and K. Sherren. 2016. Baselines of acceptability and generational change on the Mactaquac hydroelectric dam headpond (New Brunswick, Canada). *Geoforum* 75:234–248.

Keltner, J. 1994. *The management of struggle: Elements of dispute resolution through negotiation, mediation, and arbitration*. Hampton Press, Creeskill, New Jersey.

Kenny, J. L., and A. G. Secord. 2010. Engineering Modernity: Hydroelectric Development in New Brunswick , 1945-1970. *Acadiensis* 1(1):3–26.

Kenter, J. O., L. O'Brien, N. Hockley, N. Ravenscroft, I. Fazey, K. N. Irvine, M. S. Reed, M. Christie, E. Brady, R. Bryce, A. Church, N. Cooper, A. Davies, A. Evely, M. Everard, R. Fish, J. A. Fisher, N. Jobstvogt, C. Molloy, J. Orchard-Webb, S. Ranger, M. Ryan, V. Watson, and S. Williams. 2015. What are shared and social values of ecosystems? *Ecological Economics* 111:86–99.

van de Kerkhof, M. 2006. Making a Difference: On the Constraints of Consensus Building and the Relevance of Deliberation in Stakeholder Dialogues. *Policy Sciences* 39:279–299.

Kil, N., S. Holland, and T. Stein. 2014. Place meanings and participatory planning intentions. *Society & Natural Resources* 27(5):475–491.

King, E., J. Cavender-Bares, P. Balvanera, T. H. Mwampamba, and S. Polasky. 2015. Trade-offs in ecosystem services and varying stakeholder preferences: Evaluating conflicts, obstacles, and opportunities. *Ecology and Society* 20(3).

Kingsford, R. T. 2011. Conservation management of rivers and wetlands under climate change - a synthesis. *Marine and Freshwater Research* 62:217–222.

Klain, S. C., and K. M. A. Chan. 2012. Navigating coastal values: Participatory mapping of ecosystem services for spatial planning. *Ecological Economics* 82:104–113.

Kosoy, N., and E. Corbera. 2010. Payments for ecosystem services as commodity fetishism. *Ecological Economics* 69(6):1228–1236.

Kovács, E., E. Kelemen, Á. Kalóczkai, K. Margóczi, G. Pataki, J. Gébert, G. Málovics, B.

Balázs, Á. Roboz, E. Krasznai Kovács, and B. Mihók. 2014. Understanding the links between ecosystem service trade-offs and conflicts in protected areas. *Ecosystem Services* 12:117–127.

Kremen, C. 2005. Managing ecosystem services: What do we need to know about their ecology? *Ecology Letters* 8(5):468–479.

Kröger, M. 2013. Grievances, agency and the absence of conflict: The new Suzano pulp investment in the Eastern Amazon. *Forest Policy and Economics* 33:28–35.

Kumar, M., and P. Kumar. 2008. Valuation of the ecosystem services: A psycho-cultural perspective. *Ecological Economics* 64(4):808–819.

Kurtz, H. E. 2003. Scale frames and counter-scale frames: constructing the problem of environmental injustice. *Political Geography* 22(8):887–916.

Kyle, G., K. Bricker, A. Graefe, and T. Wickham. 2004. An Examination of Recreationists' Relationships with Activities and Settings. *Leisure Sciences* 26(2):123–142.

Lamarque, P., U. Tappeiner, C. Turner, M. Steinbacher, R. D. Bardgett, U. Szukics, M. Schermer, and S. Lavorel. 2011. Stakeholder perceptions of grassland ecosystem services in relation to knowledge on soil fertility and biodiversity. *Regional Environmental Change* 11(4):791–804.

Leitner, H., E. Sheppard, and K. M. Sziartot. 2008. The Spatialities of Contentious Politics. *Transactions of the Institute of British Geographers* 33(2):157–172.

Lejon, A. G. C., B. M. Renöfält, and C. Nilsson. 2009. Conflicts associated with dam removal in Sweden. *Ecology And Society* 14(2):4.

Levin, I., S. Schneider, and G. Gaeth. 1998. All frames are not created equal: A typology and critical analysis of framing effects. *Organizational Behavior and Human Decision Processes* 76(2):149–188.

Levin, S. A. 1992. The Problem of Pattern and Scale in Ecology. *Ecology* 73(6):1943–1967.

Lewicka, M. 2011. Place attachment: How far have we come in the last 40 years? *Journal of Environmental Psychology* 31(3):207–230.

Lewicki, R. 2003. *Making sense of intractable environmental conflicts: Concepts and cases*. Island Press, Washington DC.

Lidskog, R. 2005. Siting conflicts – democratic perspectives and political implications. *Journal of Risk Research* 8(3):187–206.

van Lieshout, M., A. Dewulf, N. Aarts, and C. Termeer. 2011. Do Scale Frames Matter? Scale Frame Mismatches in the Decision Making Process of a "Mega Farm" in a Small Dutch Village. *Ecology And Society* 16(1):38.

van Lieshout, M., A. Dewulf, N. Aarts, and C. Termeer. 2012. Doing scalar politics: interactive scale framing for managing accountability in complex policy processes. *Critical Policy Studies* 6(2):163–181.

van Lieshout, M., A. Dewulf, N. Aarts, and C. Termeer. 2014. The power to frame the scale? Analysing scalar politics over, in and of a deliberative governance process. *Journal of Environmental Policy and Planning* 0(0):0.

Liu, S., N. D. Crossman, M. Nolan, and H. Ghirmay. 2013. Bringing ecosystem services into integrated water resources management. *Journal of environmental management* 129:92–102.

Low, S. M., and I. Altman. 1992. *Place attachment*. Page *Place Attachment*. Springer US.

Maes, J., B. Egoh, L. Willemen, C. Liquete, P. Vihervaara, J. P. Schägner, B. Grizzetti, E. G. Drakou, A. La Notte, G. Zulian, F. Bouraoui, M. Luisa Paracchini, L. Braat, and G. Bidoglio. 2012. Mapping ecosystem services for policy support and decision making in the European Union. *Ecosystem Services* 1(1):31–39.

Magilligan, F. J., K. H. Nislow, B. E. Kynard, and A. M. Hackman. 2016. Immediate changes in stream channel geomorphology, aquatic habitat, and fish assemblages following dam removal in a small upland catchment. *Geomorphology* 252:158–170.

Manzo, L. C. 2003. Beyond house and haven: Toward a revisioning of emotional relationships with places. *Journal of Environmental Psychology* 23(1):47–61.

Martín-López, B., I. Iniesta-Arandia, M. García-Llorente, I. Palomo, I. Casado-Arzuaga, D. G. Del Amo, E. Gómez-Baggethun, E. Oteros-Rozas, I. Palacios-Agundez, B. Willaarts, J. A. González, F. Santos-Martín, M. Onaindia, C. López-Santiago, and C. Montes. 2012. Uncovering ecosystem service bundles through social preferences. *PLoS ONE* 7(6):e38970.

Martínez Pastur, G., P. L. Peri, M. V. Lencinas, M. García-Llorente, and B. Martín-López.

2015. Spatial patterns of cultural ecosystem services provision in Southern Patagonia. *Landscape Ecology*:383–399.

Masterson, V., R. C. Stedman, J. Enqvist, M. Tengö, M. Giusti, D. Wahl, and U. Svedin. 2016. The contribution of sense of place to social–ecological systems research: a review and research agenda. *Ecology and Society* 22(1):49.

Matthes, J. 2009. What's in a Frame? A Content Analysis of Media Framing Studies in the World's Leading Communication Journals, 1990-2005. *Journalism & Mass Communication Quarterly* 86(2):349–367.

McCann, E. J. 2003. Framing Space and Time in the City: Urban Policy and the Politics of Spatial and Temporal Scale. *Journal of Urban Affairs* 25(2):159–178.

McDonald-Wilmsen, B., and M. Webber. 2010. Dams and displacement: Raising the standards and broadening the research agenda. *Water Alternatives* 3(2):142–161.

Medema, W., B. S. Mcintosh, and P. J. Jeffrey. 2008. From Premise to Practice: a Critical Assessment of Integrated Water Resources Management and Adaptive Management Approaches in the Water Sector. *Ecology And Society* 13(2):29.

Messner, F., O. Zwirner, and M. Karkuschke. 2006. Participation in multi-criteria decision support for the resolution of a water allocation problem in the Spree River basin. *Land Use Policy* 23:63–75.

Milcu, A. I., J. Hanspach, D. Abson, and J. Fischer. 2013. Cultural ecosystem services: A literature review and prospects for future research. *Ecology And Society* 18(3):44.

Miles, M. B., A. M. Huberman, and J. Saldana. 2013. *Qualitative data analysis: A methods sourcebook*. 3rd Editio.

Millennium Ecosystem Assessment (MA). 2005a. Ecosystems and Human Well-Being: Wetlands and Water. Page *in* World Resources Institute, editor. *Millennium Ecosystem Assessment*. Washington DC.

Millennium Ecosystem Assessment (MA). 2005b. *Ecosystems and human wellbeing: Synthesis*. Island Press, Washington DC.

Minsky, M. 1974. A framework for representing knowledge. Pages 211–277*in* P. Winston, editor.*The Psychology of Computer Vision*. McGraw-Hill, Washington DC.

Mitchell, B. 2005. Integrated water resource management, institutional arrangements, and land-use planning. *Environment and Planning A* 37(8):1335–1352.

Nahlik, A. M., M. E. Kentula, M. S. Fennessy, and D. H. Landers. 2012. Where is the consensus? A proposed foundation for moving ecosystem service concepts into practice. *Ecological Economics* 77:27–35.

Nahuelhual, L., A. Carmona, P. Lozada, A. Jaramillo, and M. Aguayo. 2013. Mapping recreation and ecotourism as a cultural ecosystem service: An application at the local level in Southern Chile. *Applied Geography* 40:71–82.

Nash, N., A. Lewis, and C. Green. 2010. "Not in our front garden": Land use conflict, spatial meaning and the politics of naming place. *Journal of Community & Applied Social Psychology* 20:44–56.

NATIONAL and CRA. 2016. *What Was Said Final Report*. Fredericton, Canada.

NB Power. 2016a. *Considering the future of Mactaquac*. Fredericton, Canada.

NB Power. 2016b. *Backgrounder: Mactaquac Generating Station Life Achievement Project*. Fredericton, Canada.

NB Power. 2017. *Backgrounder, Mactaquac Generating Station Life Achievement Project. Business Case and Technical Considerations*. Fredericton, Canada.

Nie, M. 2003. Drivers of natural resource-based political conflict. *Policy Sciences* 36(3/4):307–341.

Nilsson, C., and K. Berggren. 2000. Alterations of riparian ecosystems caused by river regulation. *BioScience* 50(9):783–792.

Norgaard, R. B. 2010. Ecosystem services: From eye-opening metaphor to complexity blinder. *Ecological Economics* 69(6):1219–1227.

O'Connor, J. E., J. J. Duda, and G. E. Grant. 2015. 1000 dams down and counting. *Science* 348(6234):496–497.

OECD. 2008. *Strategic Environmental Assessment and Adaption to Climate Change. Endorsed by members of the DAC Network on Environment and Development Co-operation (ENVIRONET) at their 8th Meeting on 30 October 2008*.

Paavola, J., and K. Hubacek. 2013. Ecosystem Services, Governance, and Stakeholder

Participation: an Introduction. *Ecology and Society* 18(4):42.

Palomo, I., B. Martin-Lopez, C. Lopez-Santiago, and C. Montes. 2011. Participatory Scenario Planning for Protected Areas Management under the Ecosystem Services Framework: the Doñana Social-Ecological System in Southwestern Spain. *Ecology And Society* 16(1):23.

Palomo, I., B. Marton-Lopez, P. Zorrilla-Miras, D. Garcia Del Amo, and C. Montes. 2014. Deliberative mapping of ecosystem services within and around Donana National Park (SW Spain) in relation to land use change. *Regional Environmental Change* 14(1):237–251.

Pearson, A. J., N. P. Snyder, and M. J. Collins. 2011. Rates and processes of channel response to dam removal with a sand-filled impoundment. *Water Resources Research* 47(July 2010):W08504.

Peterson, G. D., Z. V. Harmáčková, M. Meacham, C. Queiroz, A. Jiménez-Aceituno, J. J. Kuiper, K. Malmborg, N. Sitas, and E. M. Bennett. 2018. Welcoming different perspectives in IPBES: "Nature's contributions to people" and "Ecosystem services." *Ecology and Society* 23(1):39.

Peterson, T. R. 2005. Social Control Frames: Opportunities or Constraints? *Environmental Practice* 5(3):232–238.

Plieninger, T., S. Dijks, E. Oteros-Rozas, and C. Bieling. 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. *Land Use Policy* 33(July 2015):118–129.

Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The Natural Flow Regime. A paradigm for river conservation and restoration. *BioScience* 47(11):769–784.

Poff, N. L., and J. K. H. Zimmerman. 2010. Ecological responses to altered flow regimes: a literature review to inform the science and management of environmental flows. *Freshwater Biology* 55(1):194–205.

Potschin, M. B., and R. Haines-Young. 2017. Linking people and nature: Socio-ecological systems. Pages 41–43*in* B. Burkhard and J. Maes, editors.*Ecosystem Services Mapping*. Pensoft Publishers.

Raudsepp-Hearne, C., G. D. Peterson, and E. M. Bennett. 2010. Ecosystem service bundles for

analyzing tradeoffs in diverse landscapes. *Proceedings of the National Academy of Sciences of the United States of America* 107(11):5242–7.

Rauschmayer, F., and H. Wittmer. 2006. Evaluating deliberative and analytical methods for the resolution of environmental conflicts. *Land Use Policy* 23(1):108–122.

Ravikumar, A., K. Andersson, and A. M. Larson. 2013. Decentralization and forest-related conflicts in Latin America. *Forest Policy and Economics* 33:80–86.

Raymond, C. M., G. Brown, and D. Weber. 2010. The measurement of place attachment: Personal, community, and environmental connections. *Journal of Environmental Psychology* 30(4):422–434.

Raymond, C. M., B. a. Bryan, D. H. MacDonald, A. Cast, S. Strathearn, A. Grandgirard, and T. Kalivas. 2009. Mapping community values for natural capital and ecosystem services. *Ecological Economics* 68(5):1301–1315.

RBC. 2017. *New Brunswick Budget 2017*.

Redford, K. H., and W. M. Adams. 2009. Payment for ecosystem services and the challenge of saving nature. *Conservation Biology* 23(4):785–7.

Redpath, S. M., J. Young, A. Evely, W. M. Adams, W. J. Sutherland, A. Whitehouse, A. Amar, R. A. Lambert, J. D. C. Linnell, A. Watt, and R. J. Gutie. 2013. Understanding and managing conservation conflicts. *Trends in Ecology and Evolution* 28(2):100–109.

Reed, M. S. 2008. Stakeholder participation for environmental management: A literature review. *Biological Conservation* 141(10):2417–2431.

Reyers, B., R. Biggs, G. S. Cumming, T. Elmqvist, A. P. Hejnowicz, and S. Polasky. 2013. Getting the measure of ecosystem services: A social-ecological approach. *Frontiers in Ecology and the Environment* 11(5):268–273.

Rickard, L., and R. C. Stedman. 2015. From Ranger Talks to Radio Stations: The Role of Communication in Sense of Place. *Journal of Leisure Researc* 47(1):15–33.

Rodríguez, J. P., T. D. Beard, E. M. Bennett, G. S. Cumming, S. J. Cork, J. Agard, A. P. Dobson, and G. D. Peterson. 2006. Trade-offs across Space, Time, and Ecosystem Services. *Ecology And Society* 11(1):28.

Sandström, C., K. Eckerberg, and K. Raitio. 2013. Studying conflicts, proposing solutions -

Towards multi-level approaches to the analyses of forest conflicts. *Forest Policy and Economics* 33:123–127.

Santos-Martín, F., B. Martín-López, E. Kelemen, S. Jacobs, M. García-Llorente, D. Barton, E. Otero-Rozas, I. Palomo, and V. Heiva. 2016. *Social Assessment Methods and Applications. Esmeralda Deliverable 4.3*.

Saravanan, V. S., G. T. McDonald, and P. P. Mollinga. 2009. Critical review of Integrated Water Resources Management: Moving beyond polarised discourse. *Natural Resources Forum* 33(1):76–86.

Sayre, N. F., and A. V. Di Vittorio. 2009. Scale. Pages 19–28*in* R. Kitchin and N. Thrift, editors.*International Encyclopeadia of Human Geography. Vol. 1.* Elsevier, Oxford, UK.

Schluter, M., A. Baeza, G. Dressler, K. Frank, J. Groeneveld, W. Jager, M. A. Janssen, R. R. J. McAllister, B. Müller, K. Orach, N. Schwarz, and N. Wijermans. 2017. A framework for mapping and comparing behavioural theories in models of social-ecological systems. *Ecological Economics* 131:21–35.

Schmidtz, D. 2000. Natural Enemies: An Anatomy of Environmental Conflict. *Environmental Ethics* 22(Winter):397–408.

Sherren, K., T. M. Beckley, S. Greenland-Smith, and L. Comeau. 2017. How Provincial and Local Discourses Aligned Against the Prospect of Dam Removal in New Brunswick , Canada. *Water Alternatives* 10(3):697–723.

Sherren, K., T. M. Beckley, J. R. Parkins, R. C. Stedman, K. Keilty, and I. Morin. 2016. Learning (or living) to love the landscapes of hydroelectricity in Canada: Eliciting local perspectives on the Mactaquac Dam via headpond boat tours. *Energy Research & Social Science* 14:102–110.

Shmueli, D. F. 2008. Framing in geographical analysis of environmental conflicts: Theory, methodology and three case studies. *Geoforum* 39(6):2048–2061.

Shmueli, D. F., and M. Ben-Gal. 2003. Stakeholder frames in the mapping of the Lower Kishon River basin conflict. *Conflict Resolution Quarterly* 21(2):211–238.

Shmueli, D. F., M. Elliott, and S. Kaufman. 2006. Frame changes and the management of intractable conflicts. *Conflict Resolution Quarterly* 24(2):207–218.

Si, Z. 1993. A theoretical framework for social impact analysis with special reference to population relocation at the Mactaquac Dam project on the Saint John River. Dalhousie University.

Sica, C. E. 2015. Stacked scale frames: Building hegemony for fracking across scales. *Area* 47(4):443–450.

Sidaway, J. 2005. *Resolving Environmental Disputes: From Conflict to Consensus*. Earthscan.

Smaldone, D., C. Harris, and N. Sanyal. 2008. The role of time in developing place meanings. *Journal of Leisure Research2* 40(4):479–504.

Smith, J. W., M. A. Davenport, D. H. Anderson, and J. E. Leahy. 2011. Place meanings and desired management outcomes. *Landscape and Urban Planning* 101(4):359–370.

Spartz, J. T., and B. R. Shaw. 2011. Place meanings surrounding an urban natural area: A qualitative inquiry. *Journal of Environmental Psychology* 31(4):344–352.

Stanley, E. H. H., and M. W. Doyle. 2003. The ecological effects of dam removal. *Frontiers in Ecology and the Environment* 1(1):15–22.

Stantec. 2015. *Mactaquac Project Comparative Environmental Review Report*.

Statistics Canada. 2017. *Census profile, 2016 census*.

Stedman, R. 2016. Subjectivity and social-ecological systems: a rigidity trap (and sense of place as a way out). *Sustainability Science* 11(6):891–901.

Stedman, R. C. 2002. Toward a social psychology of place: Predicting behavior from place-based cognitions, attitude, and identity. *Environment and Behavior* 34(5):561–581.

Stedman, R. C. 2003. Is It Really Just a Social Construction?: The Contribution of the Physical Environment to Sense of Place. *Society & Natural Resources* 16(8):671–685.

Stedman, R. C. 2008. What Do We "Mean" by Place Meanings? Implications of Place Meanings for Managers and Practitioners. Pages 61–82*in* L. E. Kruger, T. E. Hall, and M. C. Stiefel, editors.*Understanding concepts of place in recreation research and management*. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Stedman, R. C., T. Beckley, S. Wallace, and M. Ambard. 2004. A Picture and 1000 Words: Using Resident-Employed Photography to Understand Attachment to High Amenity

Places. *Journal of Leisure Research* 36(4):580–606.

Sténs, A., and C. Sandström. 2013. Divergent interests and ideas around property rights: The case of berry harvesting in Sweden. *Forest Policy and Economics* 33:56–62.

Stokowski, P. A. 2002. Languages of place and discourses of power: Constructing new senses of place. *Journal of Leisure Research* 34(4):368–382.

Tajfel, H., M. G. Billig, R. P. Bundy, and C. Flament. 1971. Social categorization and intergroup behaviour. *European Journal of Social Psychology* 1(2):149–178.

Tallis, H., P. Kareiva, M. Marvier, and A. Chang. 2008. An ecosystem services framework to support both practical conservation and economic development. *Proceedings of the National Academy of Sciences* 105(28):9457–9464.

Termeer, C. J. A. M., A. Dewulf, and M. Van Lieshout. 2010. Disentangling Scale Approaches in Governance Research: Comparing Monocentric, Multilevel, and Adaptive Governance 15(4).

Tonitto, C., and S. J. Riha. 2016. Planning and implementing small dam removals: Lessons learned from dam removals across the eastern United States. *Sustainable Water Resources Management* 2:489–507.

Tremblay, R. 2016. Wolastoq Grand Council on the Mactaquac Dam. *NB Media Co-op*.

Trentelman, C. K. 2009. Place Attachment and Community Attachment: A Primer Grounded in the Lived Experience of a Community Sociologist. *Society & Natural Resources* 22(3):191–210.

Tuan, Y. F. 1977. *Space and place: The perspective of experience*. University of Minnesota Press, Minneapolis.

Tversky, A., and D. Kahneman. 1981. The framing of decisions and the psychology of choice. *Science* 211(4481):453–458.

Twigger-Ross, C. L., and D. L. Uzzell. 1996. Place and identity processes. *Journal of Environmental Psychology* 16:205–220.

United Nations. 2015. *Transforming our world: the 2030 Agenda for Sustainable Development*. Page *Resolution adopted by the General Assembly*.

Villamagna, A. M., P. L. Angermeier, and E. M. Bennett. 2013. Capacity, pressure, demand,

and flow: A conceptual framework for analyzing ecosystem service provision and delivery. *Ecological Complexity* 15:114–121.

Voinov, A., and F. Bousquet. 2010. Modelling with stakeholders. *Environmental Modelling & Software* 25(11):1268–1281.

Vorkinn, M., and H. Riese. 2001. Environmental Concern in a Local Context: The Significance of Place Attachment. *Environment and Behavior* 33(2):249–263.

Vörösmarty, C. J. 2000. Global Water Resources: Vulnerability from Climate Change and Population Growth. *Science* 289(5477):284–288.

Vörösmarty, C. J., P. B. McIntyre, M. O. Gessner, D. Dudgeon, a Prusevich, P. Green, S. Glidden, S. E. Bunn, C. a Sullivan, C. R. Liermann, and P. M. Davies. 2010. Global threats to human water security and river biodiversity. *Nature* 467(7315):555–61.

WCD. 2000. *Dams and Development: A new framework for decision-making*. Earthscan, London and Sterling, VA.

Westman, W. E. 1977. How much are nature's services worth? *Science* 197(4307):960–964.

White, R. M., A. Fischer, K. Marshall, J. M. J. Travis, T. J. Webb, and S. M. Redpath. 2009. Developing an integrated conceptual framework to understand biodiversity conflicts. *Land Use Policy* 26:242–253.

Williams, D. R. 2008. Chapter 2 — Pluralities of Place : A User's Guide to Place Concepts, Theories, and Philosophies in Natural Resource Management. Pages 7–30*in* L. E. Kruger, T. Hall, and M. Stiefel, editors.*Understanding concepts of place in recreation research and management, PNW-GTR-744*. USDA Forest Service, Pacific Northwest Research Station.

Williams, D. R., E. Patterson, Micahel, and J. W. Roggenbuck. 1992. Beyond the commodity metaphor: Examining emotional and symbolic attachment to place. *Leisure Sciences* 14:29–46.

Williams, D. R., and S. I. Stewart. 1998. Sense of place. An elusive concept that is finding a home in ecosystem management. *Journal of Forestry* 96(5):18–23.

Wittmer, H., F. Rauschmayer, and B. Klauer. 2006. How to select instruments for the resolution of environmental conflicts? *Land Use Policy* 23(1):1–9.

Wohl, E., S. N. Lane, and A. C. Wilcox. 2015. The science and practice of river restoration. *Water Resources Research* 51:5974–5997.

Wolff, S., C. J. E. Schulp, and P. H. Verburg. 2015. Mapping ecosystem services demand: A review of current research and future perspectives. *Ecological Indicators* 55:159–171.

Wondolleck, J. M., B. Gray, and T. Bryan. 2003. Us versus Them: How Identities and Characterizations Influence Conflict. *Environmental Practice* 5(3):207–214.

World Commission on Dams. 2000. *Dams and Development*. Earthscan, London.

Yahdjian, L., O. E. Sala, and K. M. Havstad. 2015. Rangeland ecosystem services : shifting focus from supply to reconciling supply and demand In a nutshell : *Frontiers in Ecology and the Environment* 13(1):44–51.

Yasmi, Y., J. Guernier, and C. J. . Colfer. 2009. Positive and negative aspects of forestry conflict: lessons from a decentralized forest management in Indonesia. *International Forestry Review* 11(1):98–110.

Yasmi, Y., L. C. Kelley, and T. Enters. 2013. Community-outsider conflicts over forests: Perspectives from Southeast Asia. *Forest Policy and Economics* 33:21–27.

Young, J. C., M. Marzano, R. M. White, C. P. Quine, and A. D. Watt. 2010. The emergence of biodiversity conflicts from biodiversity impacts : characteristics and management strategies:3973–3990.

Zachrisson, A., and K. Beland Lindahl. 2013. Conflict resolution through collaboration: Preconditions and limitations in forest and nature conservation controversies. *Forest Policy and Economics* 33:39–46.

FOREWORD TO CHAPTER 3

The literature review in the preceding chapter established ecosystem services as a useful concept to link the social and ecological impacts of decisions concerning water resources management, including potential removal of dams. In particular, diverging social demand for ecosystem services can be due to different and potentially conflicting interests. Understanding the variations in social demand for ecosystem services and how they conflict is thus an important component of assessing the role of competing interests in conflicts around dam removals.

This chapter and the next present two forms of assessing social demand for ecosystem services. In this chapter, the importance of considering the spatial distribution of ecosystem service benefits is highlighted and the extent to which interests can conflict in type of service demanded and in where it is demanded is considered. To do this, participatory mapping of ecosystem services is used as an empirical contribution to the literature on spatial distribution of social demand for ecosystem services in an understudied context – the dammed river (Darvill and Lindo 2014, Brummer et al. 2017).

Given that conflicts over ecosystem services involve perceptions of changes to the ecosystem, the participatory mapping methodology is extended to assess whether stakeholders can map their perceptions of the spatial distribution of ecosystem services under different future scenarios. The mapping methodology has not been used in this way to date, and therefore the extent to which stakeholders can (a) discuss their perceptions of spatial changes in a semi-structured interview, and (b) map those changes is assessed.

This paper is published in Ecosystem Services (Reilly et al. 2018; https://doi.org/10.1016/j.ecoser.2018.01.002). The format has been modified to be consistent with the remainder of this thesis. All literature cited in this chapter is listed at the end of this chapter.

The author of the thesis was responsible for the research design, data collection and analysis, and wrote the manuscript presented here. She also provided the overall direction for and contributed to the transcription and coding of interviews, the digitisation of the maps and the development of the GIS database. Dr Jan Adamowski, the thesis supervisor, was responsible for reviewing and editing the manuscript. Kimberly John assisted with transcribing and coding interviews, digitising maps, and developing the GIS database analysed in this paper.

3. Participatory mapping of ecosystem services to understand stakeholders' perceptions of the future of the Mactaquac Dam, Canada.

Reilly, K.H., Adamowski, J.F. and John, K.

3.1. Abstract

Rebuilding or removing a dam at the end of its lifespan will change provision of and access to ecosystem services. Understanding such changes involves assessing their biophysical provision, economic value and social demand, of which the latter is often neglected. We used participatory mapping to understand the spatial distribution of social benefits from ecosystem services around the Mactaquac Dam, New Brunswick, Canada, and assessed whether perceptions of ecosystem services under future scenarios can be mapped. We asked 32 participants to map places that were important to them for several ecosystem services, and asked how those places and services would change if the dam were rebuilt or removed. Participants benefitted from services throughout the reservoir, downstream of the dam, and in unaffected tributaries. Those who preferred to rebuild the dam mapped places in and around the reservoir, while those who wanted to remove it preferred the tributaries and downstream reach. Most participants could not map service distribution if the dam were removed, but could describe non-place-specific changes. Participatory mapping is useful for understanding how and where stakeholders benefit from ecosystem services, and to prompt discussion of perceived future changes. It is less useful for producing maps of ecosystem services under future scenarios, such as dam removal.

Keywords: ecosystem services; participatory mapping; stakeholders; dam removal

3.2. Introduction

Large dams change river ecology, and in doing so alter the provision of and access to ecosystem services, including flood regulation, soil fertility, and cultural services such as recreation (World Commission on Dams (WCD) 2000; Dudgeon et al. 2006; Auerbach et al. 2014). Now that many of the large dams built in the early to mid-twentieth century are reaching the end of their lifespans, the balance between those positive and negative changes to ecosystem services informs decisions on whether to rebuild or remove them (WCD 2000). Assessing ecosystem services enables the ecological and social impacts of the possible options to be linked (Daily and Matson 2008), and can provide a framework for stakeholder participation (Cowling et al. 2008; Bryan et al. 2010; Reed et al. 2013).

The impacts of dam construction and removal on ecosystem services vary spatially, particularly between upstream and downstream reaches and the dam site (Hart et al. 2002; Auerbach et al. 2014; Kirchherr et al. 2016). However, how and where people currently benefit from ecosystem services in dammed river environments, and how that might change if the dam is removed, has not been extensively studied to date (Zhu et al. 2010; Darvill and Lindo 2014; Brummer et al. 2017). Participatory mapping allows stakeholders to express where they benefit from ecosystem services, which can be used to understand stakeholders' values in the area and possible conflicts between them (Brown 2003; Klain and Chan 2012; Brown and Raymond 2014). It also has the potential to reveal perceptions of ecosystem services under different future management scenarios, although this has not been explored.

The aims of this study, therefore, were: (1) to explore the spatial distribution of different types of ecosystem services in and around a dammed river and how it varied between stakeholder groups, and (2) to assess the potential usefulness of participatory mapping for eliciting stakeholders' perceptions of the spatial distribution of ecosystem services under various future scenarios.

3.3. Literature review

3.3.1. Social benefits of ecosystem services in dammed and free-flowing rivers

Understanding how the ecological components and processes that provide ecosystem services benefit human wellbeing is important for determining the effects of ecological change (Cowling et al. 2008), including that caused by dam construction and removal (Brismar 2002). Dam construction changes the ecosystem services provided by free-flowing rivers, including soil fertilisation, water purification, and habitat for species with intrinsic value (Poff et al. 1997;

Bunn and Arthington 2002; Auerbach et al. 2014). It also may introduce new ecosystem services such as hydropower and recreation on the reservoir (Table 3.1) (Brismar 2002; Auerbach et al. 2014). Removing dams can, to some extent, reverse these changes, by restoring fish passage and reducing some types of recreation, for example (Born et al. 1998; Bednarek 2001; Auerbach et al. 2014; Magilligan et al. 2016). Rebuilding a dam offers the opportunity to upgrade its design, such as by installing fish ladders, and preserves the reservoir's ecosystem services (Pittock and Hartmann 2011), but also locks in other negative impacts for the lifespan of the replacement dam.

Table 3.1. Examples of ecosystem services provided by free-flowing rivers and by dammed rivers (adapted from Brismar 2002, Auerbach et al. 2014). Exact services provided will depend on river ecology, environmental context, type of dam, etc.

Ecosystem services provided by free-flowing rivers	**Ecosystem services provided by dammed rivers**
Intrinsic value of free-flowing river ecosystem.	Reservoir-based recreation, including boating and fishing.
Recreational fishing.	Aesthetic appreciation.
Recreational canoeing and kayaking throughout river.	Production of reservoir fish species (may be non-native).
Aesthetic appreciation.	Hydropower production.
Production of native fish species, including migratory species.	Water supply through diversion from the reservoir.
Floodwater storage in floodplains.	Flood control both up and downstream through reservoir management and prevention of ice jams.
Sediment transportation, creating riverine and estuarine habitats downstream.	Lacustrine habitat in the reservoir.
Soil fertilisation in the floodplain.	

The changes in ecosystem service provision caused by removing or rebuilding dams will affect people in different ways, making social assessment of ecosystem services essential (Cowling et al. 2008). However, few studies have explored the social benefits of ecosystem services in dammed river environments and assessed how they would be affected by removing or rebuilding the dam (Lejon et al. 2009; Fox et al. 2016; Brummer et al. 2017; Reilly and Adamowski 2017).

How people benefit from a given set of ecosystem services has been found to vary between individuals according to their interest(s) (Casado-Arzuaga et al., 2013), level of scientific

knowledge/expertise (Lamarque et al. 2011; Martín-López et al. 2012), degree of familiarity with the location (Fagerholm et al. 2012), experiences in the area (Lamarque et al. 2011), and several other factors (Darvill and Lindo 2014; García-Nieto et al. 2015). Social benefits from ecosystem services also vary spatially (Brown et al. 2002; Fagerholm et al. 2012; Plieninger et al. 2013; Potschin and Haines-Young 2013). This is partly because of variation in the biophysical provision of different services (Plieninger et al. 2013; Brown 2013; Van Berkel and Verburg 2014), but is also related to accessibility. Service use is affected by distance from the home or from roads, with the nature of the relationship varying between services (Brown et al. 2002; Fagerholm et al. 2012). For example, Brown et al. (2002) found that services used directly, such as recreation, tended to be near communities, while indirect benefits, such as intrinsic value, were further away. Even within a given spatial pattern of ecosystem service provision, individuals vary in where they derive benefits according to where they live, how long they have been in the area, their values, stakeholder group, and other factors (Fagerholm et al. 2012; Darvill and Lindo 2014).

Spatially explicit assessment of the social benefits derived from ecosystem services is therefore a useful contribution to the decision-making process around the future of dams (Cowling et al. 2008). It allows individuals' concerns and values about specific places to be taken into account, and ensures that decision makers understand how the spatial impacts of the decision will affect different people (Darvill and Lindo 2014). Lastly, it can inform mitigation measures to restore or enhance ecosystem service hotspots where multiple people experience benefits (Alessa et al. 2008; Bryan et al. 2010).

3.3.2. Participatory mapping of ecosystem services

Participatory mapping is a popular approach to determine the spatial distribution of social benefits from ecosystem services to support decision making and/or engage stakeholders (Bryan et al. 2010; Brown and Fagerholm 2014; Brown et al. 2017). It can be used to gather objective local ecological knowledge or to reveal stakeholders' personal perceptions and experiences of ecosystem services (Fagerholm et al. 2012; Brown 2013; De Vreese et al. 2016). In this study, we focus on the latter to understand perceptions of the social impacts of a decision on a dam.

A wide variety of methods are used for participatory mapping of ecosystem services (Brown and Fagerholm 2014; Brown and Kyttä 2014), which divide into two approaches: quantitative and qualitative (Brown and Fagerholm 2014; Brown et al. 2017). Quantitative studies use

random sampling and large sample sizes ($n > 500$), and typically require participants to map a pre-defined list of ecosystem services (Brown and Raymond 2007; Alessa et al. 2008; Brown and Fagerholm 2014; Brown et al. 2017). Qualitative studies use purposive sampling size and smaller sample sizes ($n = 22$ to $n = 218$), primarily to test methodology or to provide an in-depth assessment of local circumstances (Raymond et al. 2009; Ruiz-Frau et al. 2011; Fagerholm et al. 2012; Klain and Chan 2012; Darvill and Lindo 2014; De Vreese et al. 2016). Most qualitative studies use an inductive approach, in which the ecosystem services mapped emerge from qualitative analysis of interview data (Raymond et al. 2009; Klain and Chan 2012).

While participatory mapping has been used in a variety of contexts, the spatial distribution of social benefits from ecosystem services in a dammed river environment has been little studied (Zhu et al. 2010; Darvill and Lindo 2014). In the context of decision-making processes around dam removal, it is also necessary to determine how stakeholders perceive that their benefits from ecosystem services will change. The utility of participatory mapping to assess perceptions of different management scenarios has not been tested to date.

3.4. Study area

This research was focused on the Mactaquac Dam, a large hydroelectric dam on the Saint John River, New Brunswick, Canada (Figure 3.1). This case was chosen because a decision-making process about whether to rebuild or remove the dam was underway at the time of study, triggered by a structural problem that shortened its lifespan (New Brunswick (NB) Power 2014). The possible options for the dam (rebuild or remove) were perceived to change future ecosystem service provision and benefits (NATIONAL and CRA 2016; Reilly and Adamowski 2017) but how those perceived changes were distributed spatially was not known.

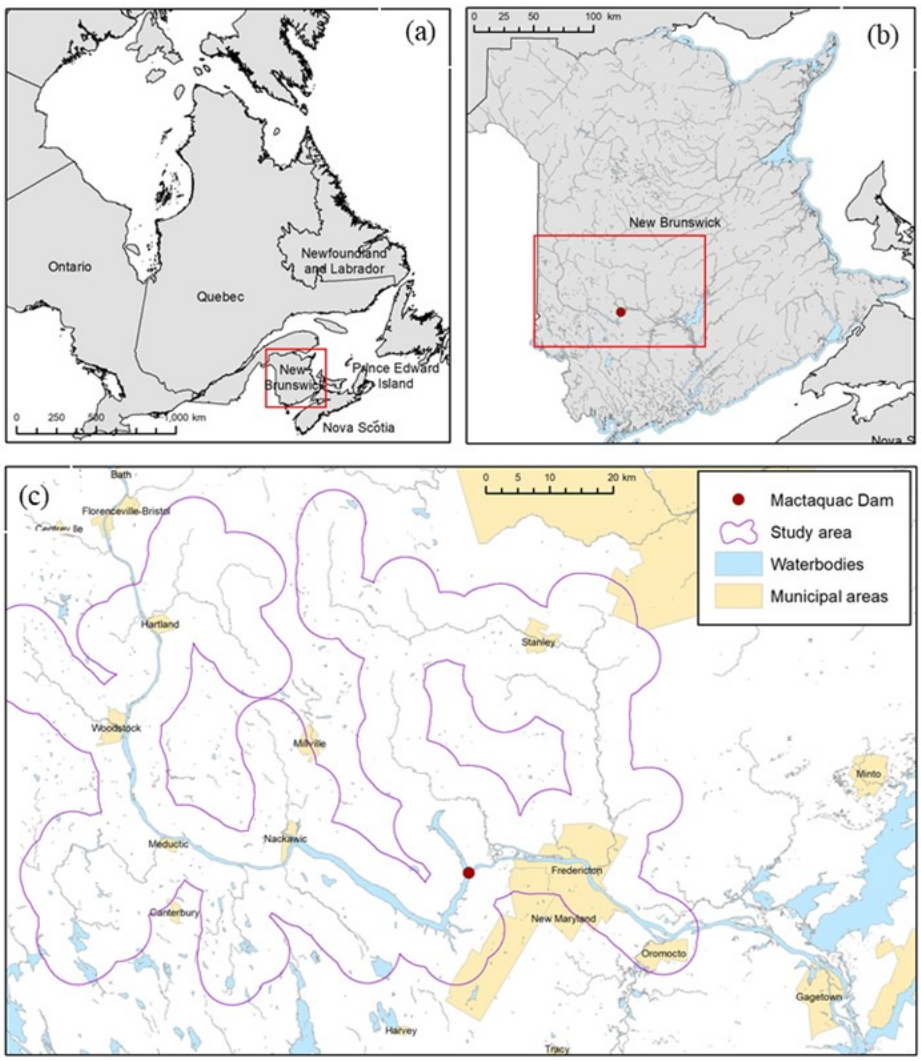


Figure 3.1. Location of the study area in Canada (a) and New Brunswick (b). Boundaries of the study area shown in (c) and defined as a 5000 m buffer around the reach of the river most hydrologically affected by the dam (approximately Hartland to Oromocto) and its tributaries. Produced in ArcGIS 10.4 (ESRI 2016) and contains information licensed under the GeoNB Open Data Licence and under the Open Government Licence – Canada, as well as data from Natural Earth.

The Saint John River watershed is in a region of humid continental climate with cold winters and warm summers. The annual mean flow for the river is 1100 m^3/s, which peaks in late spring due to snowmelt, with a smaller peak in autumn (Canadian Rivers Institute 2011). Most land in the study area, defined as the reach of the river hydrologically affected by the dam and its tributaries and riparian zones, is forested, with smaller areas of agriculture, wetlands, water and settlement (Figure 3.2). The area is biodiverse, with several species at risk and 53 fish species (Canadian Rivers Institute 2011).

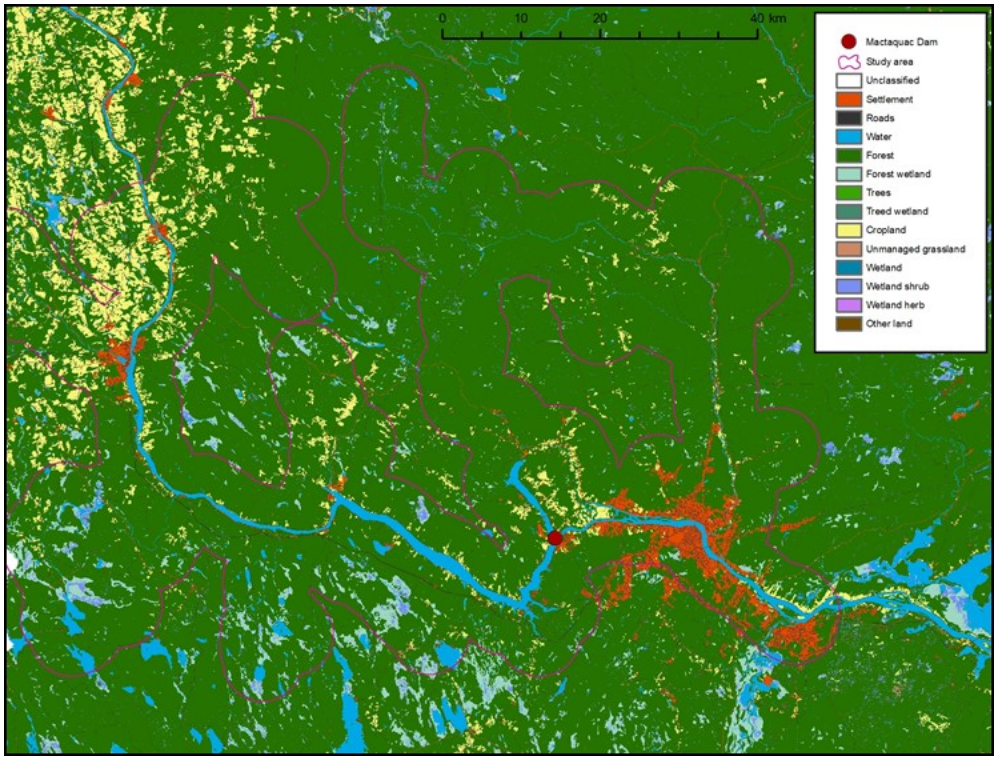


Figure 3.2. Land use in the study area. Produced in ArcGIS 10.4 (ESRI 2016) and contains information licensed under the GeoNB Open Data Licence and from Agriculture and Agri-Food Canada under the Open Government Licence – Canada, as well as data from Natural Earth.

Construction of the dam created a reservoir, known as the Mactaquac headpond, that reaches nearly 100 km upstream to the town of Hartland (Figure 3.1) and is deeper and slower moving than the free-flowing river (Canadian Rivers Institute 2011). The dam and headpond form a barrier to migrating fish, including Atlantic salmon, and the headpond provides habitat for non-native species, including muskellunge and smallmouth bass (Canadian Rivers Institute 2011). The salmon fishery is currently closed due to population decline, for which the Mactaquac Dam is thought to be partially responsible (Canadian Rivers Institute 2011; Government of New Brunswick 2016). The creation of the headpond also resulted in a loss of productive farmland, historical and cultural heritage, and numerous homes (Bourgoin 2013).

Despite these changes, many other ecosystem services remain or have become important locally (Reilly and Adamowski 2017). There is widespread concern for the intrinsic value of ecosystems; the stakeholder consultation for the decision identified environmental protection as a priority (NATIONAL and CRA 2016). Recreation that depends on ecosystems, including

fishing, boating, and fiddlehead harvesting, is locally popular (NATIONAL and CRA 2016; Reilly and Adamowski 2017), and supports tourism (Stantec 2015).

The dam produces 12% of New Brunswick's electricity, but its concrete electricity generating structures are affected by an alkali-aggregate reaction that is shortening the life of the dam (Stantec 2015). Thus, the dam's owners, New Brunswick Power, had to decide whether to rebuild the affected concrete structures and repower the dam, retain only the earthen dam to maintain the headpond, or remove the dam entirely (NB Power 2014). Local stakeholders were divided about which option should be chosen, with some interest groups advocating for retaining the dam and others for removing it (Keilty et al. 2016; NATIONAL and CRA 2016; Sherren et al. 2016; Reilly and Adamowski 2017).

Data collection occurred during and immediately after the final stages of New Brunswick Power's public consultation process (NATIONAL and CRA 2016). By the time of writing, the decision had been made to intensify maintenance to prolong the dam's lifespan and install a fish ladder (NB Power 2016). Nevertheless, participatory mapping of ecosystem services allowed an understanding of current use of the dammed river environment.

3.5. Methods

3.5.1. Sample selection

We used non-proportional quota sampling of stakeholder groups to incorporate the widest possible range of ecosystem service benefits and interests, and explore the differences between people (Darvill and Lindo 2014; García-Nieto et al. 2015; Brown et al. 2017). To achieve this, we re-invited stakeholders who participated in an earlier phase of the study (Reilly and Adamowski 2017) and invited others following internet research and consultation with a local contact to identify interest groups and individuals who had not yet been contacted. We also used snowball sampling to include interests not yet represented in the study and those who had been difficult to reach otherwise (Darvill and Lindo 2014; Brown et al. 2017).

We interviewed 32 stakeholders, who produced 29 maps – the other three participants were family members who contributed to interviews but did not produce separate maps. The small sample size enabled in-depth exploration of the participants' experiences of ecosystem services (Klain and Chan 2012; Brown et al. 2017), while still being larger than the recommended sample size for mapping using polygons (Brown and Pullar 2012). The sample included residents upstream and downstream of the dam, small business owners, watershed groups, representatives of municipalities, recreational groups of several types, members of

environmental and heritage groups, and student researchers. First Nations and industry representatives were invited to participate in the earlier phase of the study but ultimately chose not to be involved. The participants were located throughout the study area.

3.5.2. Participatory mapping exercise

The participatory mapping exercise was conducted during in-person interviews (Brown et al. 2014, 2017). We used interviews rather than focus groups so that participants would feel free to express their own perspectives, even when it was a minority opinion in the area (Sherren et al. 2016). They lasted for approximately 40–90 min and were conducted in May and June 2016.

The interviews followed a guide to elicit ecosystem service benefits (Appendix 3.1) adapted from that used by Klain and Chan (2012) and Gould et al. (2015), which we chose because it was designed to be accessible to non-experts with a broad range of experiences. We included prompts for the ecosystem services that were identified in the area during the first phase of this study and omitted prompts for those that were not (Reilly and Adamowski 2017). However, participants could bring up these services and other experiences in answers to other questions.

We chose paper-based mapping for the participatory mapping exercise as opposed to digital mapping because it was more accessible for the participants who were less familiar with internet-based mapping and/or did not have good internet connections. We used a map produced using datasets from GeoNB (Province of New Brunswick 2016) for roads, waterbodies, municipal areas, aboriginal lands and provincial parks, and a GeoGratis dataset (Natural Resources Canada 2003) for dams. We also added local points of interest, including Kings' Landing Historical Settlement (Figure 3.3). The A1 size map was printed in colour at a scale of 1:125,000.

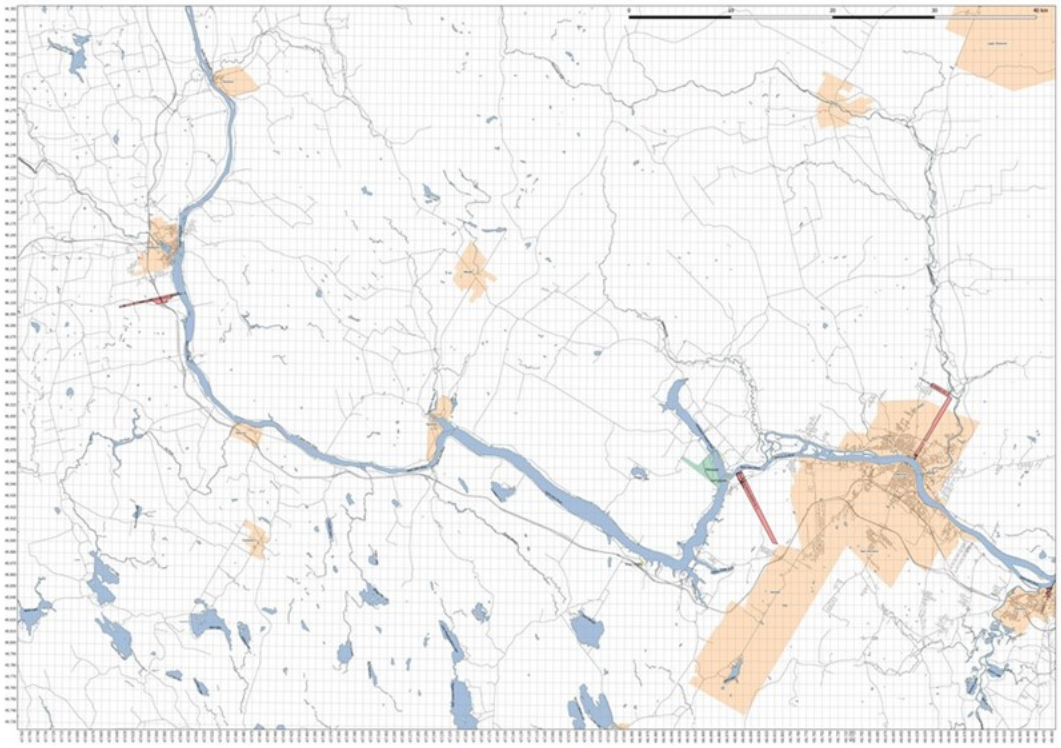


Figure 3.3. Map of the study area used for the participatory mapping exercise. Produced in ArcGIS 10.4 (ESRI 2016) and contains information licensed under the GeoNB Open Data Licence and under the Open Government Licence – Canada.

We started the tape-recorded interviews by asking participants their preferred option for the future of the dam. Participants that had been interviewed in the first phase of the study (Reilly and Adamowski 2017) were asked if they had changed their opinion in the year since.

We then presented the participants with the map and specified that we were interested in places in, near or around the river. We first asked them to mark their house and place of work, to ensure they understood the map and the method. We then asked participants the open-ended questions from the interview guide that they answered by drawing polygons (Figure 3.4) to mark places on a map (Raymond et al. 2009; Klain and Chan 2012). We asked them to draw polygons rather than points because polygons allow spatially significant places to be identified with a smaller sample size (Brown and Pullar 2012). We followed with probing questions on why the mapped place was important to them. This approach allowed participants to discuss any benefits that were not included in the interview guide and enabled them to easily identify where multiple ecosystem services were experienced in the same place (de Groot and Ramakrishnan 2005; Klain and Chan 2012; Miles et al. 2013; Plieninger et al. 2013).

Figure 3.4. Example of part of a stakeholder-produced map. The participant's mapped places are shown in orange and numbered in blue.

Lastly, we asked how they expected the mapped places to change under each option for the dam (i.e. rebuild or removal), and whether they expected any new services or places to become available if the dam were removed. They were asked to map these new places if they could, or to explain why they could not.

3.5.3. Data processing

We transcribed and summarised the interview recordings, and returned the summaries to the participants for them to check. Of the 14 stakeholders that responded, five requested minor changes.

We georeferenced the scanned paper maps in ArcMap 10.4 (ESRI 2016) to the datasets from which we produced the basemap and digitised the participants' mapped places. We entered the number of each shape and the participant's position on the dam's future, location, and stakeholder group into the geodatabase. The data was clipped to the study area (Figure 3.1 (3)).

Using RQDA (Huang 2014), we inductively coded the interview transcripts to identify ecosystem services used at each place, regardless of the prompt that they were mentioned in

response to (Miles et al. 2013; Brown et al. 2017). In an iterative process of coding and checking against the dataset, we produced a codebook of ecosystem services (Appendix 3.2) and entered all ecosystem services experienced at each mapped place into the geodatabase.

3.5.4. GIS analysis

We exported the data to Excel to calculate descriptive statistics, including the mean number of shapes mapped per participant, shape area, number of ecosystem services per shape, and the number of shapes per service.

We then used ArcGIS 10.4 (ESRI 2016) to analyse the distribution of mapped places across the study area. We first converted the polygon shapefiles to points by mapping the (x, y) centroid of each polygon (Brown et al. 2017) and clipped them to the study area (Figure 3.1 (3)). We then spatially joined the centroid points to a 1 km^2 'fishnet' sampling grid to produce counts of mapped places per grid cell. A 1 km^2 grid was chosen because it produced an appropriate balance between resolution and variation in number of points per grid cell to compare densities (Brown and Raymond 2014). We removed all grid cells with zero counts prior to analysis.

We produced heatmaps using simple point densities (Brown and Raymond 2014) for the entire dataset and various sub-groups (participants' position on the dam, ecosystem service). In each case, we classified the density values into five equal classes to allow qualitative comparison between heatmaps (Scolozzi et al. 2015). We then used global Moran's I (Moran 1950) to assess spatial autocorrelation in the incident data (points mapped per 1 km^2 grid cell) and determine if its distribution was dispersed, random or clustered. To identify hotspots more objectively, we used the Getis-Ord Gi$*$ statistic to identify locations of clusters of more points per grid cell than would be expected in a random distribution (Getis and Ord 1992; Zhu et al. 2010; Brown and Raymond 2014; Brown et al. 2017).

3.5.5. Qualitative analysis

We used qualitative data analysis methods to analyse participants' reasons for not mapping places and their perceptions of the different options for the dam's future. We used RQDA (Huang 2014) to code participants' refusals to map a place, and categorised the resulting codes into the major reasons given for the refusals. We then analysed participants' perceptions of how each mapped place would be affected by each option and of whether any new places or experiences/activities would become available. We used inductive coding to identify the major perceived impacts of dam removal, since that represented the biggest change from the status

quo. To understand the processes that led to the perceived impacts, we used causation coding (Miles et al. 2013). This involved coding the interviewee's perception of the causes of their anticipated outcome. From the final list of causation codes, we identified their perceptions of major changes caused by dam removal, the outcomes of the major changes, and the intermediate causative variables (Miles et al. 2013).

3.6. Results

3.6.1. Spatial patterns in ecosystem service benefits

Participants mapped 278 shapes, in which they benefitted from 26 ecosystem services. The mean number of ecosystem services identified per mapped shape was 2.1, with a range of one to nine services per shape. On average, 9.6 shapes were mapped per participant, and the mean area of shapes mapped was 9.1 km^2. Land-based recreation was mapped both by the greatest proportion of participants (79.3% of participants) and in the highest number of places (11.1% of places) (Table 3.2). The ecosystem service covering the largest total area was fishing (1125.5 km^2) and the smallest was soil fertility (0.03 km^2).

Table 3.2. Ecosystem services mapped by participants.

Category	Ecosystem service	Total area (km^2)	Mean area/ shape (km^2)	No. (%) of shapes	No. (%) of partici-pants	No. (%) of retainers	No. (%) of removers	No. (%) of neutrals
Cultural	Aesthetics	188.6	4	47 (8%)	21 (72.4%)	12 (75)	7 (70)	2 (67)
Cultural	Bequest	184.4	8.8	21 (3.6%)	13 (44.8%)	8 (50)	3 (30)	2 (67)
Cultural	Camping	76.5	4	19 (3.3%)	12 (41.4%)	8 (50)	2 (20)	2 (67)
Cultural	Canoeing and kayaking	428.9	9.1	47 (8%)	14 (48.3%)	7 (44)	4 (40)	3 (100)
Cultural	Cultural significance	164.9	5	33 (5.7%)	15 (51.7%)	9 (56)	4 (40)	2 (67)
Cultural	Fishing	1125.5	17.6	64 (11%)	17 (58.6%)	12 (75)	5 (50)	0
Cultural	Hunting	87.1	29	3 (0.5%)	2 (6.9%)	2 (13)	0	0
Cultural	Motorised boating	390.5	6.2	63 (10.8%)	14 (48.3%)	13 (81)	0	1 (33)
Cultural	Non-use (intrinsic) value	589	13.4	44 (7.5%)	16 (55.2%)	9 (56)	6 (60)	1 (33)

Category	Ecosystem service	Total area (km^2)	Mean area/ shape (km^2)	No. (%) of shapes	No. (%) of partici-pants	No. (%) of retainers	No. (%) of removers	No. (%) of neutrals
Cultural	Other land-based recreation	687.5	10.6	65 (11.1%)	23 (79.3%)	15 (94)	6 (60)	2 (67)
Cultural	Other water-based recreation	138.5	4.2	33 (5.7%)	16 (55.2%)	12 (75)	2 (20)	2 (67)
Cultural	Place memories	258.8	6.6	39 (6.7%%)	17 (58.6%)	10 (63)	6 (60)	1 (33)
Cultural	Relaxation	183	11.4	16 (2.7%)	10 (34.5%)	7 (44)	3 (30)	0
Cultural	Sailing	25.7	3.7	7 (1.2%)	5 (17.2%)	4 (25)	0	1 (33)
Cultural	Social connections	182.8	5.1	36 (6.2%)	18 (62.1%)	11 (69)	6 (60)	1 (33)
Cultural	Transport	14.1	1.1	13 (2.2%)	6 (20.7%)	5 (31)	0	1 (33)
Provisioning	Food provision	160.3	11.5	14 (2.4%)	8 (27.6%)	3 (19)	4 (40)	1 (33)
Provisioning	Hydropower	0.1	0.1	1 (0.2%)	1 (3.4%)	0	1 (10)	0
Provisioning	Non-food materials	20.6	6.9	3 (0.5%)	3 (10.3%)	2 (13)	0	1 (33)
Provisioning	Water supply	3.1	0.4	7 (1.2%)	4 (13.8%)	3 (19)	0	1 (33)
Regulating	Carbon sequestration	0.9	0.9	1 (0.2%)	1 (3.4%)	0	1 (10)	0
Regulating	Erosion protection	2.3	1.1	2 (0.3%)	2 (6.9%)	1 (6)	0	1 (33)
Regulating	Filtration	2.6	0.9	3 (0.5%)	3 (10.3%)	1 (6)	0	2 (67)
Regulating	Flood regulation	0.9	0.9	1 (0.2%)	1 (3.4%)	0	1 (10)	0
Regulating	Pollution dilution	0.2	0.2	1 (0.2%)	1 (3.4%)	0	0	1 (33)
Supporting	Soil fertility	0.03	0.03	1 (0.2%)	1 (3.4%)	1 (6)	0	0

There were some differences in the ecosystem services mapped by participants who wanted to retain the dam ('retainers'; 16 participants), remove the dam ('removers'; 10 participants) and who were neutral (three participants) (Table 3.2). The largest proportions of retainers mapped other land-based recreation (94%), followed by motorised boating (81%), and aesthetics,

fishing and other water-based recreation (e.g. swimming) (75% each). The greatest proportion of removers mapped aesthetics (70%), followed by non-use (intrinsic) value, place memories, other land-based recreation and social connections (60% each). All neutral participants mapped places for canoeing and/or kayaking. Cultural services were most frequently mapped across all groups, followed by provisioning services. Regulating and supporting services were rarely mapped.

Several participants refused to map some ecosystem services, especially non-use, because they did not consider them to be restricted to specific places. Instead, they thought that the whole headpond, whole river, or all natural areas were important. Two participants considered regulating services to be provided by a functioning system rather than individual places. Several others identified the types of places that provide regulating services but did not know where they were.

The mapped places were clustered (global Moran's Index = 0.039, $z = 2.25$, $p = 0.02$). Clusters were located around the confluences of major tributaries with the Saint John River, including with the Meduxnekeag and Nashwaak Rivers (map (a) Figure 3.5), the town of Nackawic, the area close to the dam where Mactaquac Provincial Park is located, parts of the south shore between Nackawic and the dam (including around King's Landing Historical Settlement and Long's Creek), and the islands upstream of Fredericton. Of these areas, the hotspots around Nackawic, King's Landing, Long's Creek, Mactaquac Provincial Park, the islands and the Nashwaak-Saint John confluence were statistically significant hotspots (map (b) Figure 3.5).

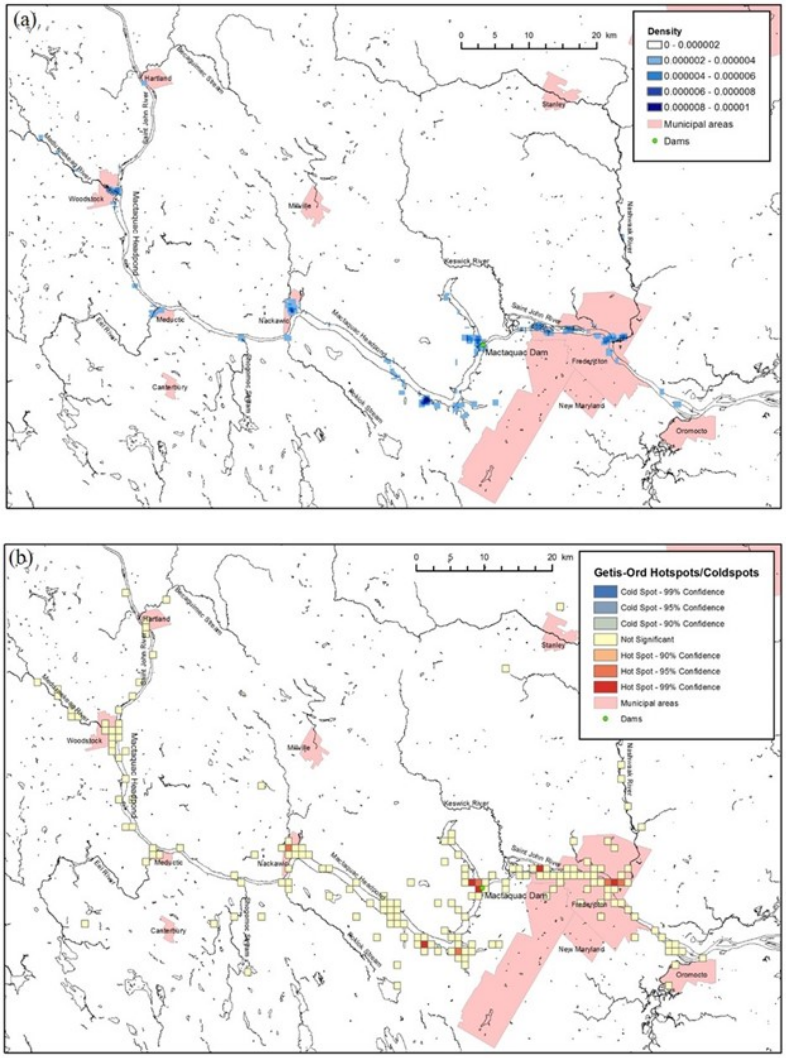


Figure 3.5. Distribution of centroid points of mapped places in the study area, displayed as (a) point density and (b) significant hotspots and coldspots indicated by the Getis-Ord Gi* statistic.

There were some qualitative differences in the places mapped by participant groups (map (a) Figure 3.6). Retainers mapped places around the mainstem of the river throughout the study area, but particularly upstream of the dam along the headpond (Hartland to the dam). In addition, 14 retainers mentioned the entire headpond for recreation, non-use values, aesthetics, bequest value, or for its general importance. Seven mentioned the entire river as being important for aesthetics, non-use values or general importance.

The removers mapped fewer places around the headpond (map (b) Figure 3.6). There were greater densities around the islands upstream of Fredericton, the Nashwaak-Saint John confluence, and upstream on both the Nashwaak and the Meduxnekeag tributaries. Two removers identified the entire headpond as important for others' recreation, while six deemed the entire river as important for non-use values, bequest value, cultural significance, artistic

inspiration and others' recreational pursuits. Neutral participants tended to map places around Fredericton, including the islands and the Nashwaak-Saint John confluence (map (c) Figure 3.6). One thought the entire river was important for bequest values, cultural significance and canoeing/kayaking.

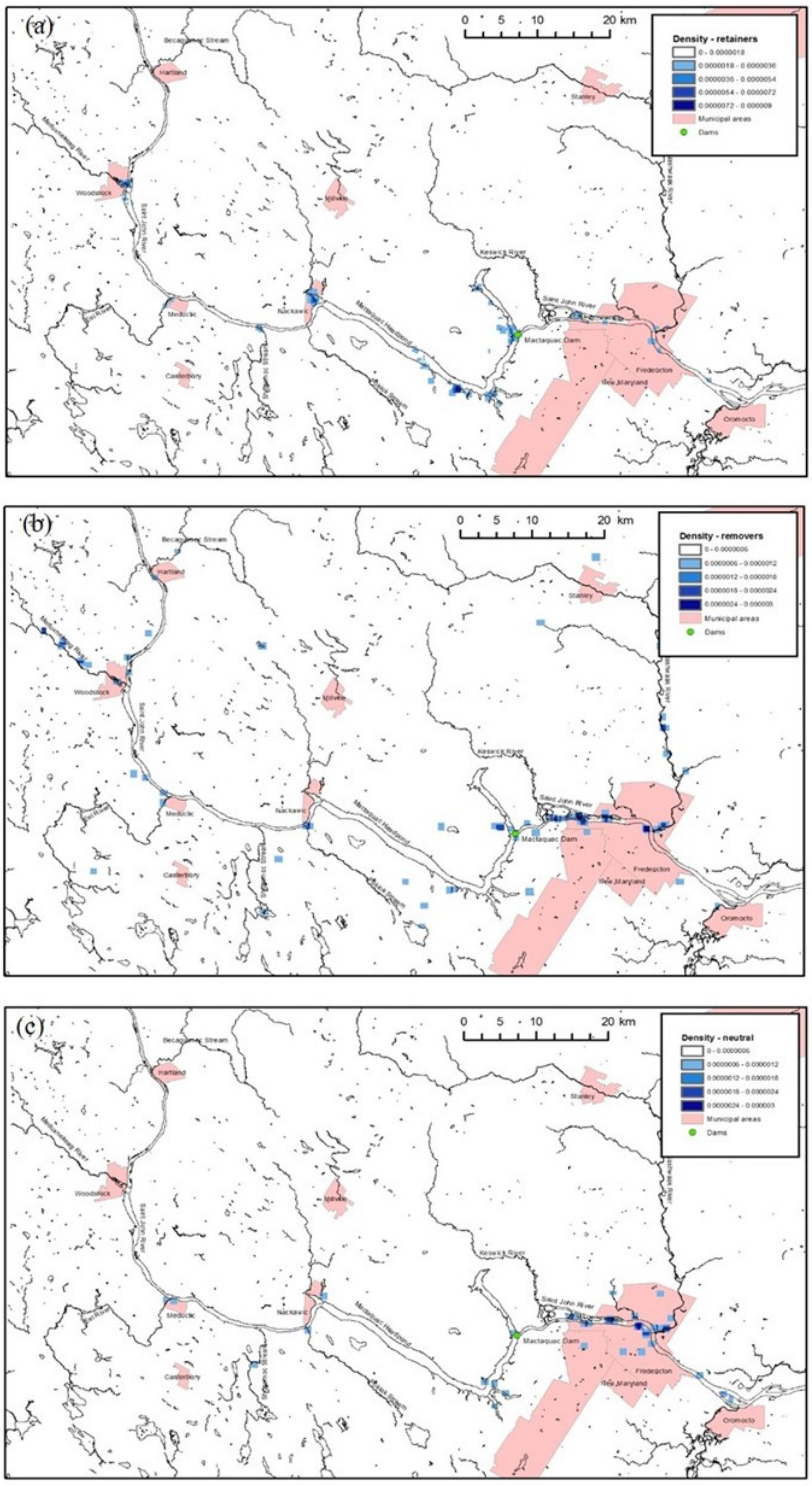
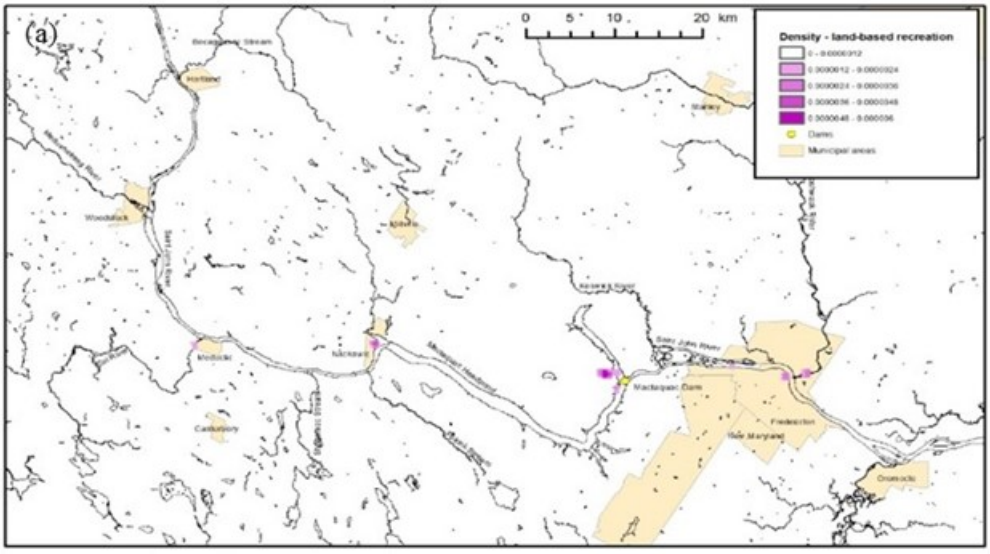
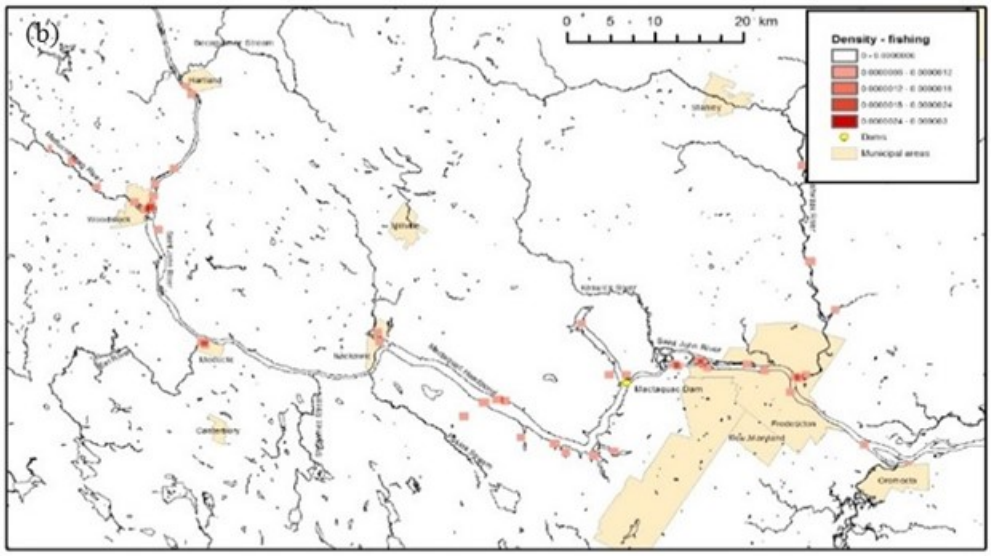


Figure 3.6. Point density distribution of centroids of places mapped by (a) retainers, (b) removers and (c) neutral participants.

The spatial distribution varied between services, as illustrated with four of the services among the five most frequently mapped services both in terms of number of places and number of participants (Figure 3.7). Other land-based recreation was primarily concentrated in the area around the dam (where the Mactaquac Provincial Park is located) and the town of Nackawic, with a few points mapped in Fredericton (map (a) Figure 3.7). Participants mapped places for fishing along the mainstem of the Saint John River, including through the headpond, and up the major tributaries (map (b) Figure 3.7). Aesthetic value was distributed throughout the study area, especially Fredericton and the lower headpond (Nackawic to the dam) (map (c) Figure 3.7). The points mapped for non-use values were mostly concentrated around Fredericton and Woodstock, Mactaquac Park, and the Nashwaak and Meduxnekeag tributaries. There were relatively few points mapped for non-use value in the headpond (map (d) Figure 3.7).





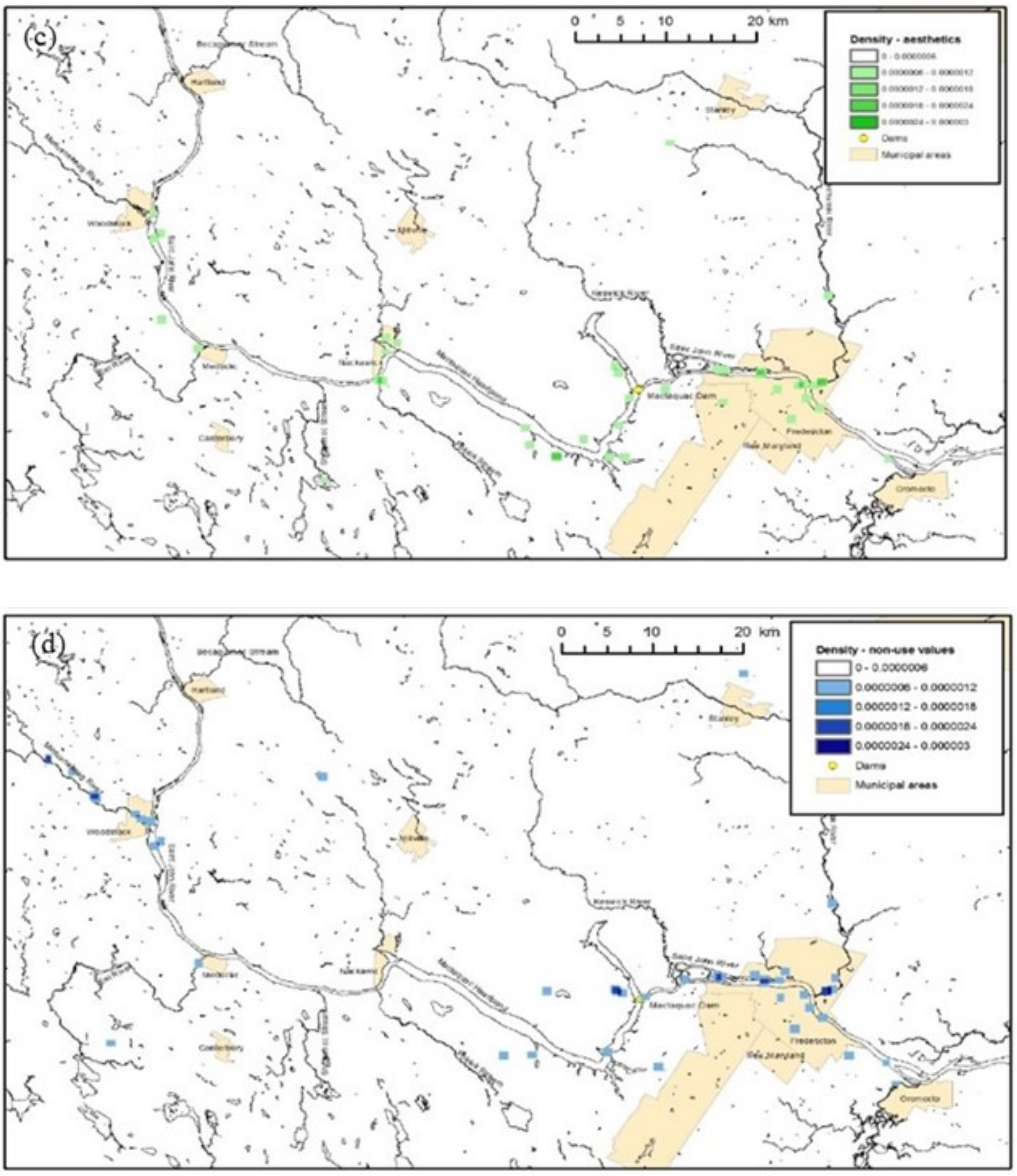


Figure 3.7. Point density distribution of centroid points of places mapped for (a) other land-based recreation, (b) fishing, (c) aesthetics, and (d) non-use value.

3.6.2. Mapping perceptions of future ecosystem services benefits post removal

Only three participants could map new places that might become available for ecosystem services, including fishing, cultural significance, soil fertility and aesthetics, if the dam were removed. The participants remembered these places or knew they existed before the dam was built, and assumed they would be restored by its removal. For example, Participant 21 described their hopes for restoration of a salmon pool: '*that was a very famous salmon pool, years ago when the salmon were running and there was fishing*'. Others mentioned ecosystem

service loss in specific places if the dam were removed: '*the area that I was mentioning,* [place number] *13, that wouldn't be there anymore. That whole area would be gone*' (Participant 22).

Many more participants could explain their perceptions of change to ecosystem services if the dam were removed, but could not link these perceived changes to specific places and therefore could not map them. This was either because they expected the whole system to be affected or because they did not know where location-specific changes would occur. For example, in response to a question about where fertile land might be, one participant answered: '*Who knows. And who knows, out here, where our intervale land was, is there any soil left there or did it all wash away?*' (Participant 32). Others thought changes would occur throughout the entire river system: '*What else would there be if they took the dam out? I don't know. It becomes a continuous ecosystem again. That's a good thing*' (Participant 39).

The participants perceived the changes to ecosystem services to result from the absence of the dam itself, the resulting decrease in water level in the headpond, and the faster streamflow in that same reach. These changes resulted in perceptions of both gains in ecosystem services and losses (Figure 3.8). Retainers primarily focused on losses of existing services and places, while removers mostly discussed new places and services becoming available. For example, several participants anticipated benefits for recreation and non-use services that would arise from the improved river connectivity: '*The dam here is a big stop for the migrating fish. So that's the biggest reason I would say it all should be removed*' (Participant 38). Other participants thought that the narrower and shallower river would cause ecosystem service loss, primarily difficulty in boating and fishing: '*I would think that this wouldn't be very deep. I don't think it would support a boat, or certainly wouldn't support a very big boat*' (Participant 01).

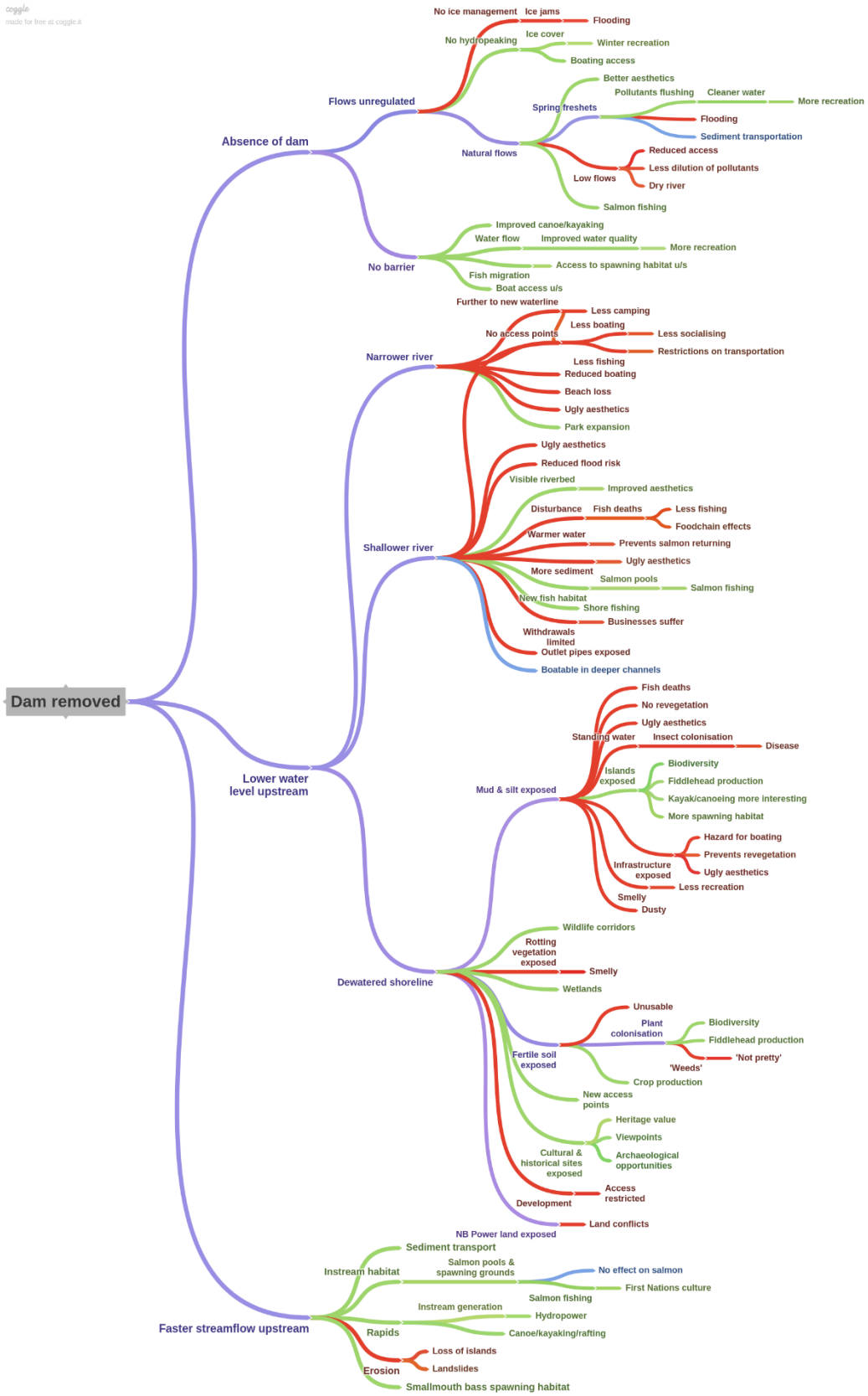


Figure 3.8. Perceptions of change post-removal. Red branches indicate loss of ecosystem services and places, while green branches indicate gains in services and/or places. Blue branches are neutral. Produced using Coggle (https://coggle.it).

3.7. Discussion

This study used the case of the Mactaquac Dam, New Brunswick, Canada, to illustrate the range of ecosystem services in a dammed river environment and how the benefits derived from them varied between individual stakeholders. The results revealed that participants benefitted from a range of ecosystem services in the dammed river environment, particularly cultural services, which clustered in several locations up and downstream of the dam. The clusters were primarily located at key human settlements, including a provincial park, an outdoor museum, and towns, as well as at important features of the river environment, namely islands and bays. The retainers' ecosystem service benefits were concentrated around the headpond upstream of the dam, while the removers' benefits were primarily downstream of the dam and around undammed tributaries.

The participatory mapping activity was effective at eliciting current uses of ecosystem services. However, most participants had difficulty mapping the expected distribution of ecosystem services under scenarios of future management. The interview-based approach revealed their non-spatially-specific perceptions of change.

3.7.1. Spatial distribution of ecosystem services in a dammed river environment

The results of this exploratory case study indicated that stakeholders benefitted from ecosystem services throughout the river reach affected by the dam. Their use of ecosystem services throughout this reach indicates that damming or undamming a river is likely to both increase and decrease ecosystem services, including recreation, aesthetic appreciation, transport, and non-use values (Auerbach et al. 2014; Reilly and Adamowski 2017). The spatial distribution of ecosystem service benefits varied with the participants' position on the future of the dam, although these differences should be confirmed in a randomly selected larger sample (Brown et al. 2014, 2017). Specifically, the retainers preferred the slower-flowing and deeper headpond, while removers preferred the free-flowing tributaries and downstream reach. Therefore, decision makers should be aware of whose use of ecosystem services is affected, both positively and negatively, by the options considered (Brismar 2002). Policies and management measures should be put in place to minimise the impacts of these trade-offs, the effects of which should be monitored (Rodríguez et al. 2006; Howe et al. 2014).

Several clusters of ecosystem services were located close to settlements. This demonstrated the importance of urban ecosystem services (albeit in small towns) (Bolund and Hunhammar 1999; Plieninger et al. 2013), even when surrounded by non-urban land and water that are more often

associated with ecosystem services. For example, the waterfront trails in all towns provided opportunities for outdoor recreation, and boat launches and fishing tournaments facilitated access to ecosystem services experienced on the water, both of which may help connect people with nature (Dearborn and Kark 2010). Overall, this finding agrees with Klain and Chan's (2012) suggestion that some ecosystem services may be mapped in places that are easily accessible, rather than in wild places without human activity (Beverly et al. 2008; Klain and Chan 2012).

The identification of ecosystem service hotspots can inform the spatial targeting of protection or restoration measures (Raymond et al. 2009). For example, if the dam were removed, the hotspots around the headpond, such as at the town of Nackawic, indicate priority areas for rehabilitation. Restoration measures should seek to preserve or recreate the features of those places that allow stakeholders to benefit from ecosystem services, including both the services themselves and access to them. They could include adaptation of access points, such as boat launches, and actively planting dewatered land to manage the impact of the lower water level (Orr and Koenig 2006; Tullos et al. 2016). Particularly if the dam were rebuilt, the character of the two most valued tributaries, the Meduxnekeag and the Nashwaak, and of the reach downstream of the dam should be preserved, because they were the most significant for removers. Maintenance of services in these areas, including non-use value, recreation and aesthetics, through improved access to the water, habitat protection and flow management at the dam, would be worthwhile under both scenarios.

The participant-produced maps should, however, not be used as licence to neglect, disrupt or eliminate ecosystem service provision in other areas (Brown et al. 2017), especially as the regulating and supporting services that underpin provisioning and cultural services were rarely mapped (Raymond et al. 2009; Brown et al. 2012; Klain and Chan 2012). Therefore, neglecting unmapped places risks disrupting the ecological processes that support ecosystem service benefits elsewhere. It also underplays the potential for management actions, such as improving fish passage at the dam, to enhance some ecosystem services throughout the system, while not significantly affecting others.

3.7.2. Utility of participatory mapping for ecosystem service assessment in this context

In this context, the qualitative interview-based approach to participatory mapping that was used in this study allowed us to ensure that the interpretation of each service was consistent across

participants, regardless of responses to particular prompts. This was useful since an earlier phase of this study found that the different groups used the same service in very different ways (Reilly and Adamowski 2017). The detail provided by the interview approach would allow ecosystem services to be disaggregated as far as needed for decision making support and provide context for the results (Bryan et al. 2010), whereas use of a predefined typology of services would not have that flexibility.

The interview-based approach also allowed us to account for services that participants could not or would not map (Klain and Chan 2012). Non-use and bequest values, in particular, were identified by both retainers and removers as being spread over large areas, and therefore were not mapped. Similarly, a small number of participants believed regulating services were provided by the river functioning as an interconnected system. A participatory mapping exercise that did not allow participants to explain their decisions not to map a place may risk excluding such values and worldviews (Klain and Chan 2012). We suggest that a survey-based approach to ecosystem service mapping should include a questionnaire that allows participants to offer explanations for services that they cannot map.

Because dam removal would create both losses and gains in ecosystem services (Reilly and Adamowski 2017), it was important to explore stakeholders' perceptions of their spatial distribution post removal. However, most participants had difficulty linking their perceptions of change to specific places. Maps of perceptions of the post-removal scenario would therefore be of limited utility for supporting decision making. Such maps would exclude perceived impacts, both positive and negative, that were widespread across the study area, as well as impacts of unknown location. They also risk bias towards participants who could remember the original configuration of the river and thus could map places that might be restored. However, the interview data both revealed participants' perceptions of the ecological processes that produce ecosystem services currently and their assumptions of the consequences of removal. Comparisons of these perceived causal pathways with hydrological and ecological studies of the outcomes of dam removal could identify accurate assumptions that should be mitigated with management actions, as discussed above, and inaccurate assumptions that should be corrected with information and education (Reilly and Adamowski 2017). We suggest, therefore, that participatory mapping could be useful in assessing different scenarios if a map of current valued places is used as a prompt to discuss the impacts of each scenario.

3.8. Conclusion

This study revealed that stakeholders used ecosystem services throughout a dammed river reach, although the types of ecosystem services used and their location differed according to stakeholders' position on the future of the dam. Participants in favour of retaining the dam identified several changes to the headpond if the dam were removed that would limit their use of services there. Participants who preferred to remove it identified changes at the dam site and through the headpond that would improve their service use, as well as create new locations for services. The qualitative interviewing approach allowed us to disaggregate ecosystem service categories as they made sense for the study, and provided detail on stakeholders' perceptions of change. While few stakeholders could link those perceptions of change post removal to specific places, they were able to discuss them in considerable detail. Therefore, we conclude that participatory mapping may be of limited utility to assess perceptions of spatial changes in a system, but maps of current benefits are a useful prompt for discussion. Future research should confirm these findings in a larger sample, and test other methods of eliciting perceptions of ecosystem services under different future management scenarios.

REFERENCES

Alessa, L., A. Kliskey, and G. Brown. 2008. Social–ecological hotspots mapping: A spatial approach for identifying coupled social–ecological space. *Landscape and Urban Planning* 85(1):27–39.

Auerbach, D. A., D. B. Deisenroth, R. R. McShane, K. E. McCluney, and N. L. Poff. 2014. Beyond the concrete: Accounting for ecosystem services from free-flowing rivers. *Ecosystem Services* 10:1–5.

Bednarek, A. 2001. Undamming rivers: A review of the ecological impacts of dam removal. *Environmental Management* 27(6):803–814.

Van Berkel, D. B., and P. H. Verburg. 2014. Spatial quantification and valuation of cultural ecosystem services in an agricultural landscape. *Ecological Indicators* 37(PART A):163–174.

Beverly, J. L., K. Uto, J. Wilkes, and P. Bothwell. 2008. Assessing spatial attributes of forest landscape values: an internet-based participatory mapping approach. *Canadian Journal of Forest Research* 38(2):289–303.

Bolund, P., and S. Hunhammar. 1999. Ecosystem Services in Urban Areas. *Ecological Economics* 29:293–301.

Born, S. M., K. D. Genskow, T. L. Filbert, N. Hernandez-Mora, M. L. Keeper, and K. A. White. 1998. Socioeconomic and institutional dimensions of dam removals: The Wisconsin experience. *Environmental Management* 22(3):359–370.

Bourgoin, S. 2013. Disregarded sentiments: Discovering the voices of opposition to the Mactaquac Dam. St Mary's University.

Brismar, A. 2002. River systems as providers of goods and services: A basis for comparing desired and undesired effects of large dam projects. *Environmental Management* 29(5):598–609.

Brown, G. 2003. A method for assessing highway qualities to integrate values in highway planning. *Journal of Transport Geography* 11(4):271–283.

Brown, G. 2013. The relationship between social values for ecosystem services and global land cover: An empirical analysis. *Ecosystem Services* 5:58–68.

Brown, G., S. Donovan, D. Pullar, A. Pocewicz, R. Toohey, and R. Ballesteros-Lopez. 2014. An empirical evaluation of workshop versus survey PPGIS methods. *Applied Geography* 48:42–51.

Brown, G., and N. Fagerholm. 2014. Empirical PPGIS/PGIS mapping of ecosystem services: A review and evaluation. *Ecosystem Services* 13:119–133.

Brown, G. G., and D. V. Pullar. 2012. An evaluation of the use of points versus polygons in public participation geographic information systems using quasi-experimental design and Monte Carlo simulation. *International Journal of Geographical Information Science* 26(2):231–246.

Brown, G. G., P. Reed, and C. C. Harris. 2002. Testing a place-based theory for environmental evaluation: An Alaska case study. *Applied Geography* 22(1):49–76.

Brown, G., and M. Kyttä. 2014. Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. *Applied Geography* 46:122–136.

Brown, G., J. M. Montag, and K. Lyon. 2012. Public Participation GIS: A Method for Identifying Ecosystem Services. *Society & Natural Resources* 25(7):633–651.

Brown, G., and C. Raymond. 2007. The relationship between place attachment and landscape values: Toward mapping place attachment. *Applied Geography* 27(2):89–111.

Brown, G., and C. M. Raymond. 2014. Methods for identifying land use conflict potential using participatory mapping. *Landscape and Urban Planning* 122:196–208.

Brown, G., J. Strickland-Munro, H. Kobryn, and S. A. Moore. 2017. Mixed methods participatory GIS: An evaluation of the validity of qualitative and quantitative mapping methods. *Applied Geography* 79:153–166.

Brummer, M., B. Rodríguez-Labajos, T. Thanh Nguyen, and D. Jorda-Capdevila. 2017. 'They Have Kidnapped Our River': Dam Removal Conflicts in Catalonia and Their Relation to Ecosystem Services Perceptions. *Water Alternatives* 10(3):744–768.

Bryan, B. a., C. M. Raymond, N. D. Crossman, and D. H. Macdonald. 2010. Targeting the management of ecosystem services based on social values: Where, what, and how? *Landscape and Urban Planning* 97(2):111–122.

Bunn, S. E., and A. H. Arthington. 2002. Basic principles and ecological consequences of

altered flow regimes for aquatic biodiversity. *Environmental Management* 30(4):492–507.

Canadian Rivers Institute. 2011. *The Saint John River: A State of the Environment Report*.

Casado-Arzuaga, I., I. Madariaga, and M. Onaindia. 2013. Perception, demand and user contribution to ecosystem services in the Bilbao Metropolitan Greenbelt. *Journal of Environmental Management* 129:33–43.

Cowling, R. M., B. Egoh, A. T. Knight, P. J. O'Farrell, B. Reyers, M. Rouget, D. J. Roux, A. Welz, and A. Wilhelm-Rechman. 2008. An operational model for mainstreaming ecosystem services for implementation. *Proceedings of the National Academy of Sciences of the United States of America* 105(28):9483–9488.

Daily, G. C., and P. a Matson. 2008. Ecosystem services: from theory to implementation. *Proceedings of the National Academy of Sciences of the United States of America* 105(28):9455–6.

Darvill, R., and Z. Lindo. 2014. Quantifying and mapping ecosystem service use across stakeholder groups: Implications for conservation with priorities for cultural values. *Ecosystem Services* 13:153–161.

Dearborn, D. C., and S. Kark. 2010. Motivations for conserving urban biodiversity. *Conservation Biology* 24(2):432–440.

Dudgeon, D., A. H. Arthington, M. O. Gessner, Z.-I. Kawabata, D. J. Knowler, C. Lévêque, R. J. Naiman, A.-H. Prieur-Richard, D. Soto, M. L. J. Stiassny, and C. a Sullivan. 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews of the Cambridge Philosophical Society* 81(2):163–82.

ESRI. 2016. ArcGIS Desktop version 10.4. Environmental Systems Research Institute, Redlands, CA.

Fagerholm, N., N. Käyhkö, F. Ndumbaro, and M. Khamis. 2012. Community stakeholders' knowledge in landscape assessments - Mapping indicators for landscape services. *Ecological Indicators* 18:421–433.

Fox, C. A., F. J. Magilligan, and C. S. Sneddon. 2016. 'You kill the dam, you are killing a part of me': Dam removal and the environmental politics of river restoration. *Geoforum* 70:93–104.

García-Nieto, A. P., C. Quintas-Soriano, M. García-Llorente, I. Palomo, C. Montes, and B. Martín-López. 2015. Collaborative mapping of ecosystem services: The role of stakeholders′ profiles. *Ecosystem Services* 13:141–152.

Getis, A., and J. K. Ord. 1992. The analysis of spatial association by use of distance statistics. *Geographical Analysis* 24(3):189–206.

Gould, R. K., S. C. Klain, N. M. Ardoin, T. Satterfield, U. Woodside, N. Hannahs, G. C. Daily, and K. M. Chan. 2015. A protocol for eliciting nonmaterial values through a cultural ecosystem services frame. *Conservation Biology* 29(2):575–586.

Government of New Brunswick. 2016. *Fish 2016*.

de Groot, R., and P. S. Ramakrishnan. 2005. Ecosystems and human well-being: Current State and Trends, Chapter 17: Cultural and Amenity Services. *Ecosystem and human well-being: Current State and Trends*:457–474.

Hart, D. D., T. E. Johnson, K. L. Bushaw-Newton, R. J. Horwitz, A. T. Bednarek, D. F. Charles, D. a Kreeger, and D. J. Velinsky. 2002. Dam removal: Challenges and opportunities for ecological research and river restoration. *Bioscience* 52(8):669–681.

Howe, C., H. Suich, B. Vira, and G. M. Mace. 2014. Creating win-wins from trade-offs? Ecosystem services for human well-being: A meta-analysis of ecosystem service trade-offs and synergies in the real world. *Global Environmental Change* 28(1):263–275.

Huang, R. 2014. RQDA: R-based qualitative data analysis. R package version 0.2-7.

Keilty, K., T. M. Beckley, and K. Sherren. 2016. Baselines of acceptability and generational change on the Mactaquac hydroelectric dam headpond (New Brunswick, Canada). *Geoforum* 75:234–248.

Kirchherr, J., H. Pohlner, and K. J. Charles. 2016. Cleaning up the big muddy: A meta-synthesis of the research on the social impact of dams. *Environmental Impact Assessment Review* 60:115–125.

Klain, S. C., and K. M. a. Chan. 2012. Navigating coastal values: Participatory mapping of ecosystem services for spatial planning. *Ecological Economics* 82:104–113.

Lamarque, P., U. Tappeiner, C. Turner, M. Steinbacher, R. D. Bardgett, U. Szukics, M. Schermer, and S. Lavorel. 2011. Stakeholder perceptions of grassland ecosystem services

in relation to knowledge on soil fertility and biodiversity. *Regional Environmental Change* 11(4):791–804.

Lejon, A. G. C., B. M. Renöfält, and C. Nilsson. 2009. Conflicts associated with dam removal in Sweden. *Ecology And Society* 14(2):4.

Magilligan, F. J., K. H. Nislow, B. E. Kynard, and A. M. Hackman. 2016. Immediate changes in stream channel geomorphology, aquatic habitat, and fish assemblages following dam removal in a small upland catchment. *Geomorphology* 252:158–170.

Martín-López, B., I. Iniesta-Arandia, M. García-Llorente, I. Palomo, I. Casado-Arzuaga, D. G. Del Amo, E. Gómez-Baggethun, E. Oteros-Rozas, I. Palacios-Agundez, B. Willaarts, J. A. González, F. Santos-Martín, M. Onaindia, C. López-Santiago, and C. Montes. 2012. Uncovering ecosystem service bundles through social preferences. *PLoS ONE* 7(6):e38970.

Miles, M. B., A. M. Huberman, and J. Saldana. 2013. *Qualitative data analysis: A methods sourcebook*. 3rd Editio.

Moran, P. A. P. 1950. Notes on Continuous Stochastic Phenomena. *Biometrika* 37(1/2):17–23.

NATIONAL and CRA. 2016. *What Was Said Final Report*.

Natural Resources Canada. 2003. GeoGratis.

New Brunswick (NB) Power. 2014. Mactaquac Project. https://www.nbpower.com/html/en/about/future/mactaquac.html.

NB Power. 2016. *Backgrounder: Mactaquac Generating Station Life Achievement Project*. Fredericton, Canada.

Orr, C. H., and S. Koenig. 2006. Planting and vegetation recovery on exposed mud flats following two dam removals in Wisconsin. *Ecological Restoration* 24(2):79–86.

Pittock, J., and J. Hartmann. 2011. Taking a second look: Climate change, periodic relicensing and improved management of dams. *Marine and Freshwater Research* 62(3):312–320.

Plieninger, T., S. Dijks, E. Oteros-Rozas, and C. Bieling. 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. *Land Use Policy* 33(July 2015):118–129.

Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks,

and J. C. Stromberg. 1997. The Natural Flow Regime. A paradigm for river conservation and restoration. *BioScience* 47(11):769–784.

Potschin, M., and R. Haines-Young. 2013. Landscapes, sustainability and the place-based analysis of ecosystem services. *Landscape Ecology* 28(6):1053–1065.

Province of New Brunswick. 2016. GeoNB.

Raymond, C. M., B. a. Bryan, D. H. MacDonald, A. Cast, S. Strathearn, A. Grandgirard, and T. Kalivas. 2009. Mapping community values for natural capital and ecosystem services. *Ecological Economics* 68(5):1301–1315.

Reed, M. S., K. Hubacek, A. Bonn, T. P. Burt, J. Holden, L. C. Stringer, N. Beharry-Borg, S. Buckmaster, D. Chapman, P. J. Chapman, G. D. Clay, S. J. Cornell, A. J. Dougill, A. C. Evely, E. D. G. Fraser, N. Jin, B. J. Irvine, M. J. Kirkby, W. E. Kunin, C. Prell, C. H. Quinn, B. Slee, S. Stagl, M. Termansen, S. Thorp, and F. Worrall. 2013. Anticipating and managing future trade-offs and complementarities between ecosystem services. *Ecology and Society* 18(1).

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.

Rodríguez, J. P., T. D. Beard, E. M. Bennett, G. S. Cumming, S. J. Cork, J. Agard, A. P. Dobson, and G. D. Peterson. 2006. Trade-offs across space, time, and ecosystem services. *Ecology And Society* 11(1):28.

Ruiz-Frau, A., G. Edwards-Jones, and M. J. Kaiser. 2011. Mapping stakeholder values for coastal zone management. *Marine Ecology Progress Series* 434(1987):239–249.

Scolozzi, R., U. Schirpke, C. Detassia, S. Abdullah, and A. Gretter. 2015. Mapping alpine landscape values and related threats as perceived by tourists. *Landscape Research* 40(4):451–465.

Sherren, K., T. M. Beckley, J. R. Parkins, R. C. Stedman, K. Keilty, and I. Morin. 2016. Learning (or living) to love the landscapes of hydroelectricity in Canada: Eliciting local perspectives on the Mactaquac Dam via headpond boat tours. *Energy Research & Social Science* 14:102–110.

Stantec. 2015. *Mactaquac Project Comparative Environmental Review Report*.

Tullos, D. D., M. J. Collins, J. R. Bellmore, J. A. Bountry, P. J. Connolly, P. B. Shafroth, and A. C. Wilcox. 2016. Synthesis of common management concerns associated with dam removal. *Journal of the American Water Resources Association* 52(5).

De Vreese, R., M. Leys, C. M. Fontaine, and N. Dendoncker. 2016. Social mapping of perceived ecosystem services supply – The role of social landscape metrics and social hotspots for integrated ecosystem services assessment, landscape planning and management. *Ecological Indicators* 66:517–533.

World Commission on Dams (WCD). 2000. *Dams and Development: A new framework for decision-making*. Earthscan, London and Sterling, VA.

Zhu, X., S. Pfueller, P. Whitelaw, and C. Winter. 2010. Spatial differentiation of landscape values in the Murray river region of Victoria, Australia. *Environmental Management* 45(5):896–911.

APPENDIX 3.1

Interview protocol

The purpose of the study was explained to participants, along with confidentiality procedures, and consent was requested. The mapping activity was briefly introduced.

Section 1: General questions

For new participants:

- Are you aware of the process to decide what should happen to the Mactaquac Dam when it reaches the end of its life? (Show pictures of the three options if necessary.)
- What do you think should happen to it?
- What are your reasons for that?
- How do you think removing the dam would affect you?
- And rebuilding it?
- Have you read any of the information that New Brunswick Power has published about the decision on the dam?
- Have you participated in any of the consultation activities they've been doing, like the meetings, the online comments, etc.?

For returning participants:

- Have you read any of the information that NB Power has published about the decision on the dam?
- Have you participated in any of the consultation activities they've been doing, like the meetings, the online comments, etc.?
- I'm going to ask you the same question again that I asked you last time: what do you think should happen to the dam?
- What are your reasons for that?

Section 2: Mapping

- We're going to use the map to show me places that you use and think are important near, in and around the water, including the headpond, the St John River, and its tributaries.
- I want to emphasise that there are no right or wrong ways to do this. Some of the answers to the questions might be difficult to map – that's ok.
- Firstly, could you draw a dot where your house is?
- And where your business is (if relevant).

Job-related

- Can you start by thinking about if there are places that you use most or are important to you for your work, including your volunteer work?
- Can you draw them on the map and give each one a number? Can you tell me what you do in place [x]? Why is it important to you? How often do you go there?

Personal – general

- Now we're going to think about how you use places around the river in your personal life.
- Can you draw the places that you use most or that are particularly important to you on the map? Can you number them? Think about all the seasons as well, not just where you use in summer.
- Can you tell me what you do at place number [x]? And what is it about that place that you like? What's important about it? Are there any other reasons that you go to that place in particular? How often do you go there?
- Now we're going to go through some more specific questions to see if there are any other places you'd like to add. It's ok if some of these questions make you think of places you've already drawn, just point out the number to me. It's also fine if as we're going through the questions you think of a place that answers a previous question – just draw it and then we'll talk about it.

Personal – recreation, relaxation and wellbeing

- Are there any other activities that you do or experiences that you have around the river that we've missed?
- What is it about [doing activity/having that experiences] in those particular places that you like? What's important about those places? Are there any other reasons that you go to that place in particular? How often do you go there?

Personal – non-use values

- Now I'd like you to think about any other places that you think are important but not because of anything that you directly or personally you get from them (Gould et al., 2015).
- Why are those places important?

Personal – identity and social and community connections

- Now if we think about a person's identity, it comes from their relationships, ideas, sense of belonging, and all these shape who they are (Gould et al., 2015; Klain and Chan, 2012).
- Are there any places that are important for your sense of identity? How would you describe the link between that place and your identity (Gould et al., 2015; Klain and Chan, 2012)?

Personal – heritage and memories

- Are there places that remind of you of things that happened in the past that were important for you or for your community (Gould et al., 2015; Klain and Chan, 2012)?

Personal – intergenerational/bequest

- Are there any places or experiences in and around the river that you hope that your kids or the kids around here will experience in the future (Gould et al., 2015; Klain and Chan, 2012)?
- What is it about those places that you hope they will experience?

Personal – provisioning

- I'd like you to think about if you get any physical things, like resources, food or materials from in and around the river in your work or personal life. I mean here things that you're involved in getting for yourself. Your water supply wouldn't count unless you personally are involved in collecting water.
- If you haven't already, can you draw any of the places that you get those things from? What do you get at each place? How often do you go there to get those things?
- Is it important to you to be able to get those things yourself? How?

Personal – movement

- Do you use the river to get around? Where do you go? Can you describe the difference between using the river for that and using a different way to get around, like by car? How often do you do that?

Regulating – flood control and water quality

- Are there places that you think are important for your environment more generally, like for maintaining water quality, flood control, and soil fertility?

Section 3: Mapping future use

- Now we'll look at what these places may be like after the decision is made. If the decision is made to keep the dam in some form, do you think any of those places would change?
- I'd like you to imagine what you think the river will be like if the dam is removed. Again, there are no right or wrong answers here –I just want to know what you think.
- Now you're imagining what the river will be like if the dam is removed, I'd like you to think about all those places you've just drawn.
- Would any of them stay the same? Which ones?
- Would any of them disappear or be unusable? Which ones? What is it that you think would make them unusable?
- Would any new places become important for you for doing the activities and having the experiences that we talked about earlier? Can you draw them?
- Would any new activities or experiences be possible? Can you draw where you think those might be possible? What activities would you be able to do there? Can you explain why you chose those places?
- Are there any other things that might threaten these places?

APPENDIX 3.2

Codebook for ecosystem services

Category	Code	Description	Examples
Cultural	Aesthetics	Appreciation of aesthetics of place - both visual aesthetics and appreciation of other senses (sound, smell). Positive general descriptions of aesthetics ('pretty', 'beautiful'), photogenic places, good views, and factors that contribute to positive aesthetics (running water, open spaces, etc.). Exclude descriptions that are only of built environment or infrastructure, as well as negative evaluations of future.	'The thing is, on a day like this, it's beautiful on the river'
Cultural	Bequest	Desire to preserve ecological functions or processes for future generations to enjoy, learn from, etc.	'What I'd really love to see is that each child have the opportunity to experience something in this river valley that shapes their life forever'
Cultural	Camping	Camping near the river in tents, caravans, etc. whether at formal campsites or not.	'It's more about the social than it is a camp ground. But I wouldn't be interested in staying there if it wasn't right on the water'
Cultural	Canoe/Kayak	Recreational use of canoes, kayaks, tubes and rowing boats, either for its own enjoyment or as a means of fishing. Infrastructure needed to access the water, such as launches, included.	'It's very calm, there's lots of nature, great fishing, great canoeing around those islands because it usually stays very calm'
Cultural	Cultural significance	The links between human culture and ecosystems, including 'memories' of past cultures that remind people of individual and collective 'historic roots' (De Groot and Ramakrishnan, 2005). Requires a statement of a place's importance, not just a description (e.g. of where the swimming pool used to be).	'You're sort of connected to that history and the culture that related to founding fathers coming up the river, but for which we'd be part of America and we'd be a republic.'
Cultural	Fishing	Recreational fishing for any species, both from boats and from shore. Mentions of fishing access points, salmon pools and other fish habitat, and tournaments included. Fishing only to supply food and commercial fishing are excluded (in food provision).	'You can go out there and fish if you want. But that's a recreational thing again for me. I don't think there's anybody that's fishing to make a living off of it'
Cultural	Hunting	Recreational hunting (birds, mammals, etc.). Fishing and hunting solely for food supply are excluded.	'You've got abundance of deer to hunt. And I mean there's a lot of people come to this area just to hunt white tailed deer'

Category	Code	Description	Examples
Cultural	Motorised Boating	Recreational use of motorised boats (motor boats, pontoon boats, jet boats), both purely for enjoyment and for recreational fishing. Include waterskiing and boat-towed tubing. Infrastructure needed to access the water, such as launches, included.	'I consider it's like a waterway, like it's accessible, it's deep, you can go places in a motorboat and get to see nature and see the homes'
Cultural	Non-use	Ecosystem components valued even if they aren't used, including general support for environmental management/restoration independent of what it would offer that person. Exclude neutral descriptions of ecosystem or of the effects of removal (have to include a statement of their feelings about those effects).	'Let's make good decisions that are good for the people, for the animals, for everybody. We now have an ecosystem. Let's not destroy this ecosystem'
Cultural	Place Memories	Individuals' memories of places not directly connected to other ecosystem services (i.e. memories of fishing coded as fishing).	'We spent summer vacations there. My parents and always got a cottage and rented it for years. And that was a very important part of the water'
Cultural	Other land-based recreation	Other land-based recreational activities not otherwise in a category (e.g. hiking, snowmobiling & skiing on land). Mactaquac Park included, unless specifically mentioned in relation to water.	'There's a stream that comes in to Kelly Creek and so I often hike up that stream'
Cultural	Other water-based recreation	Other water-based recreational activities not otherwise in a category, including those that use the river when frozen (e.g. swimming, skating, snowmobiling). General mentions of water-based recreation also included.	'There was a time we would skate on the river. I haven't done that for a few years'
Cultural	Relaxation	Feelings of relaxation and peacefulness (including enjoying quiet) from being outside, in nature or from specific ecological processes. Can be in combination with a recreational activity.	'When I'm out in my boat by myself, especially by myself, I find it's like therapy. I just get so excited and when I get out there it's like this sense of relief. And I don't know, I just love the peacefulness'
Cultural	Sailing	Recreational use of sailboats and windsurfs, meaning boats powered only by the wind. Ice boating (ice sailing) included. Infrastructure needed to access the water, such as marinas, included.	'When we sailboat we go from Nackawic and we sail all the way down to Great Bear'

Category	Code	Description	Examples
Cultural	Social connections	Social connections, including with friends/family/neighbours, facilitated by being outside, in nature or from specific ecological processes. Can be in combination with a recreational activity.	'Q: And why do you go to Jewett's Cove? A: It's a social gathering. It's a protected creek and on a weekend there's all kinds of boats in there'
Cultural	Transport	Use of river or trails specifically for transport, as in for the purpose of getting to a particular place, not just to explore the river. Ferries and steamboats included. Use of roads and recreational use excluded.	When I was younger I would take my canoe to get downtown. I didn't have a driver's license. So I'd just use my canoe'
Provisioning	Food provision	Individuals directly collecting food from nature, including fishing for food supply (not for recreation), fiddlehead gathering, etc. Farming excluded.	'It used to be that we would fiddlehead. We would get fiddleheads on the island for years'
Provisioning	Hydropower	Preference for generating power from running water, either through the Mactaquac Dam, other existing dams, or proposals for alternative ways of generating energy from water.	'If it's done right, it's going to be some of the cheapest energy we can create. The cleanest energy we can create'
Provisioning	Non-food materials	Individuals directly gathering non-food materials and resources from nature.	'I take driftwood and I put it in my garden at the camper. Fire wood for campfires'
Provisioning	Water supply	Water withdrawals for public or private water supply (including for drinking, irrigation and industrial use).	'It's certainly going to affect St Anne (the paper mill) because of the volume of water that they need'
Regulating	Carbon sequestration	Vegetation or trees valued for ability to sequester and/or store carbon.	'And the other thing that they do is that canopy, the silver maple forest, is the number one carbon sink species'
Regulating	Erosion protection	Vegetation or trees valued for ability to protect shorelines from erosion. Particular sites that will be planted for protection also included.	'To protect them from erosion they're going to replant them there'
Regulating	Filtration	Pollutants removed when water passes through soil, rock, etc., leading to improvements in water quality. Filtration through soil allowing aquifer recharge also included.	'Water quality as well. I mean that's, a lot of that plays into the whole entire area around the river and maintaining your forests and things that can actually filter out some of the contaminants'

Category	Code	Description	Examples
Regulating	Flood regulation	Wetlands, forests and other ecosystems regulating flooding by slowing run off, storing flood waters, etc. Flood regulation from the dam is excluded.	'I'd say Grand Lake meadows further down but that's outside our scope. Because I think that that is really a node or sort of a hub of many things converging, and that's a great sort of sponge for storing water'
Regulating	Pollution dilution	Pollutants that enter the water body being sufficiently diluted such that water quality is improved.	'If the dam is gone and say we get a lower water levels, the effluent may become more noticeable, the dilution rates are not as good'
Supporting	Soil fertility	Fertile soil that facilitates farming, gardening, revegetation, etc. Farming only included here when fertility of soil specifically mentioned.	'All that silt and top soils out there. And the minute that the sun hits it and it dries out, I mean, it's very fertile land. It's the best in the world right there. Things are going to shoot up really, really quick'

FOREWORD TO CHAPTER 4

The participatory maps of ecosystem services presented in chapter 3 revealed both divergences in the types of ecosystem services mapped and their spatial distribution. Those who preferred to retain the dam mostly mapped places used for ecosystem services around the reservoir upstream of the dam (known as the headpond), while those who preferred to remove it mapped places on unaffected tributaries and the reach downstream of the dam that has a similar morphology to the original, undammed river.

This chapter explores further those differences in ecosystem service benefits by investigating in more detail how they vary within and between groups. It uses an interview-based approach so that the focus is on how ecosystem services were demanded rather than their spatial distribution.

Frame theory is then used to understand the relationships between stakeholders' perceptions of the future changes to ecosystem services if the dam were removed and how they frame the issues at the centre of a decision over the dam's future. The analysis of frames revealed the assumptions and biases in stakeholders' perceptions, and how misunderstandings and biased perceptions can hinder effective communication between the groups. Furthermore, frame theory is used to understand the implications of those diverging perceptions for the groups' position on the future of the dam. Specifically, prospect theory is used to illustrate how the groups' different reference points, i.e. perceptions of the current condition of the river, affected whether they viewed dam removal as a loss or a gain. Those who wanted to retain the dam viewed removal as a loss, which explains their stronger position in relation to the decision – people are less willing to experience a loss than to forego a potential gain (Kahneman and Tversky 1979, Tversky and Kahneman 1981).

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

Reilly, K.H. and Adamowski, J.F.

4.1. 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 realise 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 prioritise the social and economic stability of the area, which relied on the ecosystem services provided by the dammed river. They emphasised 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 minimising 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

4.2. Introduction

Dams were constructed with increasing frequency during the 20th century to ensure water supply, control floods, and generate hydroelectricity (World Commission on Dams (WCD) 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 minimise 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 minimised, 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 realise 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. 2012b).

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?
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.

4.3. Conceptual framework

4.3.1. 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 organising 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 centre 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. 2012b). 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, based on frame convergences, can be identified (Lewicki 2003, Shmueli et al. 2006, Dewulf et al. 2009).

For example, Asah et al. (2012b) 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. 2012a, 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 emphasising 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 prioritised 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.

4.3.2. 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 non-use 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 experience 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. 2012c, 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. 2012a), 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.

4.4. Study area

The study area was centred 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 m3/ 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 (Figure 4.1), 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 industrialisation. 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 (Figure 4.1) because this river reach was most hydrologically affected by the dam and would therefore be most changed by its removal.

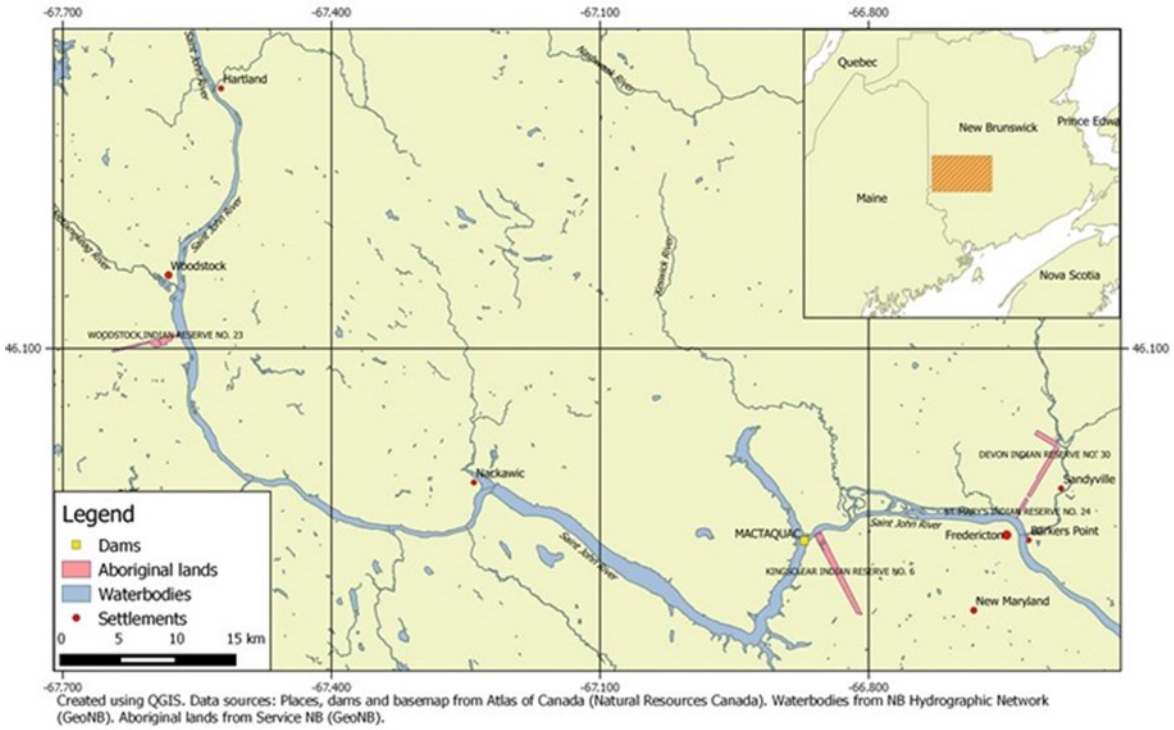

Figure 4.1. Study area: Saint John River from Hartland (upstream) to Fredericton (downstream), New Brunswick, Canada. Inset: Location of study area (in orange) within the province of New Brunswick.

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 organised 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 local Maliseet First Nations remained relatively quiet on the issue (Kenny and Secord 2010, Bourgoin 2013). The action group's concerns centred

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).

4.4.1. 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 favour 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 (New

Brunswick (NB) Power 2015). However, little is known about what is driving those divergences in opinion.

4.5. 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 analysed 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 non-proportional quota sampling from a list of approximately 80 organisations, businesses, and groups that would be affected by the decision on the dam (Freeman 1994), as opposed to members of the general public or organisations 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 organisations, anglers, headpond residents, downstream residents, industry, businesses, environmental non-governmental organisations (NGOs), watershed organisations, 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 organisations 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

organisations had several interests in the area. While some industry and First Nations organisations 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 (Figure 4.1) 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 semi structured 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 organisation and any other organisations 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 organisation, 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 (Figure 4.1)—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 (Figure 4.1) 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 organisations' 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:

- published and accessible online;

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

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 second-hand were also excluded to remove the risk that their frames were inaccurately represented. In total, documents representing 19 unique points of view were analysed. 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 categorised 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 4.1). The codebook was revised and data were recoded in an iterative process to accommodate new data and to minimise 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 4.1), 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 (MA 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 sub-column 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 colour coded each cell of the table to show predicted losses, predicted gains, and neutral change. The findings were summarised 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. 2012b). 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 summarised their themes, use of ecosystem services, and frames to confirm the findings derived from the interviews (Miles et al. 2013).

4.6. 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 organisations with a variety of main interests, and most included participants who were based upstream and downstream of the dam (Table 4.1). In addition, many of the individual participants also had several other interests in addition to their organisation's main one, through being involved with other organisations 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 illustrate the points, and are labelled with the participant's unique identifying number (e.g., Participant 01).

Table 4.1. 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 & neutral	X		X	X	X	X	X			X

The three groups talked about the decision on the dam differently, with different themes and issues being more important for each (Figure 4.2). 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.

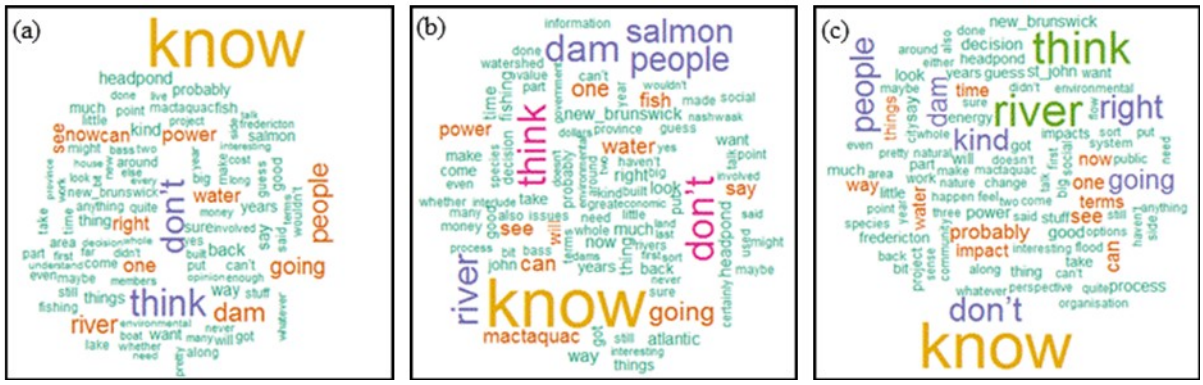

Figure 4.2. One hundred most frequently used words in the processed data for (a) the retainers, (b) the removers, and (c) those who were neutral/undecided. Words are sized and coloured according to frequency. (Produced using text mining and word cloud packages in R.)

4.6.1. Ecosystem service use

As expected, all participants who spoke from their personal perspectives (either instead of or in addition to their organisational/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 analysed. We refer here to the participants' recognised 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., non-use values). Many more individuals also commented on others' use of services and ability to access them. In addition, some who also spoke from their organisational/employers' perspectives mentioned ecosystem services that their activities relied on.

Services in all of the categories of the MA (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, non-use, place attachment, relaxation, social connections), and supporting (soil fertility). Cultural services were the most commonly used (Figure 4.3).

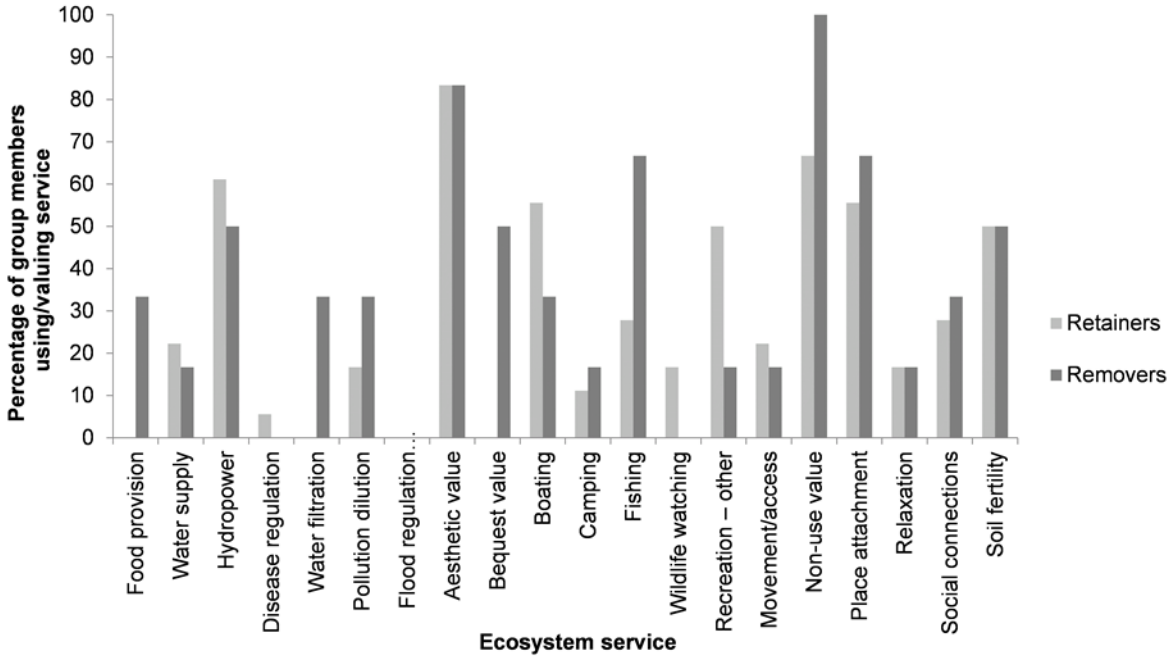

Figure 4.3. Ecosystem services used by interviewees grouped according to the MA (2005) classification.

Most of these ecosystem services (Figure 4.3) were recognised as benefits by both retainers and removers. The exceptions were disease regulation and wildlife watching, which were recognised only by retainers, and bequest values, food provision, and water filtration, which were recognised only by removers.

Both retainers and removers most frequently recognised aesthetic appreciation and non-use value (i.e., the intrinsic value of the ecosystem or species) as personally important (Figure 4.3), 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., non-use 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 organisations' perspective.

4.6.2. Effect of removal on ecosystem services

Retainers and removers differed substantially in how they expected the benefits they recognised 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 4.2).

Table 4.2. 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 (MA, 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
	Non-use value	Loss	Gain
	Place attachment	Loss	Gain
	Relaxation	Loss	

Service type (MA, 2005)	Service	Retainers	Removers
	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.

4.6.3. 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.

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 prioritised, (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 4.3).

Table 4.3. 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?	Created good social and economic conditions that now need the dam (frame A).	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 create the possibility of improving the ecological, social

Element of framing	Retainers	Removers
	It would reduce species populations and not create any ecological benefits.	and economic conditions (frame C).

Frame A: Social and economic stability should be prioritised

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).

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 minimised 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 organisations that had organisational 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 characterised 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 non-fossil 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.

4.7. Discussion

4.7.1. 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) recognised 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, non-use 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 non-use 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 non-use 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).

4.7.2. 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 prioritised) 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 minimising 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 categorisation 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 emphasised 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 prioritised) 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 analysing how each group made sense of the decision, we were also able to determine their ultimate goal for the decision by analysing 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. 2012a). 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. 2012a, Emery et al. 2013). In this case, the agreement between groups on the non-use 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 4.1 (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).

4.8. 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 prioritising 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.

REFERENCES

Adams, W. M., D. Brockington, J. Dyson, and B. Vira. 2003. Managing tragedies: understanding conflict over common pool resources. *Science* 302(5652):1915–1916.

Asah, S. T., D. N. Bengston, K. Wendt, and L. Devaney. 2012*a*. Prognostic framing of stakeholders' subjectivities: a case of all-terrain vehicle management on state public lands. *Environmental Management* 49(1):192–206.

Asah, S. T., D. N. Bengston, K. Wendt, and K. C. Nelson. 2012*b*. Diagnostic reframing of intractable environmental problems: case of a contested multiparty public land-use conflict. *Journal of Environmental Management* 108:108–119.

Asah, S. T., D. J. Blahna, and C. M. Ryan. 2012*c*. Involving forest communities in identifying and constructing ecosystem services: Millennium Assessment and place specificity. *Journal of Forestry* 110(3):149–156.

Auerbach, D. A., D. B. Deisenroth, R. R. McShane, K. E. McCluney, and N. L. Poff. 2014. Beyond the concrete: accounting for ecosystem services from free-flowing rivers. *Ecosystem Services* 10:1–5.

Babbitt, B. 2002. What goes up, may come down. *BioScience* 52(8):656–658.

Bardwell, L. V. 1991. Problem-framing: a perspective on environmental problem-solving. *Environmental Management* 15(5):603–612.

Bartlett, F. 1932. *Remembering: a study in experimental and social psychology*. Cambridge University Press, Cambridge, UK.

Bengston, D. N., S. T. Asah, and B. J. Butler. 2011. The diverse values and motivations of family forest owners in the United States: an analysis of an open-ended question in the National Woodland Owner Survey. *Small-Scale Forestry* 10(3):339–355.

Bennett, E. M., G. D. Peterson, and L. J. Gordon. 2009. Understanding relationships among multiple ecosystem services. *Ecology Letters* 12(12):1394–1404.

Born, S. M., K. D. Genskow, T. L. Filbert, N. Hernandez-Mora, M. L. Keeper, and K. A. White. 1998. Socioeconomic and institutional dimensions of dam removals: the Wisconsin experience. *Environmental Management* 22(3):359–370.

Bourgoin, S. 2013. Disregarded sentiments: discovering the voices of opposition to the Mactaquac Dam. Saint Mary's University, Halifax, Nova Scotia, Canada.

Brewer, M. B., and R. M. Kramer. 1986. Choice behavior in social dilemmas: effects of social identity, group size, and decision framing. *Journal of Personality and Social Psychology* 50(3):543–549.

Brummans, B. H. J. M., L. L. Putnam, B. Gray, R. Hanke, R. J. Lewicki, and C. Wiethoff. 2008. Making sense of intractable multiparty conflict: a study of framing in four environmental disputes. *Communication Monographs* 75(1):25–51.

Buijs, A. E. 2009. Public support for river restoration. A mixed-method study into local residents' support for and framing of river management and ecological restoration in the Dutch floodplains. *Journal of Environmental Management* 90(8):2680–2689.

Bullock, J. M., J. Aronson, A. C. Newton, R. F. Pywell, and J. M. Rey-Benayas. 2011. Restoration of ecosystem services and biodiversity: conflicts and opportunities. *Trends in Ecology & Evolution* 26(10):541–549.

Bunn, S. E., and A. H. Arthington. 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environmental Management* 30(4):492–507.

Canadian Rivers Institute. 2011. *The Saint John River: a state of the environment report*. Fredericton, New Brunswick, Canada.

Canadian Rivers Institute. 2013. Mactaquac aquatic ecosystem study – study area. http://canadianriversinstitute.com/research/mactaquac-aquatic-ecosystem-study/study-area/

Carr, J. 2001. *Downstream movements of juvenile Atlantic salmon (Salmo salar) in the dam-impacted Saint John River drainage*. Department of Fisheries and Oceans, Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2573.

Casado-Arzuaga, I., I. Madariaga, and M. Onaindia. 2013. Perception, demand and user contribution to ecosystem services in the Bilbao Metropolitan Greenbelt. *Journal of Environmental Management* 129:33–43.

Chan, K. M. A., T. Satterfield, and J. Goldstein. 2012. Rethinking ecosystem services to better address and navigate cultural values. *Ecological Economics* 74:8–18.

Creswell, J. W., and D. L. Miller. 2000. Determining validity in qualitative inquiry. *Theory into Practice* 39(3):124–130.

Davis, C. B., and R. J. Lewicki. 2003. Environmental conflict resolution: framing and intractability–an introduction. *Environmental Practice* 5(3):200–206.

Dewulf, A. 2013. Contrasting frames in policy debates on climate change adaptation. *Wiley Interdisciplinary Reviews: Climate Change* 4(4):321–330.

Dewulf, A., B. Gray, L. Putnam, R. Lewicki, N. Aarts, R. Bouwen, and C. van Woerkum. 2009. Disentangling approaches to framing in conflict and negotiation research: a meta-paradigmatic perspective. *Human Relations* 62(2):155–193.

Dillon Consulting. 2015. *Social impact comparative review*. New Brunswick Power Corporation, Fredericton, New Brunswick, Canada.

Doyle, M. W., J. M. Harbor, and E. H. Stanley. 2003. Toward policies and decision-making for dam removal. *Environmental Management* 31(4):453–465.

Doyle, M. W., E. H. Stanley, D. G. Havlick, M. J. Kaiser, G. Steinbach, W. L. Graf, G. E. Galloway, and J. A. Riggsbee. 2008. Aging infrastructure and ecosystem restoration. *Science* 319(5861):286–287.

Driscoll, D. L., P. Salib, and D. J. Rupert. 2007. Merging qualitative and quantitative data in mixed methods research: how to and why not. *Ecological and Environmental Anthropology* 3:18–28.

Elliott, M. 2003. Risk perception frames in environmental decision making. *Environmental Practice* 5(3):214–222.

Emery, S. B., M. T. Perks, and L. J. Bracken. 2013. Negotiating river restoration: the role of divergent reframing in environmental decision-making. *Geoforum* 47:167–177.

Fischer, A. P., and J. C. Bliss. 2009. Framing conservation on private lands: conserving oak in Oregon's Willamette Valley. *Society & Natural Resources* 22(10):884–900.

Fischer, A. P., and K. Marshall. 2010. Framing the landscape: discourses of woodland restoration and moorland management in Scotland. *Journal of Rural Studies* 26(2):185–193.

Fish, R. D. 2011. Environmental decision making and an ecosystems approach: some challenges from the perspective of social science. *Progress in Physical Geography* 35(5):671–680.

Fox, C. A., F. J. Magilligan, and C. S. Sneddon. 2016. 'You kill the dam, you are killing a part of me': dam removal and the environmental politics of river restoration. *Geoforum* 70:93–104.

Freeman, R. E. 1994. The politics of stakeholder theory: some future directions. *Business Ethics Quarterly* 4(4):409–421.

Gray, B. 2004. Strong opposition: frame-based resistance to collaboration. *Journal of Community & Applied Social Psychology* 14:166–176.

Gray, B., and L. L. Putnam. 2003. Means to what end? Conflict management frames. *Environmental Practice* 5(3):239–246.

Hart, D. D., T. E. Johnson, K. L. Bushaw-Newton, R. J. Horwitz, A. T. Bednarek, D. F. Charles, D. A. Kreeger, and D. J. Velinsky. 2002. Dam removal: challenges and opportunities for ecological research and river restoration. *Bioscience* 52(8):669–681.

Heath, C., R. P. Larrick, and G. Wu. 1999. Goals as reference points. *Cognitive Psychology* 38:79–109.

Hein, L., K. van Koppen, R. S. de Groot, and E. C. van Ierland. 2006. Spatial scales, stakeholders and the valuation of ecosystem services. *Ecological Economics* 57:209–228.

Hirsch, P. D., W. M. Adams, J. P. Brosius, A. Zia, N. Bariola, and J. L. Dammert. 2011. Acknowledging conservation trade-offs and embracing complexity. *Conservation Biology* 25(2):259–264.

Huang, R. 2014. RQDA: R-based qualitative data analysis. R package version 0.2–7.

Jacobs, M. H., and A. E. Buijs. 2011. Understanding stakeholders' attitudes toward water management interventions: role of place meanings. *Water Resources Research* 47(1):W01503.

Jones, N. E. 2014. The dual nature of hydropeaking rivers: Is ecopeaking possible? *River Research and Applications* 30:521–526.

Jorgensen, D., and B. M. Renöfält. 2012. Damned if you do; damned if you don't: debates on dam removal in the Swedish media. *Ecology and Society* 18(1):18.

Kahneman, D. 1992. Reference points, anchors, norms, and mixed feelings. *Organizational Behavior and Human Decision Processes* 51:296–312.

Kahneman, D., and A. Tversky. 1979. Prospect theory: an analysis of decision under risk. *Econometrica* 47(2):263–292.

Kari, S., and K. Korhonen-Kurki. 2013. Framing local outcomes of biodiversity conservation through ecosystem services: a case study from Ranomafana, Madagascar. *Ecosystem Services* 3:e32–e39.

Kaufman, S., and M. Momen. 2003. Doan Brook: latent intractability. Pages 193–223 *in* R. J. Lewicki, editor. *Making sense of intractable environmental conflicts: concepts and cases*. Island Press.

Keilty, K., T. M. Beckley, and K. Sherren. 2016. Baselines of acceptability and generational change on the Mactaquac hydroelectric dam headpond (New Brunswick, Canada). *Geoforum* 75:234–248.

Kenny, J. L., and A. G. Secord. 2010. Engineering modernity: hydroelectric development in New Brunswick, 1945–1970. *Acadiensis* 1(1):3–26.

Kovács, E., E. Kelemen, Á. Kalóczkai, K. Margóczi, G. Pataki, J. Gébert, G. Málovics, B. Balázs, Á. Roboz, E. Krasznai Kovács, and B. Mihók. 2014. Understanding the links between ecosystem service trade-offs and conflicts in protected areas. *Ecosystem Services* 12:117–127.

Lamarque, P., U. Tappeiner, C. Turner, M. Steinbacher, R. D. Bardgett, U. Szukics, M. Schermer, and S. Lavorel. 2011. Stakeholder perceptions of grassland ecosystem services in relation to knowledge on soil fertility and biodiversity. *Regional Environmental Change* 11(4):791–804.

Lejon, A. G. C., B. M. Renöfält, and C. Nilsson. 2009. Conflicts associated with dam removal in Sweden. *Ecology and Society* 14(2):4.

Levin, I. P., S. L. Schneider, and G. J. Gaeth. 1998. All frames are not created equal: a typology and critical analysis of framing effects. *Organizational Behavior and Human Decision Processes* 76(2):149–188.

Lewan, L., and T. Söderqvist. 2002. Knowledge and recognition of ecosystem services among the general public in a drainage basin in Scania, southern Sweden. *Ecological Economics* 42(3):459–467.

Lewicki, R. 2003. *Making sense of intractable environmental conflicts: concepts and cases*. Island Press, Washington, D.C., USA.

Luiker, E., J. Culp, A. Yates, and D. Hryn. 2013. *Ecosystem metabolism as a functional indicator for assessing river ecosystem health – application for New Brunswick rivers*. New Brunswick Power Corporation, Fredericton, New Brunswick, Canada.

Martel, A. L., D. F. McAlpine, J. Madill, D. L. Sabine, A. Paquet, M. Pulsifer, and M. Elderkin. 2010. Freshwater mussels (Bivalvia: Margaritiferidae, unionidae) of the Atlantic Maritime Ecozone. Pages 551–598 *in* D. F. McApline and I. M. Smith, editors. *Assessment of species diversity in the Atlantic Maritime Ecozone*. NRC Research Press, Ottawa, Ontario, Canada.

Martín-López, B., I. Iniesta-Arandia, M. García-Llorente, I. Palomo, I. Casado-Arzuaga, D. G. Del Amo, E. Gómez-Baggethun, E. Oteros-Rozas, I. Palacios-Agundez, B. Willaarts, J. A. González, F. Santos-Martín, M. Onaindia, C. López-Santiago, and C. Montes. 2012. Uncovering ecosystem service bundles through social preferences. *PLoS ONE* 7(6):e38970.

McClenachan, L., S. Lovell, and C. Keaveney. 2015. Social benefits of restoring historical ecosystems and fisheries: alewives in Maine. *Ecology and Society* 20(2):31.

McShane, T. O., P. D. Hirsch, T. C. Trung, A. N. Songorwa, A. Kinzig, B. Monteferri, D. Mutekanga, H. Van Thang, J. L. Dammert, M. Pulgar-Vidal, M. Welch-Devine, J. Peter Brosius, P. Coppolillo, and S. O'Connor. 2011. Hard choices: making trade-offs between biodiversity conservation and human well-being. *Biological Conservation* 144(3):966–972.

Milcu, A. I., J. Hanspach, D. Abson, and J. Fischer. 2013. Cultural ecosystem services: a literature review and prospects for future research. *Ecology and Society* 18(3):44.

Miles, M. B., A. M. Huberman, and J. Saldana. 2013. *Qualitative data analysis: a methods sourcebook*. 3rd edition.

Millennium Ecosystem Assessment (MA). 2005. *Ecosystems and human wellbeing: synthesis*. Island Press, Washington, D.C., USA.

Minsky, M. 1974. A framework for representing knowledge. Pages 211–277 *in* P. Winston, editor. *The psychology of computer vision*. McGraw-Hill, Washington, D.C., USA.

Naiman, R. J., and D. Dudgeon. 2011. Global alteration of freshwaters: influences on human and environmental well-being. *Ecological Research* 26(5):865–873.

New Brunswick Power (NB Power). 2014. Mactaquac Project. Fredericton, New Brunswick, Canada. https://www.nbpower.com/html/en/about/future/mactaquac.html

NB Power. 2015. Your feedback: What we heard at our Mactaquac Project open houses. Fredericton, New Brunswick, Canada.

Nilsson, C., and K. Berggren. 2000. Alterations of riparian ecosystems caused by river regulation. *BioScience* 50(9):783–792.

Norgaard, R. B. 2010. Ecosystem services: from eye-opening metaphor to complexity blinder. *Ecological Economics* 69(6):1219–1227.

O'Connor, J. E., J. J. Dud, and G. E. Grant. 2015. 1000 dams down and counting. *Science* 348(6234):496–497.

Opperman, J. J., G. E. Galloway, J. Fargione, J. F. Mount, B. D. Richter, and S. Secchi. 2009. Sustainable floodplains through large-scale reconnection to rivers. *Science* 326(5959):1487–1488.

Penney, G. H. 1987. *Dissolved oxygen and nitrogen concentrations in Mactaquac area waters, 1968, 1969 and 1972*. -Canadian Mariuscript Report of Fisheries ahd Aquatic Sciences NO. 1906, Department of Fisheries and Oceans, Halifax, Nova Scotia, Canada.

Plieninger, T., S. Dijks, E. Oteros-Rozas, and C. Bieling. 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. *Land Use Policy* 33:118–129.

Poff, N. L., and D. D. Hart. 2002. How dams vary and why it matters for the emerging science of dam removal. *BioScience* 52(8):659–668.

Poff, N. L., and J. K. H. Zimmerman. 2010. Ecological responses to altered flow regimes: a literature review to inform the science and management of environmental flows. *Freshwater Biology* 55(1):194–205.

Putnam, L. L., G. Burgess, and R. Royer. 2003. We can't go on like this: frame changes in intractable conflicts. *Environmental Practice* 5(3):247–255.

Redford, K. H., and W. M. Adams. 2009. Payment for ecosystem services and the challenge of saving nature. *Conservation Biology* 23(4):785–787.

Reed, M. S. 2008. Stakeholder participation for environmental management: a literature review. *Biological Conservation* 141(10):2417–2431.

Richter, B. D., and G. A. Thomas. 2007. Restoring environmental flows by modifying dam operations. *Ecology and Society* 12(1):12.

Saldana, J. 2009. *The coding manual for qualitative researchers*. SAGE Publications.

Sherren, K., T. M. Beckley, J. R. Parkins, R. C. Stedman, K. Keilty, and I. Morin. 2016. Learning (or living) to love the landscapes of hydroelectricity in Canada: eliciting local perspectives on the Mactaquac Dam via headpond boat tours. *Energy Research & Social Science* 14:102–110.

Shmueli, D. F. 2008. Framing in geographical analysis of environmental conflicts: theory, methodology and three case studies. *Geoforum* 39(6):2048–2061.

Shmueli, D. F., N. Collins-Kreiner, and M. Ben Gal. 2014. Conflict over sacred space: the case of Nazareth. *Cities* 41:132–140.

Shmueli, D. F., M. Elliott, and S. Kaufman. 2006. Frame changes and the management of intractable conflicts. *Conflict Resolution Quarterly* 24(2):207–218.

Singh, A., R. S. Wilson, J. Bruskotter, J. Brooks, A. Zwickle, and E. Toman. 2013. Ecosystem services and carbon sequestration in the biosphere. Pages 1–464 *in* R. Lal, K. Lorenz, R. Huttl, B. U. Schneider, and J. von Braun, editors. *Ecosystem services and carbon sequestration in the biosphere*. Springer Science+Business Media, Dordrecht, The Netherlands.

Sofaer, S. 1999. Qualitative methods: what are they and why use them? *Health Services Research* 34(5 Pt 2):1101–1118.

Spash, C. L., K. Urama, R. Burton, W. Kenyon, P. Shannon, and G. Hill. 2009. Motives behind willingness to pay for improving biodiversity in a water ecosystem: economics, ethics and social psychology. *Ecological Economics* 68(4):955–964.

Stantec. 2015. *Mactaquac Project comparative environmental review report*. Fredericton, New Brunswick, Canada.

Strauss, A., and J. Corbin. 1998. *Basics of qualitative research techniques and procedures for developing grounded theory*. 2nd edition. SAGE Publications, London, UK.

Tallis, H., P. Kareiva, M. Marvier, and A. Chang. 2008. An ecosystem services framework to support both practical conservation and economic development. *Proceedings of the National Academy of Sciences of the United States of America* 105(28):9457–9464.

Thomas, D. R. 2006. A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation* 27(2):237–246.

Tversky, A., and D. Kahneman. 1981. The framing of decisions and the psychology of choice. *Science* 211(4481):453–458.

Van Gorp, B. 2007. The constructionist approach to framing: bringing culture back in. *Journal of Communication* 57(1):60–78.

Van Looy, K., T. Tormos, and Y. Souchon. 2014. Disentangling dam impacts in river networks. *Ecological Indicators* 37(PART A):10–20.

Vörösmarty, C. J., P. B. McIntyre, M. O. Gessner, D. Dudgeon, A. Prusevich, P. Green, S. Glidden, S. E. Bunn, C. A. Sullivan, C. R. Liermann, and P. M. Davies. 2010. Global threats to human water security and river biodiversity. *Nature* 467(7315):555–561.

Wilson, R. S., J. L. Arvai, and H. R. Arkes. 2008. My loss is your loss…sometimes: loss aversion and the effect of motivational biases. *Risk Analysis* 28(4):929–938.

Wilson, R. S., P. L. Winter, L. A. Maguire, and T. Ascher. 2011. Managing wildfire events: risk-based decision making among a group of federal fire managers. *Risk Analysis* 31(5):805–818.

World Commission on Dams (WCD). 2000. *Dams and development*. Earthscan, London, UK.

APPENDIX 4.1

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.'

Code	Description	Example quote
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.'

FOREWORD TO CHAPTER 5

The frames of the decision on the Mactaquac Dam analysed in chapter 4 revealed substantial differences between stakeholders in how information about potential dam removal is received, and, combined with their previous knowledge and experiences of ecosystem services, interpreted. Diverging frames between parties involved in stakeholder conflicts of this type can reinforce their positions and the differences between them. However, analysis of those frames can also identify points of convergence, which represent shared ground that can form the basis of conflict resolution through reframing.

The frames also appeared to include different scale frames of the issue at the centre of the decision on dam removal. Therefore, in this chapter the literature on scale framing and the politics of scale is used to develop a conceptual framework for examining in more detail how those issues are scale framed, and the potential for mismatches that exacerbate the conflict.

Debates around dam removal incorporate a wide range of issues, from energy supply to species protection to preservation of cultural heritage, which occur and are managed on an equally wide range of scales and levels. The scales and levels at which the most important problems are defined imply also the scale and level at which they can be resolved. Therefore, successful positioning in a conflict involves matching the level at which the problem is defined to the level at which it is managed. This strategic manipulation of scales and scale frames is known as the politics of scale.

The results presented in this chapter reveal that different groups involved in the conflict used similar scale framing strategies to support their arguments. Scale frames of the problem and its most appropriate solution led to certain arguments and stakeholders being legitimised in the decision, and others delegitimised. Both the spatial and temporal scales, including the past, were used in scale framing.

This paper is published in Ecology and Society (Reilly et al., 2017; https://doi.org/10.5751/ES-09535-220321). The format has been modified to be consistent with the remainder of this thesis. All literature cited in this chapter is listed at the end of this chapter.

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5. Spatial and temporal scale framing of a decision on the future of the Mactaquac Dam in New Brunswick, Canada

Reilly, K.H. and Adamowski, J.F.

5.1. Abstract

Many large dams are coming to the end of their lifespans and decisions must be made about whether to rebuild/refurbish or remove them, which will have different implications across temporal and spatial scales. Such decisions are often controversial, but little is known about what drives differences in stakeholders' perspectives of them. Cognitive scale frames describe how people use scales in interpreting such an issue, including which of its elements they prioritise and which they minimise. Using interviews with 30 stakeholders and analysis of documents, we explored how stakeholders used spatial and temporal scales in their frames of a decision about whether to rebuild/refurbish or remove the Mactaquac Dam in New Brunswick, Canada. We found that stakeholders used multiple levels on spatial, hydrological, administrative, and temporal scales in their frames. Both those who wanted to retain the dam and those who wanted to remove it upscaled problems from local level to higher spatial levels, making problems seem widely shared and therefore legitimate. However, there were mismatches in the scales used: the retainers upscaled to the province on the administrative scale while the removers upscaled to the entire river on the hydrological scale. The results revealed the particular importance of temporal scale frames, particularly of the past, which have been little studied. Both groups framed problems as continuing into the future, but diverged strongly in how they framed various periods of the past as being relevant to understanding problems and their solutions in the present. Decision makers should be aware of differing scale frames when designing decision-making processes and conflict resolution efforts.

Key words: dams; scale framing; spatial scale; temporal scale

5.2. Introduction

Dams that were built in the early to mid-1900s are now beginning to reach the end of their lifespans (World Commission on Dams (WCD) 2000). Therefore, dam owners must decide whether they should be rebuilt/refurbished or removed altogether. Removal is increasingly considered a viable choice because of the cost of rebuilding dams that may no longer provide useful functions or have become a risk to public health and safety, and because removal can restore the original river environment (WCD 2000, Doyle et al. 2003, Gowan et al. 2006, Fox et al. 2016). However, many of these dams still offer benefits in stabilising water supply, generating hydropower, and controlling flooding (WCD 2000, Poff and Hart 2002), as well as enhancing river transportation and some recreational boating and fishing (Auerbach et al. 2014).

Although these end-of-life decisions on dams are taking place at a time when stakeholder participation is a priority for environmental decision makers (Reed 2008, Freeman et al. 2010, Susskind 2013, Kochskämper et al. 2016), stakeholders' perceptions of the decisions and their impacts have been little studied (Born et al. 1998, Johnson and Graber 2002, Lejon et al. 2009, Jørgensen and Renöfält 2012, Fox et al. 2016, Reilly and Adamowski 2017). There is a need to better understand why stakeholders often have diverging views on whether a dam should be removed or rebuilt/refurbished to anticipate and mediate any resulting conflict and to incorporate their perspectives into decisions (Johnson and Graber 2002, Lejon et al. 2009, Jørgensen and Renöfält 2012, Fox et al. 2016).

The concept of cognitive frames is a useful way to understand stakeholders' perceptions of a decision, particularly when diverging frames can contribute to conflict (Lewicki 2003, Dewulf et al. 2009). A frame describes how a person makes sense of a particular issue or experience, in terms of which aspects they prioritise or deem important, and which they consider unimportant (Lewicki 2003, Dewulf 2013). Therefore, understanding stakeholders' frames of an issue, such as a decision on a dam's future, reveals their position, but also their justification of that position, their assumptions, and biases, and points of agreement with other stakeholders (Lewicki 2003, Shmueli et al. 2006, Dewulf 2013).

How stakeholders frame environmental issues in terms of scale is beginning to receive particular attention (Kurtz 2003, Mansfield and Haas 2006, van Lieshout et al. 2011, Juerges and Newig 2015). Scale framing, as this process is known, means 'the process of framing an issue using a certain scale and/or level' (van Lieshout et al. 2011). Scale frames may be

particularly relevant to decisions on the future of dams because the decision will have impacts across multiple levels and scales (Hart et al. 2002, Cash et al. 2006, Moss and Newig 2010, Termeer et al. 2010). For example, ecological responses to dam removal differ according to the length of time since removal, i.e., according to different levels on the temporal scale (Hart et al. 2002, Hansen and Hayes 2012). In the days to years following removal, water levels go down and sediment transport increases, while years to decades later, plant community succession occurs (Hart et al. 2002). Similarly, responses are different at the site level and the river level (Hart et al. 2002, Van Looy et al. 2014). Removing a dam may affect specific salmon spawning or feeding sites, while allowing fish to migrate throughout the river system (Durance et al. 2006, Morley et al. 2008). On the administrative scale, such decisions have implications at several levels including energy policy at provincial or national level, and municipal-level service provision. Stakeholders use these levels and scales to define the problems associated with the decision and identify their solutions. The resulting scale frames have consequences for which arguments and stakeholders are considered legitimate to be included in the decision, potentially contributing to conflict between people with different views (McCann 2003, van Lieshout et al. 2011). Despite the importance of scale issues in decisions about dams' futures, they have not been studied to date.

We investigated how stakeholders, including business owners, anglers, boaters, and property owners, used scale to frame a decision on whether to remove or rebuild the Mactaquac Dam, a large hydropower dam on the Saint John River, New Brunswick, Canada. Its lifespan was shortened because of a structural problem with its powerhouse and spillway, although it is still functional (New Brunswick (NB) Power 2014, Stantec 2016). This case study is an interesting example of a decision on the future of a dam since, because of its shorter lifespan, the decision is occurring at a time when both the pre-dam state and the construction of the dam are in living memory. It would also be one of the largest dam removal projects globally if that option were chosen, and therefore offers a useful example for decisions on other large dams. To study scale framing in this context, we addressed the following research questions:

- How do local stakeholders use scale to frame the problems and solutions associated with the dam, its current river environment, and its potential removal?
- How do local stakeholders use scale framing strategies to construct their arguments about whether the dam should be removed or not?
- What are the implications of the scale frames and framing strategies used for decision making about the dam?

5.3. Conceptual framework

We developed a conceptual framework using the literature on frames of environmental issues in decision making, and on scale frames as part of the politics of scale, as shown in Figure 5.1 and elaborated below. Using the literature on issue framing, we distinguished problem and solution frames, because the distinction allowed us to identify how scale is used to link the two, and to compare similar frame types when assessing mismatches between stakeholders' frames. We identified a range of scale framing strategies and their implications from the literature on scale frames in environmental decision making, which allowed for a systematic identification of frames in the data.

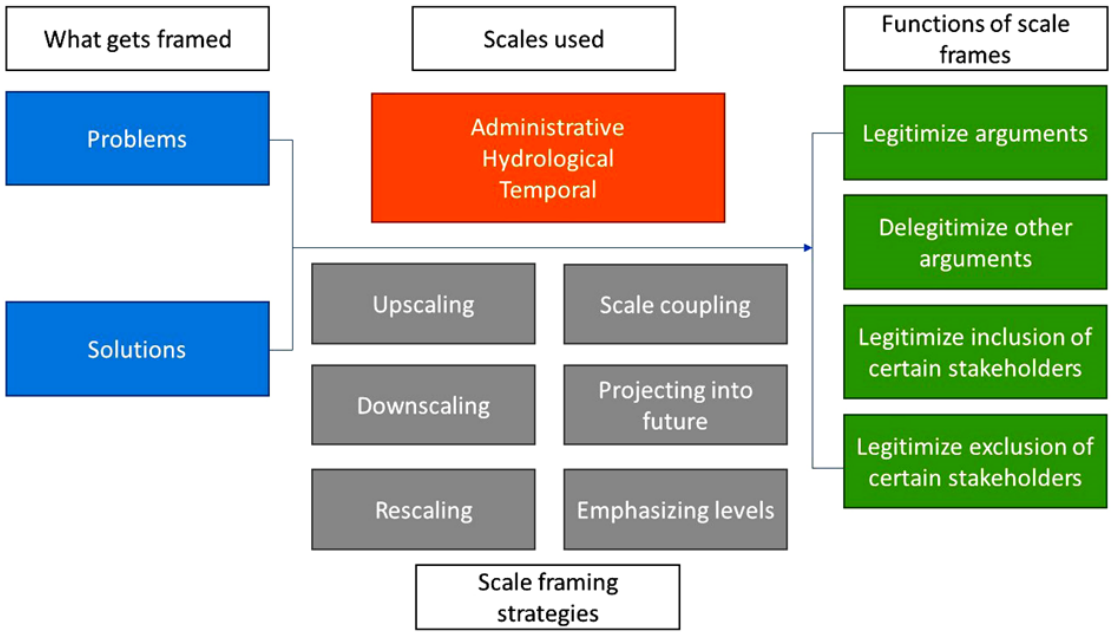

Figure 5.1. Conceptual framework describing what aspects of the decision on the dam get framed using scale, which framing strategies are used, and the likely consequences of the frames.

5.3.1. What gets framed

We focus here on stakeholders' frames of the problems and solutions at the centre of decisions on dams at the end of their lifespan, rather than the frames of identities, relationships with others, or interaction processes that have been studied elsewhere (Dewulf et al. 2009). It is these problem and solution frames that are typically subject to scale framing as people attempt to change the legitimacy of certain arguments and stakeholders in a decision-making process (van Lieshout et al. 2011, Juerges and Newig 2015).

We define problem and solution frames as cognitive structures that highlight certain aspects of a situation, minimise others, and determine its boundaries, thereby forming a model of reality stored in memory (Lewicki 2003, Shmueli et al. 2006, Dewulf et al. 2009). Through this process, a person makes sense of, or interprets, the situation. In doing so, they define the debate, including the causes of the problem and who is to blame, and justify particular solutions as being appropriate or legitimate (Lewicki 2003, Dewulf 2013). Frames also serve a strategic purpose to persuade others, reinforce a position, or communicate a message (Zald 1996, Scheufele 1999, Gray and Putnam 2003).

Problem frames define whether there is a problem at the centre of the decision-making process and what that problem is (Bardwell 1991, Lewicki 2003, Asah et al. 2012*a*). These problem frames incorporate people's 'preconceptions and assumptions that underpin how one approaches the problem', which then point to a particular solution (Bardwell 1991:605). For example, a study of frames of river restoration projects found that some residents framed the projects as problems that would reduce accessibility to the floodplain, and negatively impact cultural heritage and agricultural productivity. These residents opposed river restoration. Others framed the projects as increasing the aesthetic attractiveness and natural value of the floodplains, and thus supported river restoration (Buijs 2009). Therefore, identifying problem frames reveals where exactly stakeholders diverge in their interpretation of a problem that leads to them favouring different solutions (Bardwell 1991, Asah et al. 2012*a*).

Solution frames include both frames of a particular solution and frames of how a decision should be made (Lewicki 2003, Juerges and Newig 2015). They are closely linked to problem frames; how a person conceptualises a problem and which elements of the problem they consider most relevant will relate to how they frame solutions (Bardwell 1991). Frames of how a particular decision should be made often reflect a person's views on collaborative versus expert-led decision making, as well as their preferences for conflict resolution (Lewicki 2003, Peterson 2005). Understanding solution frames can help decision makers identify which strategies stakeholders agree and disagree on, rather than focusing on their fundamental differences (Asah et al. 2012*b*).

5.3.2. Using scale in problem and solution frames

We define scales as 'the spatial, temporal, quantitative or analytical dimensions used to describe a phenomenon' (Gibson et al. 2000, van Lieshout et al. 2012:164), a definition used in the study of environmental change from both ecological and social perspectives (Gibson et

al. 2000). Several scales are relevant to understanding and managing environmental problems, including various spatial scales that describe how ecological and geographical processes occur in space (Figure 5.1; Cash et al. 2006). In this case, the hydrological scale is the most relevant of these to the problem at hand, namely how rebuilding or removing a dam affects a river. The administrative scale refers to the 'clearly bounded and organised political units' (Cash et al. 2006) in which environmental problems are managed, including municipalities, provinces, and nations. Last, the temporal scale is highly relevant because the impacts of environmental problems, and their management, frequently vary over different periods of time (Sayre 2005).

On each of these scales, there are numerous locations or units of analysis, which we refer to as levels (Gibson et al. 2000, Cash et al. 2006, Sayre and Di Vittorio 2009). For example, a day would be a level on a temporal scale and a watershed is a level on a spatial scale (Cash et al. 2006, Daniell and Barreteau 2014). Levels can be understood as a sequence of spaces arranged in a nested hierarchy (Delaney and Leitner 1997), but not all scales consist of levels arranged in this way (Gibson et al. 2000).

These scales and levels are used in framing problems and their solutions, a process known as scale framing (Kurtz 2003, Harrison 2006, Mansfield and Haas 2006, van Lieshout et al. 2011, 2012, Edge and Eyles 2014). Scale frames therefore describe how stakeholders define the boundaries of problems and solutions in space and time (van Lieshout et al. 2011, Edge and Eyles 2014). Stakeholders use scale frames to change the relative importance of levels and scales, and/or to change or reinforce power relations (Delaney and Leitner 1997, Kurtz 2003, McCann 2003, Harrison 2006, Leitner et al. 2008). For example, McCann (2003) studied the politics of scale in a neighbourhood planning process. Residents argued that how the city defined the boundaries of the neighbourhood promoted gentrification and marginalised long-term residents, and instead argued that the boundaries should be widened to include a larger area. Although the city's boundaries were ultimately adopted, it was only after a lengthy conflict. This strategic reconfiguration of scales to meet particular ends, whether done intentionally or unintentionally, is called the politics of scale (Leitner et al. 2008, Hüesker and Moss 2015).

5.3.3. Scale framing strategies

Several strategies by which scale frames are used to meet political goals in environmental decision making have been identified (Figure 5.1; McCann 2003, van Lieshout et al. 2012, Juerges and Newig 2015, Sica 2015). The simplest is to emphasise a particular level, such as

the regional or national level, in framing an issue, which has the effect of prioritising the interests or issues found at that level (van Lieshout et al. 2014). Upscaling and downscaling involve shifting the interpretation of an issue to higher or lower levels on the same scale, respectively. They are often used in solution scale framing to argue for a change in the level at which decision making or governance of an issue occurs (Kurtz 2003, Harrison 2006, van Lieshout et al. 2012, Juerges and Newig 2015). For example, environmental organisations in Germany argued that decisions about windfarms should be taken at state level, rather than local level, to avoid local-level economic concerns overriding environmental protection (Juerges and Newig 2015). They can also be used in problem frames to magnify an issue and make it seem widely shared by upscaling it to a higher level, or minimise it by downscaling it to a lower level (van Lieshout et al. 2012, Sica 2015).

Rescaling involves shifting the scale used to frame either problems or solutions associated with an issue (van Lieshout et al. 2014, Juerges and Newig 2015). Like upscaling and downscaling, it can be used to argue for a change in governance by changing the scale on which an issue is framed, such as from the administrative to a biophysical scale (Hüesker and Moss 2015, Juerges and Newig 2015). An example of rescaling is the current focus on watersheds (a level on a hydrological scale) as a more appropriate unit for water management than municipalities or states/provinces (levels on an administrative scale; Hüesker and Moss 2015). Scale coupling involves linking two or more scales together to produce a stronger argument for a particular outcome (McCann 2003, van Lieshout et al. 2012).

On the temporal scale, the strategy of future projection involves referring to future conditions to justify an argument about a decision in the present. Such projections can include anticipations of regret if a decision is made in a certain way, promises of future benefits, and projected changes that will require a particular action now (van Lieshout et al. 2012). For example, in a debate over a megafarm in the Netherlands, the responsible municipal council member argued for a megafarm on the basis that the municipality would regret it if they chose not to allow the farm (van Lieshout et al. 2012). This strategy has been little studied in terms of how different periods in the future are framed and its implications.

5.3.4. Functions of scale frames

At a general level, scale framing strategies are used to shift power and authority, to realise interests, or to advocate for particular solutions based on perceptions of effectiveness, efficiency, or legitimacy (Kurtz 2003, McCann 2003, van Lieshout et al. 2011, 2014). In this

way, scale is used to frame a problem so that a particular solution appears logical or, conversely, inappropriate (Williams 1999, Harrison 2006, Mansfield and Haas 2006, van Lieshout et al. 2011).

One of the ways in which scale framing a problem can be used to support or reject a particular solution is in using scale to legitimise or delegitimise arguments. Arguments can be legitimised for example by magnifying their importance or making them appear widely shared. Van Lieshout et al. (2011) identified that the developer of the Dutch megafarm framed the farm as a model for the rest of the world to follow, i.e., framing it at global level. In doing so, he described its benefits as being more important than his own personal interests and made its development seem an obvious solution. Such scale frames therefore legitimise arguments that may be difficult to justify had they not been framed using that scale or level (van Lieshout et al. 2011).

Scale frames can also be used to argue for a change in the level at which a solution is implemented. For example, the need to restrict water retention in storage dams in the Murray-Darling Basin was framed as an important issue at sequentially higher levels, from local to state to national level. This resulted in the decision to limit water retention being taken by the federal government, which allowed the state government to avoid political consequences from irrigators who viewed the restriction as an injustice (Patrick et al. 2014) In this way, how issues are framed using scales and levels has implications for decision making and conflicts between stakeholders (Delaney and Leitner 1997, van Lieshout et al. 2011, Patrick et al. 2014).

By defining the boundaries of a problem in time and space, scale frames also justify the inclusion or exclusion of groups of people as being amongst those affected by the issue. Upscaling can be used to portray a larger group of people as affected by an issue, and therefore reinforce the need for it to be addressed (Kurtz 2003, Harrison 2006, van Lieshout et al. 2014). For example, activists campaigning against pesticide exposure in farm workers upscaled it from farm level to state level, which strengthened their case for action (Harrison 2006). Scale framing, particularly downscaling, can also have the opposite function: in framing an issue at a particular level, some people are described as outsiders, allowing their arguments to be dismissed (Kurtz 2003).

5.3.5. Implications of scale framing strategies and their outcomes for environmental decision making

Frames of environmental decision making have important consequences for understanding problems, identifying effective solutions, and conflict resolution, particularly when they diverge between stakeholders. Frames that incorporate distinct understandings of a problem lead to different solutions being favoured, and prevent other solutions being explored (Bardwell 1991). Such divergences in how problems and solutions are framed can cause difficulties in communication and contribute to conflict (Lewicki 2003, Shmueli et al. 2006, Dewulf et al. 2009). New information is interpreted through the frame, which further reinforces it, and therefore hinders efforts to encourage frame convergence (Shmueli et al. 2006). Furthermore, when a frame defines what is right or fair, its user can blame others who they perceive as contributing to the injustice (Lewicki 2003). These processes can solidify differences between stakeholders in conflict.

Scale frames, in particular, are the subject or source of disputes between stakeholders as they attempt to change scalar arrangements or advocate for a particular solution with scalar implications (Delaney and Leitner 1997). These disputes can take the form of mismatches between scale frames, meaning that stakeholders' scale frames of a problem or solution are incompatible (Termeer et al. 2010, van Lieshout et al. 2011). Van Lieshout et al. (2011) identified three types of mismatches between stakeholders' scale frames: (1) framing an issue differently but using the same level or scale, (2) framing the issue using a different scale, and (3) framing the issue using a different level. When different stakeholders use mismatching frames to argue for opposite solutions, communication difficulties can arise and conflict can be initiated or exacerbated (van Lieshout et al. 2011).

Understanding the assumptions and contradictions in how stakeholders scale frame a situation can allow areas of agreement, and hence compromise, to be identified, expand the range of possible solutions, and facilitate negotiation and mediation efforts (Bardwell 1991, Shmueli et al. 2006, Asah et al. 2012*a*, Emery et al. 2013). It can also inform reframing efforts or collaborative processes to create a shared understanding of the situation. This shared understanding can then provide the foundation for addressing other elements of the conflict (Schön and Rein 1995, Asah et al. 2012*a*, van Hulst and Yanow 2016).

The various scale framing strategies and their functions outlined above have been investigated in a range of contexts, including agricultural issues and renewable energy (Harrison 2006, van

Lieshout et al. 2011, 2012, 2014, Juerges and Newig 2015). We study them in a unique context: the potential removal of a large dam that would have varying consequences across time and space. We also build on the few studies that investigate how an issue is framed using different scales, including spatial, administrative, hydrological, and temporal scales, as opposed to studying the spatial scale alone (McCann 2003, van Lieshout et al. 2011, Hüesker and Moss 2015).

5.4. Study area

5.4.1. Choice of case

A decision on whether to rebuild or remove the Mactaquac Dam, a hydropower dam on the Saint John River, New Brunswick, Canada, was chosen as the focus of this study. At a height of 42.37 m above sea level, the Mactaquac Dam is one of the largest dams ever considered for removal (Stantec 2016), making it an important test case for other decisions about large dams. Its construction significantly changed the landscape and altered how communities and individuals interacted with the river. The decision made by New Brunswick Power, the dam's owner, therefore would have significant impacts on the river and how communities and individuals interact with it, and became an important issue of local concern (Dillon Consulting 2015). Opinions on which option should be chosen diverged significantly, meaning that there was ample opportunity to observe different scale frames. Furthermore, the decision-making process was ongoing at the time of the study, which allowed frames to be identified concurrently, rather than relying on people's retrospective views of a past event.

5.4.2. Background information

The Mactaquac Dam is located on the middle reach of the Saint John River (Figure 5.2), which runs through Quebec and New Brunswick, Canada, and Maine, United States. The dam, located approximately 20 km upstream of Fredericton, the capital of New Brunswick, was constructed in the 1960s and now produces approximately 12% of New Brunswick's electricity (Stantec 2016). Its construction created a reservoir, known as the Mactaquac headpond, of approximately 97 km in length and 84 km² in area that extends from Hartland downstream to the dam (Figure 5.2; Canadian Rivers Institute 2013, Stantec 2016). Fredericton is the largest population centre in the area; the area around the headpond is primarily rural with several small towns, including Nackawic and Woodstock. The study was focused on the river reach from Hartland upstream to Fredericton downstream because this area was the most affected by the dam's construction.

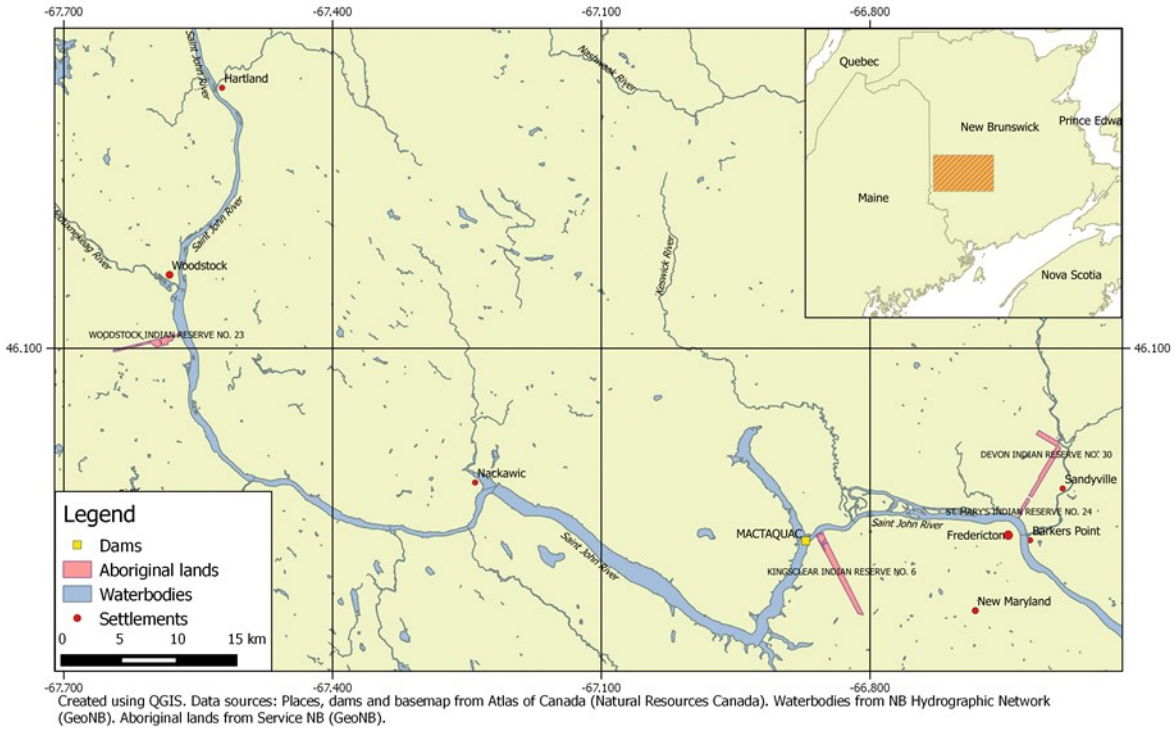

Figure 5.2. Study area: St John River from Hartland (upstream) to Fredericton (downstream), New Brunswick, Canada. Inset: Location of study area (in orange) within province of New Brunswick.

5.4.3. Impacts of the Mactaquac Dam

The dam impacted the area from Hartland to Fredericton hydrologically, ecologically, socially, and economically. The headpond is deeper and has a slower water velocity than the river prior to being dammed, creating a more lake-like environment. Downstream flow has also been affected; because water is released through the dam in response to fluctuating energy demands, water levels change by up to 1 m over the course of a day (Canadian Rivers Institute 2011, Luiker et al. 2013, Jones 2014). Some of the ecological impacts of the dam are related to this change in hydrology. The oscillations in downstream flow can dislodge benthic taxa, and salmon smolt cannot navigate the headpond because of its slow velocity and shallow gradient (Carr 2001, Canadian Rivers Institute 2011, Luiker et al. 2013, Jones 2014). The dam is a barrier to upstream migration for several species, including American shad (*Alosa sapidissima*) and Atlantic salmon (*Salmo salar*; Canadian Rivers Institute 2011).

Many local people opposed construction of the dam, including some residents both upstream and downstream of the dam site, Maliseet people, farmers, and sports fishers (Kenny and Secord 2010, Bourgoin 2013). This diverse range of stakeholders were organised into the Association for the Preservation and Development of the Saint John River in its Natural State,

which regularly appealed against the dam to the public and the provincial government. Opposition arguments centred around several issues, including loss of aesthetic beauty, impacts on fisheries, flooding of valuable agricultural land, and destruction of historical and cultural heritage. For example, residents opposed the flooding of cemeteries on ethical grounds and because they represented personal and cultural connections to the past (Bourgoin 2013). Opponents' concerns were ultimately disregarded and provincial decision makers focused on the contribution the dam's energy would make to New Brunswick's economic development and modernisation (Bourgoin 2013).

Approximately 900–1100 people were relocated (estimates vary; Si 1993, Bourgoin 2013) and were compensated monetarily. Some chose to move to higher ground at the same site, some moved site, and some left the area entirely (Si 1993). The relocations were, for the most part, traumatic (Si 1993, Keilty et al. 2016, Sherren et al. 2016). In addition, it is estimated that 16 graveyards and nine churches were relocated. Fort Meductic, an important historical site for the Maliseet people, was flooded, as well as 2.5 acres of the Woodstock First Nation's land (Bourgoin 2013). Many farms became economically unviable when highly productive low-lying land was flooded. Approximately 100 jobs were created at the Nackawic pulp and paper mill, but the regional development project associated with the dam's construction largely failed in generating employment (Si 1993).

Since then, however, the headpond has become valuable socially and economically in itself (Sherren et al. 2016). Economic activity around the headpond mostly relies on recreation and tourism, including boating, fishing, and camping (Dillon Consulting 2015). Many new houses have been built, with residents drawn to the area by the aesthetics and recreational opportunities (Lawson et al. 1985, Dillon Consulting 2015, Stantec 2016).

Many of the residents around the headpond now feel attachment to it and feel it contributes to their sense of identity (Sherren et al. 2016). Individuals, including those who remember the pre-dam river and those who moved to the area since, have adapted to the dammed landscape (Keilty et al. 2016). These individuals tend to personally value the aesthetics and recreational and business opportunities afforded by the lake-like environment (Sherren et al. 2016, Reilly and Adamowski 2017). However, there remain many others who regret the loss of many characteristics of the pre-dam river, including the Atlantic salmon run, the low-lying farmland and islands, and its aesthetics (Reilly and Adamowski 2017).

5.4.4. The decision on the dam's future

The decision on whether to retain the dam in some form or remove it was required because of a structural problem in the electricity generating components of the dam that was predicted, at the time of the study in summer 2015, to shorten its lifespan from the planned 100 years to approximately 60 years. The problem is caused by an alkali-aggregate reaction between the cement and the aggregate in the concrete spillway, powerhouse, and other structures, which causes the concrete to expand. The earthen structure that impounds the river is not affected (Stantec 2016).

At the time of the study, New Brunswick Power had identified three options for the dam's future: rebuild the affected structures to maintain electricity generation and the headpond, retain the earthen dam to maintain the headpond, or remove the dam entirely to restore the river to its natural free-flowing condition. Reviews of the environmental and social impacts of each option were underway at the time of the study (Dillon Consulting 2015, Stantec 2016), but neither had yet been released to the public. Consultations with Maliseet Nations in the area were ongoing, but the public consultation had not yet started. The decision was made by the provincial power company and provincial government based on these studies and assessments of the finances, energy, and other considerations. For this study, we focused on the option to remove the dam, because it would cause greater ecological, social, and economic changes than the other two options, which would be similar to the status quo.

Numerous issues were at stake in the decision. The electricity that the dam currently produces would have to be replaced with other renewables, in order to meet New Brunswick's legislative requirements (NB Power 2016). All options had high associated costs; utility costs were estimated at 4.3 to 5.6 billion CAD depending on the option (NB Power 2017). To manage these, New Brunswick Power planned incremental rate rises for energy consumers, with the rest of the project financed with a loan from the provincial government (NB Power 2016). Numerous other economic, environmental, and social impacts of the various options were identified during New Brunswick Power's review process (Table 5.1).

Table 5.1. Economic, environmental, and social issues of concern in the Mactaquac Dam project (Dillon Consulting 2015, Stantec 2015).

Impact category	**Particular concerns**
Atmospheric environment	Air quality, greenhouse gas emissions, microclimate
Acoustic environment	Sound quality and vibration

Impact category	Particular concerns
Surface water	Flow regime, water quality, sediment quality, flooding,
Groundwater	Groundwater quantity and quality
Aquatic environment	Fish habitat, fish mortality, species at risk, species of conservation concern
Vegetation and wetlands	Vegetation communities, species at risk, species of conservation concern, wetland area and function
Wildlife and wildlife habitat	Wildlife habitat, direct mortality, species of conservation concern
Economy and employment	Economic activity including local businesses, employment
Resource uses	Land and resource use, navigation, exposure of land/islands, land acquisition
Community and social uses	Access to recreational uses, community identity, property values, viewshed changes, river access
Infrastructure and services	Infrastructure, access, water intakes and outfalls, community emergency services, housing and accommodation, infrastructure damage
Transportation	Road infrastructure, traffic volume, disruption
Heritage resources	Archaeological, historical and palaeontological resources
Use of land and resources for traditional purposes by Aboriginal persons	Traditional use

The decision took place in a particular political and economic context. The government's debt was continuing to increase as a percentage of GDP and was expected to increase to 42% in 2017/2018 (RBC 2017). The province experienced a decline in population of 0.5% between 2011 and 2016 (Statistics Canada 2017), which, combined with an increasing number of retirees, made growing and maintaining the population a provincial priority (Government of New Brunswick 2014). To address these challenges, the provincial government was focused on promoting economic growth, including through investing in infrastructure projects (Government of New Brunswick 2016).

Given the wide-ranging impacts of all options, the decision was divisive socially. A group of residents in the headpond area formed a citizen's action group to advocate for retaining the headpond, it was much discussed in local media, and meetings held by New Brunswick Power were well attended (Keilty 2015, NB Power 2015, Sherren et al. 2016). The majority of residents and stakeholders around the headpond appeared to be in favour of rebuilding the dam, as evidenced by opinions voiced at community meetings and in New Brunswick Power's

consultation process (NATIONAL and CRA 2016, Sherren et al. 2016). For some, this was because of a desire to avoid going through trauma from removal similar to that which occurred when the dam was built (Sherren et al. 2016). Other key arguments in favour of rebuilding the dam included a desire to maintain the business and recreational opportunities of the headpond, minimise impacts on property values, avoid disturbing the headpond ecosystem, and maintain hydropower generation (Sherren et al. 2016, Reilly and Adamowski 2017). However, some stakeholders and up- and downstream residents expressed desire to remove the dam to restore Atlantic salmon populations, enhance biodiversity and the river's sustainability, and reinstate the opportunity for farming on low-lying land (Reilly and Adamowski 2017).

5.5. Methods

5.5.1. Data collection

We used semi-structured interviews as the primary method of data collection. This allowed us to identify the details of participants' opinions and experiences, which may not have been revealed by a quantitative survey (Patton 2005). The interviews were semi-structured to ensure that the same topics were addressed in every interview, while allowing interviewees the freedom to broach other subjects. We triangulated the interview data with data from documents to determine the consistency of results across methods (Creswell and Miller 2000, Yin 2003). Documents have the advantage of revealing people's perspectives without any input from the researcher (Creswell and Miller 2000, Gray 2004).

We interviewed 30 individuals, most of whom were located between Woodstock and Fredericton (Figure 5.2). They were selected using non-proportional quota sampling (Patton 2005) to ensure that the sample included the greatest range of opinions on the future of the dam. We therefore aimed to include individuals located throughout the study area, and representing the main parties in the decision, including First Nations, anglers, headpond residents, downstream residents, industry, businesses, environmental non-governmental organisations (NGOs), watershed organisations, heritage groups, and recreational groups. The final sample, however, did not include any interviewees located between Woodstock and Hartland, but did include two located outside the study area who had strong professional and/or personal interests in the area. Industry and representatives of First Nations declined to participate. Possible reasons for this include insufficient time or resources to participate, lack of interest, or in the latter case, prior involvement with New Brunswick Power's consultation. None of the stakeholders included in the sample had direct decision-making power but all had the ability to influence the decision through New Brunswick Power's consultation process.

Some were involved in organisations operating at the provincial level, while the majority were focused on the local level.

Twenty-one of the participants were interviewed individually and nine in groups, at their own request; all were conducted between May and July 2015. All but one were conducted in person in the study area, at a location of the participant's choosing. The remaining interview was conducted by Skype. We continued to conduct interviews until theoretical saturation was reached, meaning that interviewees introduced no new themes (Strauss and Corbin 1998). It should be noted, however, that the inclusion of representatives of First Nations and industry in the sample may have introduced new themes.

In each interview, lasting 45 minutes to an hour, we addressed the participant's role and interest in the area and the decision, how they used the river in the study area, their opinions on the dam's future, and their perceptions of each option's impacts. The participants were not directly asked about scale (Apostolopoulou and Paloniemi 2012). Each main theme was introduced with an open-ended question, and closed questions were used where necessary to ensure understanding. Because most of the interviewees had multiple interests in the decision, through their professional and personal lives, they chose which perspective they were most comfortable talking from (Lewan and Söderqvist 2002, Lamarque et al. 2011). Reasons for their choice included whether the organisation they were involved with had developed a position on the dam and the extent to which they were personally affected. Most talked from multiple perspectives and made that clear in their answers.

We collected documents through Google searches, using the keywords 'Mactaquac' and 'Mactaquac Dam', and from online versions of local newspapers, namely the Fredericton Daily Gleaner, the Saint John Telegraph Journal, and the Woodstock Bugle-Observer. All relevant documents were retained for background information, and a subset were used for analysis. We included in this subset all documents published between August 2014 and August 2015 that included the author's opinion on what should happen to the dam, as opposed to background facts, with sufficient information for us to identify their frames. This time period was chosen because it was long enough to include several documents, and it ended when information on the decision was published by New Brunswick Power and the consultation period began. In this way, we ensured that the writers of the documents had access to similar information on the decision as the interviewees. We excluded any documents that repeated opinions that were

published in a very similar form elsewhere. The final sample included 19 documents, including blog posts, comments in online forums, editorials, and letters to the editor.

5.5.2. Data analysis

We coded the transcribed interviews and documents in RQDA, a qualitative data analysis package in R (Huang 2014). In a combined deductive-inductive approach, we used the conceptual framework to develop a codebook of problem and solution frames, and hydrological, administrative, spatial, and temporal scales. We used the codebook to code the data by identifying passages where problems or solutions were framed, and determining if scale(s) were used in the framing. Based on the data, we modified the codebook by subdividing the codes into different problem and solution types, and by dividing the scales into levels, based on an inductive analysis of the data. This was an iterative process of coding, revising the codebook, checking the consistency of passages coded with the same code and their distinctions with other codes, and recoding. We ultimately coded the data using a codebook that included several problem and solution subtypes, and divisions of each scale into levels (Table 5.2).

Table 5.2. Indicators for scale and level codes, adapted from van Lieshout et al. (2011).

Code	Definition	Indicators
Problem – current	Descriptions of aspects of the current condition of the river, i.e. with the dam in place, as problematic.	Perceived problems associated with the current dammed river or with the current environmental, social, economic, political context, including continuing historical problems.
Problem – removal	Descriptions of removal of the dam and the resulting river condition as problematic.	Perceived problems, in either the dammed river or the broader context, associated with removal of the Mactaquac Dam.
Solution – rebuilding	Arguments in favour of rebuilding the dam	Reasons why the dam should be rebuilt that are not linked to problems associated with removal.
Solution – removing	Arguments in favour of removing the dam.	Reasons why the dam should be removed that are not linked to problems associated with the current state.
Solution – decision making process	Perceptions of how the decision on the dam's future should be made.	Preferences for how the decision should be made, including participation, scientific studies, etc., as well as perceptions of how the decision will be made.

Code	Definition	Indicators
Hydrological scale – river level	The entire river system from source to sea, including tributaries and at-sea processes.	References to the Saint John River system and its watershed, its hydrology and ecology, management of the river, other dams, the salmon run, flooding as an issue in the entire river system. Impacts of the dam downstream.
Spatial/hydrological scale – headpond level	The headpond as a component of the hydrological system and as a spatial unit (the two could not always be distinguished in the data). The headpond refers to the reservoir upstream of the dam.	References to the headpond as a body of water, its recreational opportunities and aesthetics, its hydrological and ecological functions, as a community. References to the reach that is currently the headpond after removal.
Spatial scale – global level	The world or planet as a spatial unit.	References to the global hydrological system, global issues, global climate change, being a world leader.
Spatial scale – national level	The nation of Canada as a spatial unit, but not when referred to as an administrative unit.	References to issues as common across the country, being a national leader.
Spatial scale – local level	Local areas, including parks and towns, but not when referred to as an administrative district.	References to communities, towns, parks, etc., issues arising in those locations.
Spatial scale – property level	A house or property as a spatial unit.	References to issues at an individual property or house, including their land.
Spatial/administrative scale – provincial level	The province as an administrative unit and as a spatial unit (the two could not always be distinguished from the data).	References to New Brunswick, the provincial government, provincial policies, issues common to the province, costs to the province, energy generation.
Administrative scale – municipal level	A city, village or town as an administrative district.	References to town politics, municipal services, municipal taxes.
Time scale – future level	Any period of time any length in the future.	References to sustainability, future generations, lengths of time in the future.
Time scale – past level	Any period of time any length in the past.	References to the dam's construction, the period of time before the dam, the period of time since the dam, history, etc.

The coded data was then summarised into a table with a line for each participant and a column for each subtype of problem and solution frame to allow systematic comparison between participants. The various scales and levels a participant used to frame each subtype were

entered into the corresponding cell. We then identified how the problem and solution frames were constructed. To do this, we looked for how arguments either for or against dam removal were constructed by identifying which scales and levels were used to describe perceived issues, and whether those issues were all perceived in the same direction, i.e., positive or negative. If they were described in the same direction they were considered part of a scale framing strategy, as described in the conceptual framework. By comparing the direction of argument, levels and scales used, links between those levels and scales, and scale framing strategies across participants, we identified the most common scale frames used to construct arguments.

5.6. Results

We identified several scale frames of problems associated with the current river condition and with removal of the dam, as well as several solution scale frames, using spatial, hydrological, administrative, and temporal scales (Figure 5.1). Those who wanted to retain the dam (hereafter the retainers) focused on recreation, aesthetics, energy, tourism, and property values and related tax issues, among others:

I see the beauty of the lake and the recreational value of the lake [...]. The loss of those will be, I think, a tremendous cost and it will have some impact on tourism economics (Participant 25; retainer).

Those who wanted to remove the dam (hereafter the removers) also discussed recreation, aesthetics, and tourism, but emphasised biodiversity, river connectivity, Atlantic salmon populations, farmland, and sustainability:

Thinking about the interconnection of the main stream with the tributaries and the life that flows, and the nature of the river and the flowing water, and how it is such a great catalyst to all kinds of biodiversity, to me it's a no brainer (Participant 15; remover).

The frames identified in this section were shared between participants within the subgroups. However, as previously noted, the sample did not include some key groups in the study area, namely Maliseet First Nations communities or organisations and industry. Therefore, the analysis of frames presented here illustrates how scales and scale framing strategies can be used in framing problems and solutions associated with the dam, rather than offering a comprehensive inventory of all scale frames used. In the remainder of this section, we describe the various problem and solution frames identified, the scales used, and the scale framing strategies inherent in them (Figure 5.1). The outcomes or functions of the scale frames are interpreted in the discussion.

5.6.1. Problem scale frames

Consistent with their positions, the retainers' problem frames focused on problems that would be caused by the removal of the dam, while the removers mainly framed the current situation as a problem. Although some members of each group acknowledged problems associated with their chosen option for the dam, those problems did not contribute to the participant's central argument:

I would certainly sympathise with the landowners up on the Mactaquac Lake [the headpond]. That would be a mess (Participant 21; remover).

We focus here on the most commonly used problem scale frames, although there were other less common frames, including the emphasis of some retainers on the local level problems caused by dam removal.

Scale frames of the current situation as a problem

Several scale frames of the current river condition with the dam in place were used by removers to build their argument that the dam should be removed. These frames used spatial, hydrological, administrative, and temporal scales, and involved the scale framing strategies of upscaling, rescaling, emphasising level and future projection, as well as interpretation of the past (Figure 5.1 and Table 5.3).

Table 5.3. Removers' scale frames of the problem of the dam.

Frame	Name	Description	Scales and levels used	Scale framing strategy used	Quote
A	What has happened to the dammed reach (the headpond) has happened to the river	Problems caused by the dam upscaled from local level and/or headpond level problems to the Saint John River system.	Spatial-hydrological Spatial	Upscaling, rescaling	'They (NB Power) have […] completely eliminated salmon runs in the Saint John River' (Participant 18; remover)
B	The provincial context is negative	Problems at provincial level that are not directly caused by the dam but will have implications for the decision, including neglect of the environment and provincial debt.	Spatial-administrative	Emphasising level	'It's building a dam versus 400 million in deficit. It's what the priority? (Participant 17; remover)
C	The dam is not sustainable	Problems caused in the future by the dam remaining in place.	Temporal	Future projection	'A natural river is sustainable. A manmade dam is not'

Frame	Name	Description	Scales and levels used	Scale framing strategy used	Quote
					(Participant 29; remover)
D	The pre-dam state was better than the current situation	The state of the river before the dam was built was better than the current one, and has since been forgotten.	Temporal	Past interpretation	'Certainly, the lament for the loss of what was lost in the 1960s was for a reason, I think. And over time, over 50 years, I guess people forget, or they've never even experienced it' (Participant 15; remover)

Of the two spatial scale frames, frame A was more common. The negative impacts of the construction and presence of the dam were upscaled and rescaled from local (spatial scale) or headpond level (spatial-hydrological scale) to the river level (hydrological scale). This upscaling and rescaling served to put the issues caused by the dam in the context of the hydrological system of the Saint John River as a whole.

Some participants referred to the same issues at each level, while others referred to different issues. For example, participant 15 discussed the river no longer being a community focal point since the dam was built (local level), increasing populations of invasive species (headpond level) and a loss of biodiversity (river level):

Local level: *Guys [...] used to, after work they'd keep their fishing poles and their rods in their cars, and after supper they would just head to the river. It was just a place that, it was kind of living and a focal point of existence much more so than now.*

Headpond level: *The other thing the headpond did was [...] generate the ability for invasive species to take off.*

River level: *It sort of doesn't live and breathe and function like a river should. I mean, it's not a natural thing anymore. To me* (Participant 15; remover).

Frame B did not discuss the direct impacts of the dam on the province, but emphasised the provincial level by outlining its negative characteristics as the context in which the decision

would take place. Short-term thinking, a bias toward job creation rather than the environment, and population decline were mentioned:

'If you read anything about New Brunswick, everything they say, "there will be jobs." There might be jobs only for six months, but there are jobs. And the change that they make may last for a hundred years or may last for a thousand, but there were jobs for the first year and that's all they ask' (Participant 18; remover).

When constructing temporal scale frames, both retainers and removers divided the past into three main periods: pre-dam construction, dam construction, and postconstruction to present. They divided the future into two periods: a period of ecological and social transition after dam removal, and a more stable post-transition period. The length of time that each period in the future represented was not constant and was subject to framing by the participants.

Two temporal scale frames of the current situation as a problem were identified, one which looked to the future (frame C) and one which referred to the past (frame D). The participants using frame C projected the problems caused by the dam into the future (scale framing strategy; Figure 5.1), thereby accentuating their significance. These participants referred to the costs of maintaining a dam over time and the unsustainable nature of a dammed river compared to a free-flowing river, and argued that removal was necessary to avoid these long-term damages. For example, participant 18 argued that the long-term future was not given sufficient weight in decisions to the detriment of the environment:

'When you build a dam and they do all these costs, they don't measure the losses. They don't say you're going to lose salmon for the next thousand years, five hundred years' (Participant 18; remover).

Frame D referred to the past before the dam was constructed, using a strategy of past interpretation that was not identified in the conceptual framework (Figure 5.1). The participants using this frame argued that the pre-dam state should be relevant to the decision but that many people do not remember its positive condition and that it is minimised in the decision-making process. They described its positive characteristics in terms of the aesthetics, agricultural potential, and environmental benefits of the river valley before the dam was built:

'Even in the spring, the cakes of ice that used to flow, you used to hear them and see them and it was spectacular. Now it's not. Because it's just Mactaquac Lake' (Participant 15; remover).

Therefore, frame D interprets the past in a way that enhances its relevance to the decision made in the present.

Scale frames of removal as a problem

We similarly identified both spatial and temporal scale frames of problems associated with dam removal (Table 5.4), which were mostly used by retainers in constructing their arguments against removal. On the spatial scale, frame 1 was used most frequently. Like frame A, it involved upscaling and rescaling negative impacts of the perceived problem as scale framing strategies (Figure 5.1). However, participants using this frame upscaled from the headpond level (spatial-hydrological scale) to the provincial level (spatial-administrative scale), rather than to the river level on the hydrological scale as was the case for frame A. Some participants using frame 1 started by discussing impacts at their property or their town (local level, spatial scale), before arguing that those impacts would also occur throughout the headpond (headpond level, spatial-hydrological scale). They then upscaled again to the provincial level, (spatial-administrative scale). Others only upscaled from the headpond level to the province, without discussing the local level.

Table 5.4. Retainers' spatial and temporal scale frames of the problem of dam removal.

Frame	Name	Description	Scales and levels used	Scale framing strategy used	Quote
1	What happens to the headpond happens to the province	Impacts at property and local level upscaled to headpond level and then again to provincial level.	Spatial-hydrological Spatial-administrative Spatial	Upscaling, rescaling	'If they take it down, it would be the largest dam ever removed anywhere in the world. So here we are with 750 000 people, how do we pay for it? From a realistic point of view, 2 billion dollars to tear it down would break the province' (Participant 23; retainer)
2	The headpond is the centre of the decision	The headpond level was emphasised, with no upscaling to provincial level. Issues at property or local level may have been	Spatial Spatial-hydrological	Emphasising level	'Without the dam, without the draws that are beside the dam, the, 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

Frame	Name	Description	Scales and levels used	Scale framing strategy used	Quote
		upscaled to headpond level.			area would be devastated without the water being there' (Participant 08; retainer)
3	The future after removal will not be pleasant	Future framed only in terms of the transition period post-removal. No post-transition period future envisaged.	Temporal	Future projection	'If they let the water out, there's no way on earth you'll ever grow grass on that' (Participant 06; retainer)
4	The past cannot be restored	Focuses on the pre-dam past and frames it as being irretrievable	Temporal	Past interpretation	'You get some of the nostalgic crowd that, "we'll get our land back". Well, you won't get the land back. NB Power bought the land. It was all bought and paid for.' (Participant 14; retainer)
5	Post-dam adaptation	Focuses on post-dam past and frames it as being stable, and wanting to avoid disruption of dam construction period	Temporal	Past interpretation	'Most people don't want it to go, because there are still some around who went through it the first time and, I understand, it was horrible' (Participant 19)

Like frame A, some participants referred to the same issues when upscaling, including lower property values from loss of waterfront, and reduced tourist numbers because of recreational losses. For example, Participant 02 described the impacts on property values:

Property and headpond level: '*I can't imagine that they will bring [the river] back. Because if that happens, then the property values will be way lower. And that will affect many, many people [...]. Your house isn't valued as much if you don't have a big piece of waterway out there, if you only have a mud flat.*'

Provincial level: '*If your home value goes down, the government is not going to be able to tax you. So they're going to lose money*' (Participant 02; retainer).

Others used a sequence of different issues at each level to construct their argument. Although the issues attributed to each level were different, they were all described as causing negative impacts:

Property level: '*In front of my house there's a 90 foot drop to the gorge. That is going to be 90 feet of mud. Bare rock and mud.*'

Headpond level: '*[Removal] would affect the fish because you would have a tremendous loss of volume of water [in the headpond].*'

Provincial level: '*If they take it down, it would be the largest dam ever removed anywhere in the world. So here we are with 750,000 people, how do we pay for it? From a realistic point of view, 2 billion dollars to tear it down would break the province*' (Participant 23; retainer).

Frame 2 also involved using the spatial scale to frame dam removal as a problem, but emphasised the headpond level or upscaled from property/local level to the headpond level but no further. For example, Participant 06 had numerous concerns about removal for the headpond area, but did not refer to any implications at higher levels:

'*My main concern is the devastation of the value that people have put in their homes and their businesses and so on that surround the headpond for another 50 miles upriver. If it's not there then business is just going to go down, because, it's like all these other places, that campground and so on, there'd be no reason for people to be there if the headpond's gone*' (Participant 06; retainer).

On the temporal scale, frame 3 projected negative impacts of dam removal into the future (scale framing strategy; Figure 5.1), and particularly focused on the transition period between removal of the dam and the river 're-establishing itself'. For example, they described the newly dewatered land as being muddy and smelly rather than being revegetated, and were concerned about fish deaths during the draining process. Although their perceptions of the length of time it would take for the area to be in an acceptable condition varied, they all implied it would be too long, and dismissed the possibility of any eventual restoration. For example, Participant 19 thought the area would be in an unacceptable condition forever:

'*I've heard people say, "it'll be all green again in a year and it'll be fine." I don't believe that. I think it's had years and years of muck and silt and, I just doubt it'll ever be good for much of anything*' (Participant 19; retainer).

Two frames involved a strategy of interpreting the relevance of the past to the current decision. Frame 4 focused on the pre-dam past, which is defined as irrelevant to the decision, while frame 5 focused on the postconstruction past, which is deemed central to the decision. The participants using frame 4 argued that specific attractive aspects of the pre-dam past, including the Atlantic salmon fishery and agriculture on the low-lying land, could not be restored even if they were desirable:

'*We know what the economy was before the dam, it was subsistence farming and small farms and a little bit of lumbering. [...] But when that disappears, when the water goes back down, that's not going to come back*' (Participant 09; retainer).

Frame 5 by contrast focuses on the recent past post-dam construction and has two main components: a desire to avoid both the pain of the dam's construction in the first place, and disruption of the social, ecological, and economic adaptation that has taken place since. For example, Participant 05 describes the disruption associated with the construction of the dam:

'*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; retainer).

Therefore, these frames, in combination with frame 3, frame the present as the best condition the area could be in, and argue in favour of preserving it.

Mismatches in scale frames of problems

We identified all three mismatches in van Lieshout et al.'s (2011) typology between the problem frames used by the retainers and the removers (Table 5.5). All three were present between the spatial scale frames: mismatches in framing an issue at a particular level, mismatches in the scales used to frame an issue, and mismatches in the levels used to frame an issue. On the temporal scale, there were mismatches in both how a level was framed and in the levels used to frame an issue.

Table 5.5. Summary of mismatches between the various scale frames identified.

	Removers' problem frames			
	Frame A	**Frame B**	**Frame C**	**Frame D**

Retainers' frames	**Frame 1**	Scale mismatch (hydrological vs administrative) Level mismatch (headpond to river vs headpond to province)	None	None	None
	Frame 2	Level mismatch (river vs headpond)	None	None	None
	Frame 3	None	None	Scale frame mismatch Level mismatch (post transition vs transition period)	None
	Frame 4	None	None	None	Scale frame mismatch
	Frame 5	None	None	None	Level mismatch (pre-dam past vs post-dam past)

There were both level and scale mismatches between frame A and frame 1 because they upscaled to different higher levels, the river level for removers and the provincial level for retainers, and used different scales, the hydrological scale and the spatial/administrative scale respectively:

'*They've created a very nice recreational spot [in the headpond] but they've completely eliminated salmon runs in the Saint John River*' (Participant 18; remover; upscaling to the river).

'*They [the government] know what's going to happen [if they take the dam out], they will have a lawsuit they can't afford from all the people on the headpond*' (Participant 13; retainer; upscaling to the province).

Therefore, while both frames involved the same strategies (upscaling and rescaling), they were employed differently in constructing the arguments.

There were also significant mismatches in the levels used and how they were framed on the temporal scale (Figure 5.3). The removers framed the pre-dam past and the post-transition period as being positive and the most relevant to the decision, and linked them together: dam removal would enable the positive aspects of the pre-dam past to be restored. The retainers, by

contrast, described dam construction as traumatic, which should not be replicated during the removal process. They also focused on the transition period, which would disrupt the positive aspects of the dammed river. Therefore, the two groups did not agree on whether each time period would be negative or positive, nor on which periods were most relevant to the decision-making process.

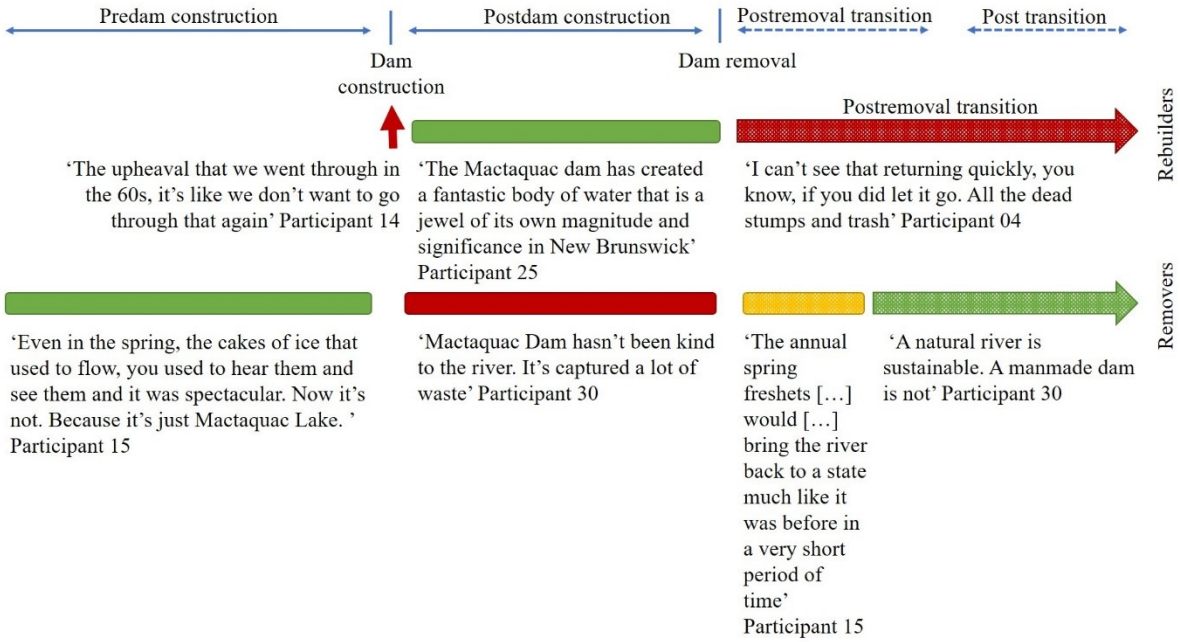

Figure 5.3. Mismatches in temporal scale framing between rebuilders and removers. Green bars/arrows represent perceptions of a period of time as positive, while red bars/arrows represent negative perceptions. Yellow bars are neutral. The length of the bars relative to the timeline at the top of the figure represent participants' perceptions of the length of each time.

5.6.2. Solution scale frames

The scale frames used to argue in favour of a preferred solution reflected those used to define problems. For example, the retainers particularly emphasised the headpond level, and sometimes upscaled to the provincial level (scale framing strategies; Figure 5.1), in their solution scale frames:

'*If they go to the full deal, the restore electricity, it's the largest project the province has ever seen*' (Participant 14; retainer).

Some projected the benefits of hydropower to the long-term future:

'*It's clean, dependable, the river goes on and on and on. It'll be here long after I've gone and it'll still be producing power*' (Participant 23; retainer).

The removers also used the same scale frames to argue for removal as they used to argue that the current river condition was a problem, while some also upscaled the benefits of removal from the local level and/or the headpond level to the provincial level.

The scale frames of how the decision should be made were less clear-cut and varied both within and between groups. For some of the removers, the key factor in the decision making should be the future or long-term benefits of the option chosen, and they therefore emphasised this level on the temporal scale:

'*Think beyond the four-year term and just think objectively about what's the best decision for the future*' (Participant 15; remover).

Some retainers also used future projection to determine how the decision should be made, but focused specifically on long-term hydropower benefits:

'*I think the ongoing value of the energy generation is a big, big factor that has to be measured carefully*' (Participant 25; retainer).

Members of both groups emphasised the provincial level when discussing how the decision should be made by arguing that either provincial residents should be asked directly, in a vote or referendum, or that the provincial government should decide on behalf of the electorate. For example, participant 18 argued the following:

'*We live in a democracy, so sort it out to the point where, if more people want it than don't want it, then that's what they do*' (Participant 18; remover).

Participant 16, a retainer, agreed:

'*They should have a public vote or referendum in the province and do it that way.*'

However, some retainers thought this might be risky because residents of other parts of the province might not want to keep the dam. For some of those retainers, this was a reason to reject holding a provincial vote, whilst others acknowledged the risk but did not change their mind:

'*Even though probably that could work against us, because I'm sure there's lots of people in Moncton or Saint John that would probably say take it out. Take the dam out. And that would be the views of the public as well*' (Participant 22; retainer).

Those retainers that did not want a provincial vote were explicit that this was because they wanted the headpond to be the focus in the decision making in a process of downscaling:

'*There's a lot of general public that have never even seen the Mactaquac headpond and they would be just voting on how they feel about rivers and how they feel about dams [...], not totally understanding the whole impact of everything*' (Participant 01; retainer).

5.7. Discussion

In this study, we aimed to demonstrate how different stakeholders used scale to frame problems and solutions associated with the dam and its potential removal. The results show that stakeholders in both groups, the retainers and the removers, framed problems using both spatial and temporal scales, but used them in different ways. The study of scale frames illuminates not only how stakeholders interpret the problem in general (Reilly and Adamowski 2017), but how they define its boundaries in space and time.

5.7.1. The roles of scales and strategies in scale framing

The results show that the participants in the study sample used similar scales and scale framing strategies to frame problems and solutions associated with the dam. Both groups used spatial, hydrological, administrative, and temporal scales in their frames, and employed the strategies of upscaling, rescaling, emphasising levels, projecting to the future, and interpreting the past. However, the combinations of scales and strategies used in framing a problem or solution were different between the participant groups, in ways that had consequences for decision making.

The scales and strategies used in problem and solution framing (Figure 5.1), including upscaling and future projection, had implications for which arguments were legitimised and which were delegitimised, and which stakeholders were deemed relevant to the decision and which were excluded (Kurtz 2003, Harrison 2006, van Lieshout et al. 2011, Sica 2015). The retainers perceived that they would be personally affected by removal, through loss of recreational access and property values, for example (Reilly and Adamowski 2017). However, they upscaled these personal impacts to the headpond and then the provincial level, as well as projecting them to the post-removal future. This served to magnify the importance of the impacts of removal beyond their personal interests. In doing so, the retainers using this scale frame assumed that other households and towns around the headpond area, as well as future generations, would be affected by the same impacts and experience them in the same way. The removers used a similar process to highlight the impacts beyond those on the ecosystem services that they benefit from or value (Reilly and Adamowski 2017), by discussing how those

impacts affect the whole river system. In this way, both groups broadened their argument beyond their personal interests (Kurtz 2003, van Lieshout et al. 2011). The study, therefore, offers evidence that scale framing can be present and can affect which arguments are legitimised and which stakeholders are included in decision-making processes around dams, in addition to the agricultural, energy, and industrial contexts previously studied (Kurtz 2003, Harrison 2006, van Lieshout et al. 2011, Sica 2015).

The results of this study revealed divergences in temporal scale framing. The participants had different interpretations of the condition, relative importance, and duration of different time periods in the past and the future. Although temporal scale framing is less studied in the literature on the politics of scale than spatial frames, the results provide support for McCann (2003) and van Lieshout et al.'s (2011, 2012, 2014) suggestion that time plays a role in the politics of scale. In particular, we suggest that interpretation of the past is an important scale framing strategy, somewhat analogous to future projection (van Lieshout et al. 2012); although the importance of frames of the past have been identified, they have been little studied (McCann 2003, Reed and Bruyneel 2010). Depending on how the past is framed, it makes some solutions seem possible and/or desirable, while portraying others as unjust. For example, the removers' frames of the pre-dam past produce an attractive vision of what the river could be post-removal and portray this choice as an opportunity to regain what was lost in the dam's construction. By contrast, the retainers' frames of the dam's construction as traumatic, and the period since as stable, foreclose the option of removal. It may also have implications for which groups of people are perceived to have the authority or legitimacy to define the relevance of the past (McCann 2003).

The study provided support for van Lieshout et al.'s (2011) typology of scale frame mismatches, of which we found evidence for all three: mismatches in framing the issue at different levels on the same scale, framing the issue on different scales, and using different scale frames. The disparate use of scale in problem framing reinforces differences between participants in how they frame the decision around the dam in general (Reilly and Adamowski 2017). Mismatches can further hinder a shared understanding of the problem to be addressed, by disputing which levels are most affected and how impacts on different scales are related. They can obscure the interests at stake and create divisions between stakeholders (Mansfield and Haas 2006, van Lieshout et al. 2011, Juerges and Newig 2015).

Finally, by differentiating problem and solution frames we identified participants' attempts to link the level of a problem to the level at which decisions about it are made (Towers 2000, Kurtz 2003, Harrison 2006). For example, in their upscaling of the problem of dam removal to provincial level, some retainers intentionally or unintentionally connected the level of the problem to the level of decision making, i.e., provincial level. This process of matching the 'scales of meaning', i.e., the problem frames, to 'scales of regulation', i.e., the solution frames, has been identified as a strategy used by groups seeking environmental justice, as a tactical way of making their claims relevant to decision makers (Towers 2000, Kurtz 2003). Some of our results also suggest that the converse process can occur to match the 'scale of regulation', the solution frame, to the 'scale of meaning', the problem frame (Juerges and Newig 2015). For example, other retainers downscaled their solution frames, arguing against a provincial vote on the basis that people in other parts of the province would not properly consider the impact of the decision on the headpond. The extent to which this reverse strategy occurs in other contexts and its implications deserves further study.

Overall, therefore, the study suggested that findings on scale framing and its implications in other contexts are also applicable to decisions on the future of dams, and that the temporal scale, particularly the past, is an important component of scale framing. However, the study cannot provide an exhaustive typology of the scale frames present in the debate around the future of the Mactaquac Dam. This is for two reasons. Although the sample was purposefully small, to allow an in-depth exploration of the details of stakeholders' frames, and sought to include all perspectives, two key groups, First Nations and industry, did not participate. The inclusion of First Nations and industry in the sample could be expected to introduce new scale frames, and potentially new scale framing strategies. Furthermore, the data was collected during a single period during the decision-making process. It does not account for any changes in scale framing or strategies used during the consultation period or after the decision was made.

5.7.2. Implications of scale framing for making end-of-life decisions for dams

Dam construction, and subsequent removal or replacement, has implications across spatial and temporal scales (Hart et al. 2002, Cash et al. 2006, Moss and Newig 2010, Termeer et al. 2010). Although these implications may be assessed as part of technical or environmental reviews of the options for a dam at the end of its life, stakeholders' frames of those scales should also be considered.

First, the different perceptions of the scale and level on which problems are or will be experienced should be reflected in the design of the decision-making process, including impact assessments and stakeholder consultations. No one scale or level will be the most appropriate (Cash et al. 2006, Juerges and Newig 2015). Decision makers should be aware that how these processes are scaled will affect how the problem is defined, which solutions are possible, and which issues and stakeholders are included or given priority (Lebel 2006, Vreugdenhil et al. 2010, Juerges and Newig 2015). The choice of scale will therefore influence stakeholders' perceptions of the legitimacy of the consultation and assessment process (Lebel 2006, Moss and Newig 2010).

Second, stakeholders' scale frames must be recognised in mediation or conflict resolution methods. Typically, such methods revolve around encouraging reframing of a topic or building on convergences between frames. However, divergence between frames not only in the issues used, but in the scales on which they are interpreted, presents an additional complication. Reframing efforts must first recognise the scales and levels used, and their implications for highlighting and concealing interests, before proceeding (van Lieshout 2014).

The results also suggest some avenues for future research. The role of temporal scale framing in decision making requires further attention. For example, future research could further investigate the extent to which temporal scale frames function in similar ways to spatial scale frames that legitimise/delegitimise arguments and include/exclude people from consideration in a decision. The interactions between spatial and temporal scale frames could also be explored in more depth. Last, temporal scale framing of the past was found here in a distinct context, in which the construction of the dam created a division in the past between the pre-dam and post-dam periods, which may be interpreted differently by stakeholders. Therefore, the relevance of scale framing of the past in other circumstances without this particular context would be worth investigation.

5.8. Conclusion

This study revealed the role of scale framing in a conflict over whether a dam should be removed or not. We found that the retainers and removers used similar strategies in their spatial scale frames of the problem, including upscaling, rescaling, and emphasising levels, but that there were mismatches in the scales used (spatial/administrative and hydrological scales, respectively), and in the levels to which problems were upscaled (province and river, respectively). These mismatches had implications for which arguments were legitimised and

which stakeholders were included in the problem definition. In terms of the temporal scale, the importance of projection to the future to justify a stakeholder's argument was confirmed. We identified the significance of diverging interpretations of the past as contributing to conflict around such decisions. Authorities involved in deciding a dam's future should be aware of the upheaval caused by the dam's construction, the adaptation since, and the variations between individuals in how those periods of the past are interpreted.

REFERENCES

Apostolopoulou, E., and R. Paloniemi. 2012. Frames of scale challenges in Finnish and Greek biodiversity conservation. *Ecology and Society* 17(4):9.

Asah, S. T., D. N. Bengston, K. Wendt, and L. Devaney. 2012*b.* Prognostic framing of stakeholders' subjectivities: a case of all-terrain vehicle management on state public lands. *Environmental Management* 49(1):192-206.

Asah, S. T., D. N. Bengston, K. Wendt, and K. C. Nelson. 2012*a.* Diagnostic reframing of intractable environmental problems: case of a contested multiparty public land-use conflict. *Journal of Environmental Management* 108:108-119.

Auerbach, D. A., D. B. Deisenroth, R. R. McShane, K. E. McCluney, and N. L. Poff. 2014. Beyond the concrete: accounting for ecosystem services from free-flowing rivers. *Ecosystem Services* 10:1-5.

Bardwell, L. V. 1991. Problem-framing: a perspective on environmental problem-solving. *Environmental Management* 15(5):603-612.

Born, S. M., K. D. Genskow, T. L. Filbert, N. Hernandez-Mora, M. L. Keeper, and K. A. White. 1998. Socioeconomic and institutional dimensions of dam removals: the Wisconsin experience. *Environmental Management* 22(3):359-370.

Bourgoin, S. 2013. *Disregarded sentiments: discovering the voices of opposition to the Mactaquac Dam.* Thesis. St Mary's University, Halifax, Nova Scotia, Canada.

Buijs, A. E. 2009. Public support for river restoration. A mixed-method study into local residents' support for and framing of river management and ecological restoration in the Dutch floodplains. *Journal of Environmental Management* 90(8):2680-2689.

Canadian Rivers Institute. 2011. *The Saint John River: a state of the environment report*. Canadian Rivers Institute, Fredericton, New Brunswick, Canada.

Canadian Rivers Institute. 2013. *Mactaquac aquatic ecosystem study - study area.* Canadian Rivers Institute, Fredericton, New Brunswick, Canada. [online] URL: http://canadianriversinstitute.com/research/mactaquac-aquatic-ecosystem-study/study-area/

Carr, J. 2001. *Downstream movements of juvenile Atlantic salmon (Salmo salar) in the dam-impacted St John River Drainage*. Canadian Manuscript Report of Fisheries & Aquatic Sciences No. 2573, Dept. of Fisheries & Oceans Canada, Ottawa, Ontario, Canada.

Cash, D. W., W. Adger, F. Berkes, P. Garden, L. Lebel, and P. Olsson. 2006. Scale and cross-scale dynamics: governance and information in a multilevel world. *Ecology and Society* 11(2):8.

Creswell, J. W., and D. L. Miller. 2000. Determining validity in qualitative inquiry. *Theory Into Practice* 39(3):124-130.

Daniell, K. A., and O. Barreteau. 2014. Water governance across competing scales: coupling land and water management. *Journal of Hydrology* 519(PC):2367-2380.

Delaney, D., and H. Leitner. 1997. The political construction of scale. *Political Geography* 16(2):93-97.

Dewulf, A. 2013. Contrasting frames in policy debates on climate change adaptation. *Wiley Interdisciplinary Reviews: Climate Change* 4(4):321-330.

Dewulf, A., B. Gray, L. Putnam, R. Lewicki, N. Aarts, R. Bouwen, and C. van Woerkum. 2009. Disentangling approaches to framing in conflict and negotiation research: a meta-paradigmatic perspective. *Human Relations* 62(2):155-193.

Dillon Consulting. 2015. *Social impact comparative review*. Dillon Consulting, Toronto, Ontario, Canada.

Doyle, M. W., J. M. Harbor, and E. H. Stanley. 2003. Toward policies and decision-making for dam removal. *Environmental Management* 31(4):453-465.

Durance, I., C. Lepichon, and S. J. Ormerod. 2006. Recognizing the importance of scale in the ecology and management of riverine fish. *River Research and Applications* 22:1143-1152.

Edge, S., and J. Eyles. 2014. The socio-spatial (re)configuration of legitimacy, knowledge, and practice in chemical risk governance: integrating boundary-work and scale-frame analytics. *Environmental Politics* 23(2):282-301.

Emery, S. B., M. T. Perks, and L. J. Bracken. 2013. Negotiating river restoration: the role of divergent reframing in environmental decision-making. *Geoforum* 47:167-177.

Fox, C. A., F. J. Magilligan, and C. S. Sneddon. 2016. 'You kill the dam, you are killing a part of me': dam removal and the environmental politics of river restoration. *Geoforum* 70:93-104.

Freeman, R. E., J. S. Harrison, A. C. Wicks, B. L. Parmar, and S. de Colle. 2010. *Stakeholder theory: the state of the art*. Cambridge University Press, Cambridge, UK.

Gibson, C. C., E. Ostrom, and T. K. Ahn. 2000. The concept of scale and the human dimensions of global change: a survey. *Ecological Economics* 32(2):217-239.

Government of New Brunswick. 2014. *New Brunswick population growth strategy 2014-2017*. Government of New Brunswick, Fredericton, New Brunswick, Canada.

Government of New Brunswick. 2016. *The New Brunswick economic growth plan*. Government of New Brunswick, Fredericton, New Brunswick, Canada.

Gowan, C., K. Stephenson, and L. Shabman. 2006. The role of ecosystem valuation in environmental decision making: hydropower relicensing and dam removal on the Elwha River. *Ecological Economics* 56(4):508-523.

Gray, B. 2004. Strong opposition: frame-based resistance to collaboration. *Journal of Community & Applied Social Psychology* 14:166-176.

Gray, B., and L. L. Putnam. 2003. Means to what end? Conflict management frames. *Environmental Practice* 5(3):239-246.

Hansen, J. F., and D. B. Hayes. 2012. Long-term implications of dam removal for macroinvertebrate communities in Michigan and Wisconsin Rivers, United States. *River Research and Applications* 28:1540-1550.

Harrison, J. L. 2006. 'Accidents' and invisibilities: scaled discourse and the naturalization of regulatory neglect in California's pesticide drift conflict. *Political Geography* 25(5):506-529.

Hart, D. D., T. E. Johnson, K. L. Bushaw-Newton, R. J. Horwitz, A. T. Bednarek, D. F. Charles, D. A. Kreeger, and D. J. Velinsky. 2002. Dam removal: challenges and opportunities for ecological research and river restoration. *Bioscience* 52(8):669-682.

Huang, R. 2014. *RQDA: R-based qualitative data analysis. R package version 0.2-7.* The R Project for Statistical Computing, Vienna, Austria. [online] URL: http://rqda.r-forge.r-project.org/

Hüesker, F., and T. Moss. 2015. The politics of multi-scalar action in river basin management: implementing the European Union Water Framework Directive. *Land Use Policy* 42:38-47.

Johnson, S. E., and B. E. Graber. 2002. Enlisting the social sciences in decisions about dam removal. *BioScience* 52(8):731-738.

Jones, N. E. 2014. The dual nature of hydropeaking rivers: Is ecopeaking possible? *River Research and Applications* 30:521-526.

Jørgensen, D., and B. M. Renöfält. 2012. Damned if you do, damned if you don't: debates on dam removal in the Swedish media. *Ecology and Society* 18(1):18.

Juerges, N., and J. Newig. 2015. What role for frames in scalar conflicts? *Land Use Policy* 49:426-434.

Keilty, K. 2015. *Understanding landscape values and baselines of acceptability on the Mactaquac Dam and headpond, New Brunswick.* Thesis. Dalhousie University, Halifax, Nova Scotia, Canada.

Keilty, K., T. M. Beckley, and K. Sherren. 2016. Baselines of acceptability and generational change on the Mactaquac hydroelectric dam headpond (New Brunswick, Canada). *Geoforum* 75:234-248.

Kenny, J. L., and A. G. Secord. 2010. Engineering modernity: hydroelectric development in New Brunswick, 1945-1970. *Acadiensis* 1(1):3-26.

Kochskämper, E., E. Challies, J. Newig, and N. W. Jager. 2016. Participation for effective environmental governance? Evidence from Water Framework Directive implementation in Germany, Spain and the United Kingdom. *Journal of Environmental Management* 181:737-748.

Kurtz, H. E. 2003. Scale frames and counter-scale frames: constructing the problem of environmental injustice. *Political Geography* 22(8):887-916.

Lamarque, P., U. Tappeiner, C. Turner, M. Steinbacher, R. D. Bardgett, U. Szukics, M. Schermer, and S. Lavorel. 2011. Stakeholder perceptions of grassland ecosystem services in relation to knowledge on soil fertility and biodiversity. *Regional Environmental Change* 11(4):791-804.

Lawson, P. M., G. Farnsworth, and M. A. Hartley. 1985. *The Nackawic Bend*. Town of Nackawic, Nackawic, New Brunswick.

Lebel, L. 2006. The politics of scale in environmental assessments. Pages 37-57 *in* W. V. Reid, F. Berkes, T. Wilbanks, and D. Capistrano, editors. *Bridging scales and knowledge systems*. Island Press, Washington, D.C., USA.

Leitner, H., E. Sheppard, and K. M. Sziartot. 2008. The spatialities of contentious politics. *Transactions of the Institute of British Geographers* 33(2):157-172.

Lejon, A. G. C., B. M. Renöfält, and C. Nilsson. 2009. Conflicts associated with dam removal in Sweden. *Ecology And Society* 14(2):4.

Lewan, L., and T. Söderqvist. 2002. Knowledge and recognition of ecosystem services among the general public in a drainage basin in Scania, Southern Sweden. *Ecological Economics* 42(3):459-467.

Lewicki, R. 2003. *Making sense of intractable environmental conflicts: concepts and cases*. Island Press, Washington, D.C., USA.

Luiker, E., J. Culp, A. Yates, and D. Hryn. 2013. *Ecosystem metabolism as a functional indicator for assessing river ecosystem health - Application for New Brunswick rivers*. Final Report. Canadian Rivers Institute, University of New Brunswick. Prepared for the New Brunswick Environmental Trust Fund, Government of New Brunswick, Fredericton, New Brunswick, Canada.

Mansfield, B., and J. Haas. 2006. Scale framing of scientific uncertainty in controversy over the endangered Steller sea lion. *Environmental Politics* 15(1):78-94.

McCann, E. J. 2003. Framing space and time in the city: urban policy and the politics of spatial and temporal scale. *Journal of Urban Affairs* 25(2):159-178.

Morley, S. A., J. J. Duda, H. J. Coe, K. K. Kloehn, and M. L. McHenry. 2008. Benthic invertebrates and periphyton in the Elwha River Basin: current conditions and predicted response to dam removal. *Northwest Science* 82(sp1):179-196.

Moss, T., and J. Newig. 2010. Multilevel water governance and problems of scale: setting the stage for a broader debate. *Environmental Management* 46(1):1-6.

NATIONAL and Corporate Research Associates Inc (CRA). 2016. *What was said: final report*. NB Power, Fredericton, New Brunswick, Canada. [online] URL: https://www.nbpower.com/media/689752/what_was_said_report_mactaquac.pdf

New Brunswick (NB) Power. 2014. *Mactaquac life achievement project.* NB Power, Fredericton, New Brunswick, Canada. [online] URL: https://www.nbpower.com/html/en/about/future/mactaquac.html

NB Power. 2015. *Your feedback: What we heard at our Mactaquac Project open houses.* NB Power, Fredericton, New Brunswick, Canada.

NB Power. 2016. *Considering the future of Mactaquac*. NB Power, Fredericton, New Brunswick, Canada.

NB Power. 2017. *Backgrounder, Mactaquac Generating Station Life Achievement Project. Business Case and Technical Considerations*. NB Power, Fredericton, New Brunswick, Canada.

Patrick, M. J., G. J. Syme, and P. Horwitz. 2014. How reframing a water management issue across scales and levels impacts on perceptions of justice and injustice. *Journal of Hydrology* 519(PC):2475-2482.

Patton, M. Q. 2005. Qualitative research. Pages 1633-1636 *in* B. S. Everitt and D. C. Howell, editors. *Encyclopaedia of statistics in behavioural science*. John Wiley & Sons, Chichester, UK.

Peterson, T. R. 2005. Social control frames: opportunities or constraints? *Environmental Practice* 5(3):232-238.

Poff, N. L., and D. D. Hart. 2002. How dams vary and why it matters for the emerging science of dam removal. *BioScience* 52(8):659-668.

Royal Bank of Canada (RBC). 2017. *New Brunswick Budget 2017*. RBC, Toronto, Ontario, Canada.

Reed, M. G., and S. Bruyneel. 2010. Rescaling environmental governance, rethinking the state: a three-dimensional review. *Progress in Human Geography* 34(5):646-653.

Reed, M. S. 2008. Stakeholder participation for environmental management: a literature review. *Biological Conservation* 141(10):2417-2431.

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.

Sayre, N. F. 2005. Ecological and geographical scale: parallels and potential for integration. *Progress in Human Geography* 29(3):276-290.

Sayre, N. F., and A. V. Di Vittorio. 2009. Scale. Pages 19-28*in* R. Kitchin and N. Thrift, editors. *International encyclopaedia of human geography. Vol. 1.* Elsevier, Oxford, UK.

Scheufele, D. 1999. Framing as a theory of media effects. *Journal of Communication* 49(1):103-122.

Schön, D., and M. Rein. 1995. *Frame reflection: toward the resolution of intractable policy controversies*. Basic Books, New York, New York, USA.

Sherren, K., T. M. Beckley, J. R. Parkins, R. C. Stedman, K. Keilty, and I. Morin. 2016. Learning (or living) to love the landscapes of hydroelectricity in Canada: eliciting local perspectives on the Mactaquac Dam via headpond boat tours. *Energy Research & Social Science* 14:102-110.

Shmueli, D. F., M. Elliott, and S. Kaufman. 2006. Frame changes and the management of intractable conflicts. *Conflict Resolution Quarterly* 24(2):207-218.

Si, Z. 1993. *A theoretical framework for social impact analysis with special reference to population relocation at the Mactaquac Dam project on the Saint John River.* Dissertation. Dalhousie University, Halifax, Nova Scotia, Canada.

Sica, C. E. 2015. Stacked scale frames: building hegemony for fracking across scales. *Area* 47(4):443-450.

Stantec. 2016. *Mactaquac Project comparative environmental review report*. Stantec Consulting Ltd., Fredericton, New Brunswick, Canada.

Statistics Canada. 2017. *Census profile, 2016 census*. Statistics Canada, Ottawa, Ontario, Canada.

Strauss, A., and J. Corbin. 1998. *Basics of qualitative research techniques and procedures for developing grounded theory*. Second edition. SAGE, London, UK.

Susskind, L. 2013. Water and democracy: new roles for civil society in water governance. *International Journal of Water Resources Development* 29(4):666-677.

Termeer, C. J. A. M., A. Dewulf, and M. Van Lieshout. 2010. Disentangling scale approaches in governance research: comparing monocentric, multilevel, and adaptive governance. *Ecology and Society* 15(4):29.

Towers, G. 2000. Applying the political geography of scale: grassroots strategies and environmental justice. *Professional Geographer* 52(1):23-36.

van Hulst, M., and D. Yanow. 2016. From policy 'frames' to 'framing': theorising a more dynamic, political approach. *American Review of Public Administration* 46(1):92-112.

van Lieshout, M. 2014. *Framing scales and scaling frames: the politics of scale and its implications for the governance of the Dutch intensive agriculture.* Dissertation. Wageningen University, Wageningen, The Netherlands.

van Lieshout, M., A. Dewulf, N. Aarts, and C. Termeer. 2011. Do scale frames matter? Scale frame mismatches in the decision making process of a 'mega farm' in a small Dutch village. *Ecology and Society* 16(1):38.

van Lieshout, M., A. Dewulf, N. Aarts, and C. Termeer. 2012. Doing scalar politics: interactive scale framing for managing accountability in complex policy processes. *Critical Policy Studies* 6(2):163-181.

van Lieshout, M., A. Dewulf, N. Aarts, and C. Termeer. 2014. The power to frame the scale? Analysing scalar politics over, in and of a deliberative governance process. *Journal of Environmental Policy and Planning* 1-24.

Van Looy, K., T. Tormos, and Y. Souchon. 2014. Disentangling dam impacts in river networks. *Ecological Indicators* 37(PART A):10-20.

Vreugdenhil, H., J. Slinger, E. Kater, and W. Thissen. 2010. The influence of scale preferences on the design of a water innovation: a case in Dutch river management. *Environmental Management* 46(1):29-43.

Williams, R. W. 1999. Environmental injustice in America and its politics of scale. *Political Geography* 18(1):49-73.

World Commission on Dams. 2000. *Dams and development*. Earthscan, London, UK.

Yin, R. K. 2003. *Case study research: design and methods*. SAGE, Thousand Oaks, California, USA.

Zald, M. N. 1996. Culture, ideology and strategic frames. Pages 261-274 *in* D. McAdam, J. D. McCarthy, and M. N. Zald, editors *Comparative perspectives on social movements: political opportunities, mobilizing structures, and cultural framings*. Cambridge University Press, Cambridge, UK.

Foreword to chapter 6

The previous two chapters have shown how decision making around dam removals is framed and how diverging frames, of issues and using scales, reinforce differences between groups involved in the conflict, and both render effective communication difficult and reveal potential common ground.

The strong role of the past in scale framing suggests the importance of personal and community history in the affected area. The role of emotions, including emotional attachments to place developed through time spent there, is increasingly acknowledged in studies of environmental conflicts. In particular, previous research has suggested that opposition to infrastructure projects that would change the character of a place is related to strong emotional attachment to that place. However, this relationship is moderated by the meanings that people attribute to that place – if the project appears to fit with prevailing place meanings, it is more likely to be supported than if it is in opposition to them.

In this chapter, therefore, the emotional dimension of the conflict around the Mactaquac Dam, and potentially other possible removals of large dams, is captured using the concept of place meanings. In particular, the focus is on the intangible place meanings, i.e. the subjective, emotional meanings attached to specific locations, rather than the tangible meanings, i.e. how that place can support ecological, economic and experiential meanings. The latter types are captured by the use of ecosystem services discussed in chapters 3 and 4.

The range of ways in which places support individuals' sense of personal and community identity are explored. The results revealed that the two groups involved in the conflict for the most part expressed remarkably similar intangible place meanings. This suggests that the emotional dimension of conflicts over potential dam removals may not be a source of difference between parties but rather could reinforce other differences, such as tangible meanings/ecosystem service use.

This paper has been submitted to Ecology and Society. The format has been modified to be consistent with the remainder of this thesis. All literature cited in this chapter is listed at the end of this chapter.

The author of the thesis was responsible for the research design; data collection, processing and analysis; and writing the manuscript presented here. Dr Jan Adamowski, the thesis supervisor, was responsible for reviewing and editing the manuscript. Kimberly John assisted with transcribing and coding interviews.

6. The role of place meanings in opposition to water-related infrastructure projects – the case of the Mactaquac Dam, New Brunswick, Canada

Reilly, K.H., Adamowski, J.F. and John, K.

6.1. Abstract

Place attachment is often associated with opposition to infrastructure projects that change the characteristics of locations, including dam construction and removal. More recently, it has been suggested that in circumstances in which a project's perceived impacts are compatible with prevailing tangible place meanings, projects can be accepted even where local place attachment is strong. In this study, we focus on the role of intangible place meanings in opposition to and acceptance of the potential removal of the Mactaquac Dam, New Brunswick, Canada. Based on interviews with 32 local stakeholders, we identified a range of place meanings related to community and personal identity. Continuity over time, community distinctiveness, and the role of various activities and experiences in developing identity were key themes. Those who wanted to retain the dam and those who wanted to remove the dam shared many place meanings, and only diverged in two of those related to community identity. We suggest that conflict between the two groups may either be primarily based in different tangible meanings but escalated by the more emotional intangible meanings or that the two diverging community identities were highly important. Further studies should further investigate the specific role of intangible place meanings in conflict where place attachment is strong.

Key words: place meaning; identity; conflict; dams

6.2. Introduction

End of life planning for large dams built during the early to mid-20th century in North America is becoming an important issue as those dams age and as removal is increasingly a viable option (Doyle et al. 2008). Dam removal generates considerable environmental, social and economic change that impacts stakeholder groups differently (Johnson and Graber 2002, Stanley and Doyle 2003, Brummer et al. 2017). The uneven distribution of costs and benefits created from those differential impacts can result in the development of conflict between the stakeholders affected (Sidaway 2005, Lejon et al. 2009, Perlaviciute and Steg 2014, Tonitto and Riha 2016, Reilly and Adamowski 2017a). Many conflicts over these and similar infrastructure projects become emotionally charged, which is thought to be at least partly due to disruptions to people's connections to locations that the project would affect (Buijs and Lawrence 2013, Devine-Wright 2013).

The concept of sense of place describes people's connections to a given locale and the values they imbue it with (Tuan 1977). Although the definition of sense of place varies between fields, we define it as consisting of both attachment to a place and the meanings attributed to it (Tuan 1977, Rickard and Stedman 2015, Masterson et al. 2016, Stedman 2016). Place attachment is the strength of a person's emotional bond with a location, which could be positive or negative (Low and Altman 1992, Manzo 2003, Stedman 2016). Place meanings define the nature of a place for a particular person, i.e. what type of place it is for them (Stedman 2016).

The meanings given to places and how people attach to them become highly relevant in making decisions about projects that may change the character of those places, and thus have the potential to trigger highly emotional opposition and/or conflict between stakeholders (Davenport and Anderson 2005, Buijs and Lawrence 2013, Devine-Wright 2013). Numerous studies have investigated the relationship between strength of place attachment and the degree of project acceptance, particularly but not exclusively in the context of energy infrastructure projects, and have found both positive and negative correlations (Vorkinn and Riese 2001, Stedman 2002, Devine-Wright and Howes 2010, Devine-Wright 2011, 2013, Jacquet and Stedman 2014). The relationship between place attachment and management of water resources and environments has also been studied (Jorgensen and Stedman 2001, Stedman 2003, Davenport and Anderson 2005, Smith et al. 2011, Brehm et al. 2013). To explain why attachment correlates positively with acceptance of some projects and negatively with acceptance of others, some studies suggest that place meanings may mediate the relationship. Amongst people with strong attachment to place, projects are accepted when there is a fit

between the meanings attributed to a place and those given to the project, and vice versa (Stedman 2002, Devine-Wright and Howes 2010, Devine-Wright 2011). Although efforts have been made to identify the types of attachment associated with acceptance (Devine-Wright 2013), less attention has been paid to differentiating the variety of meanings, both tangible and intangible, amongst those who accept and those who oppose a project.

We used a decision on the future of the Mactaquac Dam, New Brunswick, Canada, to study the meanings stakeholders attributed to places in the dammed landscape and their association with acceptance of potential dam removal. We focused on removal because it constituted the greatest change to the status quo with the dam in operation. Earlier phases of this research addressed how stakeholders framed the impacts of each option in terms of losses and gains and in terms of scale (Reilly and Adamowski 2017a, 2017b), and their tangible, experiential place meanings analysed using the ecosystem services concept (Reilly et al., 2018). In this paper, we therefore shift from addressing tangible place meanings, including experiential, economic and ecological meanings, to intangible place meanings, including community identity and personal identity. We investigated the following research questions:

1) What are the intangible place meanings in terms of community and personal identity associated with the dammed river environment and how do they vary between people with different positions on the future of the dam?
2) How do individual and social meanings relate to the biophysical environment?
3) To what extent might intangible place meanings be affected by a change to the biophysical environment, such as removal of the dam?

6.3. Conceptual framework

We developed a conceptual framework (Figure 6.1Figure 6.1) to link the intangible place meanings that individuals associated with the dammed river environment to other factors that may influence acceptance of dam removal. The framework draws on research on place meanings (Williams and Patterson 1999, Davenport and Anderson 2005, Smith et al. 2011, Kil et al. 2014) and on research that conceptualises project opposition as a desire to protect places (Stedman 2002, Devine-Wright 2009, Devine-Wright and Howes 2010, Anderson et al. 2013). In this study, we focused on the concepts in bold (Figure 6.1). Earlier phases of this research addressed tangible place meanings (Reilly and Adamowski 2017a, Reilly et al., 2018), perceptions of project impacts (Reilly and Adamowski 2017a) and perceptions of the spatial distribution of impacts (Reilly et al., 2018), and hence these were excluded from this study.

The participants that supported and opposed dam removal in this study were qualitatively assessed as being strongly and positively attached, so this aspect was not considered in detail here as a source of difference between stakeholder groups.

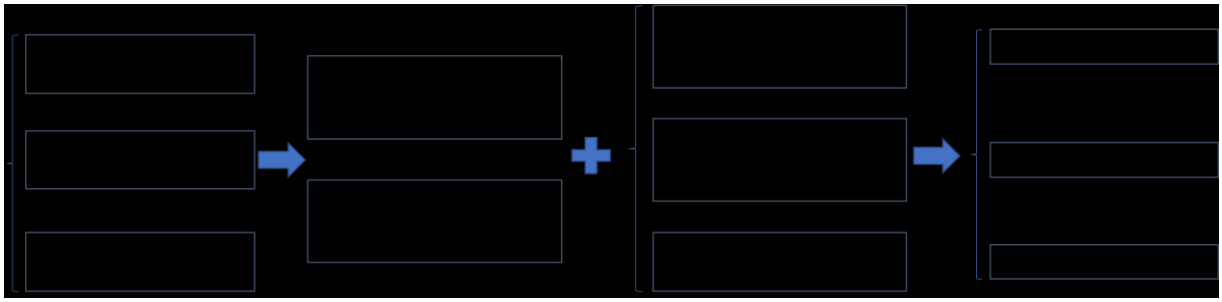

Figure 6.1. Conceptual framework illustrating the relationship between place meanings and project support or opposition.

6.3.1. Forms and development of place meanings

People imbue locales with symbolic and evaluative meanings in a process that creates what is known as place, as Tuan (1977 p. 6) defines: 'what begins as undifferentiated space becomes place as we get to know it better and endow it with value'. These meanings describe what type of place a location is, and are the basis for the development of place attachment (Stedman et al. 2004, Beckley et al. 2007, Stedman 2008, Masterson et al. 2016). Because meanings are often specific to individuals, communities and contexts, a variety of meanings can be attributed to any given location, which may lead to conflict if some are threatened (Williams and Patterson 1996, Davenport and Anderson 2005, Beckley et al. 2007, Gunderson and Watson 2007, Anderson et al. 2013, Buijs and Lawrence 2013).

Many studies distinguish two main types of place meanings: tangible and intangible (Table 6.1) (Williams and Patterson 1999, Davenport and Anderson 2005, Smith et al. 2011, Kil et al. 2014). Tangible meanings are defined as properties of the location, and can therefore be viewed as objective and verifiable, and relatively functional. Intangible meanings are subjective, and can be both personal and socially constructed (Davenport and Anderson 2005, Williams 2008, Kil et al. 2014). It is useful to differentiate the two categories in assessing the impacts of a project, but it must be recognised that they are often intertwined (Cheng et al. 2003).

Table 6.1. Summary of tangible to intangible place meanings and their associated components.

Tangibility	Meaning category (Williams and Patterson 1999)	Sub-components	References
Tangible	Inherent meanings	Appreciation of aesthetic appeal, support for ecological integrity, supports valued ecosystem	Davenport and Anderson 2005, Smith et al. 2011, Kil et al. 2014
Tangible	Goal-directed meanings	Enjoyment from experiences, economic meaning/dependence	Davenport and Anderson 2005, Smith et al. 2011, Kil et al. 2014
Intangible	Community meanings	Family identity, community identity	Smith et al. 2011, Kil et al. 2014
Intangible	Individual expressive meanings	Individual identity, place identity, expression of the self	Davenport and Anderson 2005, Smith et al. 2011, Kil et al. 2014

Of the tangible meanings, some are inherent in the place itself, which often take the form of aesthetic value attributed to certain biophysical features (Williams and Patterson 1999). Ecological meanings, i.e. valuing a location for its ecological components and processes that maintain ecological integrity, are also sometimes included in this category as objective qualities of the landscape (Smith et al. 2011, Kil et al. 2014). Others acknowledge, however, that both aesthetic and ecological value can be socially constructed within the boundaries of a location's biophysical features (Masterson et al. 2016).

The second type of tangible meanings involves how a place allows a person to meet their goals, in terms of spending time there or having a particular experience (Williams and Patterson 1999, Smith et al. 2011). While these meanings vary between individuals, depending on what goals or needs they expect a place to meet, a location's biophysical features limit the range of possible activities; as an obvious example, hunting requires the presence of species that can be hunted (Williams and Patterson 1999, Masterson et al. 2016, Stedman 2016). These meanings can also extend to a site providing the goods and services that contribute to an area's economy (Davenport and Anderson 2005, Smith et al. 2011, Kil et al. 2014).

In this study, however, we focus on intangible meanings, since they have been less studied in similar contexts than tangible meanings and earlier phases of this research focused on ecosystem services as a form of tangible place meanings (Reilly and Adamowski 2017a, Reilly et al., 2018). Such intangible meanings can take two forms. The first are community meanings, which are socially constructed and vary depending on the social and cultural context and its

location in time and space, as well as on individuals' personal and family history (Williams and Patterson 1999, Kil et al. 2014). In constructing these meanings, a family, community or social group defines its identity. Locations contribute to community identity development by supporting bonds between individuals and generations, being the setting for family memories and community history, and being a source of pride (Kil et al. 2014). These meanings are shared within a social group, but different groups may have developed different meanings over time, which may compete (Williams and Patterson 1999).

The second type of intangible meanings is individual expressive meanings, which contribute to an individual's sense of identity (Williams and Patterson 1999). The contribution of place to personal identity is formed from a person's emotional, psychological, spiritual and/or symbolic bond with that place (Williams and Patterson 1999, Kil et al. 2014). Both individual and community meanings are therefore intangible and subjective, and are associated with a holistic sense of place that builds up over time (Williams and Patterson 1999, Kil et al. 2014).

Place meanings are thought to develop from a combination of the biophysical characteristics of a location, an individual's experiences and personal characteristics, and the discourses and expectations of the social context (Jacquet and Stedman 2014, Masterson et al. 2016, Stedman 2016). While there is considerable debate in the literature about the relative importance of these factors (Stedman 2003, Lewicka 2011, Jacquet and Stedman 2014), we assume that all contribute by shaping and constraining the possible meanings that can be attributed to a location at a given point in time (Masterson et al. 2016, Stedman 2016).

The biophysical environment contributes to place meanings both directly and indirectly. Its biophysical characteristics directly contribute to the type of description a place is given, such that a remote, wild forest can be labelled as wilderness; some researchers refer to this as providing the 'raw material for meanings' (Jacquet and Stedman 2014, Masterson et al. 2016, Stedman 2016). For example, Stedman (2003) found that undeveloped lakes with clearer water and less public access were more likely to be given meaning as a place of escape than those with extensive shoreline development. Indirectly, the biophysical environment limits how a person can interact with it, which influences the intangible meanings that can emerge from that interaction (Masterson et al. 2016). Therefore, if the biophysical environment changes, the range of possible social interactions and place meanings will also change (Davenport and Anderson 2005, Jacquet and Stedman 2014).

The social and cultural context of a location or a person also shapes their place meanings. Some researchers consider meanings to be mediated and sustained by ongoing social interactions in a location (Greider and Garkovich 1994, Stokowski 2002). At a higher level than individual interactions, power and authority can shape place meanings through communications, regulations and cultural norms (Rickard and Stedman 2015, Masterson et al. 2016). For example, communications from national park services have been found to influence visitors' place meanings by teaching them what kind of place it is, in this case a blend of human and natural elements (Rickard and Stedman 2015). Cultural norms also shape an individual's experiences in a place through social expectations of their role, for example as an angler or hunter, and how they should behave (Masterson et al. 2016).

Within the constraints set by the biophysical environment and by the social and cultural context, people's direct and indirect interactions with a location give it meaning, and therefore different modes of interaction can produce different meanings for the same setting (Jorgensen and Stedman 2001, 2006, Smith et al. 2011). Such modes of interaction could include permanent residence, seasonal residence, tourism, recreation, work, family history and others (Stedman 2002, Kyle et al. 2004, Farnum et al. 2005, Smaldone et al. 2008). For example, a study of residents of a lake in Wisconsin found that permanent lakeshore residents gave the lake meaning as a neighbourly community, while for seasonal residents the same lake had meaning as an escape (Stedman 2002, 2008). Through a combination of different modes of interaction and personal characteristics, individuals develop a unique set of place meanings for a given social and biophysical context (Masterson et al. 2016)

6.3.2. The contribution of place meanings to project acceptance or opposition

Opposition to infrastructure projects that change the characteristics of a locale has been conceptualised as the desire to protect a person's sense of place, including both their attachment to it and meanings they imbue it with (Wester-Herber 2004, Devine-Wright 2009, Jacquet and Stedman 2014). Whether opposition occurs depends on whether a person perceives the changes a project induces as threatening their sense of place (Devine-Wright 2009, Jacquet and Stedman 2014).

It was initially thought that project opposition derived from strong attachment to place (Stedman 2002, Devine-Wright 2009). For example, an early study of public acceptance of a hydropower project in Norway found that strong place attachment was linked to opposition to the project (Vorkinn and Riese 2001). However, later studies found that individuals and social

groups within an area affected by a project can have different responses, and negative correlations between place attachment and degree of project opposition are possible (Devine-Wright 2011). For example, strong place attachment was associated with support for a tidal energy project in Northern Ireland, which was interpreted as providing local employment, slowing economic decline, and as an 'exciting novelty' (Devine-Wright 2011). It was therefore proposed that the relationship between place attachment and project acceptance is mediated by place meanings (Stedman 2002, Devine-Wright and Howes 2010, Devine-Wright 2011).

Opposition to a project is influenced by whether it is perceived to enhance or contradict prevailing place meanings (Stedman 2002, Devine-Wright and Howes 2010, Devine-Wright 2011, Anderson et al. 2013). For example, a study of a proposed wind farm in the United Kingdom found that place attachment was negatively correlated with project acceptance where the dominant place meaning was natural beauty that would be disrupted by the project (Devine-Wright and Howes 2010). Similarly, a study of plantation forestry in Australia found that those whose place meanings related to supporting lifestyles and amenity value viewed plantation forestry as risky, whereas those with meanings related to production saw it as both risky and of benefit (Anderson et al. 2013). However, individuals and social groups vary in the meanings they hold, their perceptions of the impacts of a project and their spatial location, leading to different responses (Anderson et al. 2013).

To determine whether a project is considered to support or interfere with place meanings, it is important to understand how affected people perceive its impacts on places (Devine-Wright 2009). Perceptions of change can arise from both a psychological process (Stedman 2002, Reilly and Adamowski 2017a) and from a social process, in which they are negotiated between people and with institutions (Devine-Wright 2009, Devine-Wright and Howes 2010). In either case, they can vary spatially based on uneven distribution of impacts from the project and/or variation in prevailing meanings. We do not assess stakeholders' perceptions of change in this study, since they have been analysed for this case using cognitive frame theory in an earlier phase of this research, which found some stakeholders perceived dam removal as a loss and others as a gain, depending on their ecosystem service use (Reilly and Adamowski 2017a).

6.4. Study area

6.4.1. Choice of case

The Mactaquac Dam, a large hydropower dam on the Saint John River, New Brunswick, Canada, was chosen as the case study for this research (Figure 6.2). It was selected because

both the river in its pre-dammed state and the reservoir created by the construction of the dam, known locally as the Mactaquac headpond, are of high local importance. The construction of the dam considerably changed the morphology of the river upstream of the dam, from a shallow river with several islands, to a deep, slow-flowing reservoir. Despite local opposition to its construction (Bourgoin 2013), many people have adapted to its presence and now demonstrate attachment to it and to the headpond (Keilty et al. 2016, Sherren et al. 2016). However, others would like to see the dam removed, and the original river morphology and way of life restored (Reilly and Adamowski 2017a). Therefore, the case provides an opportunity to explore how place meanings vary between people with diverging views on the possibility of dam removal.

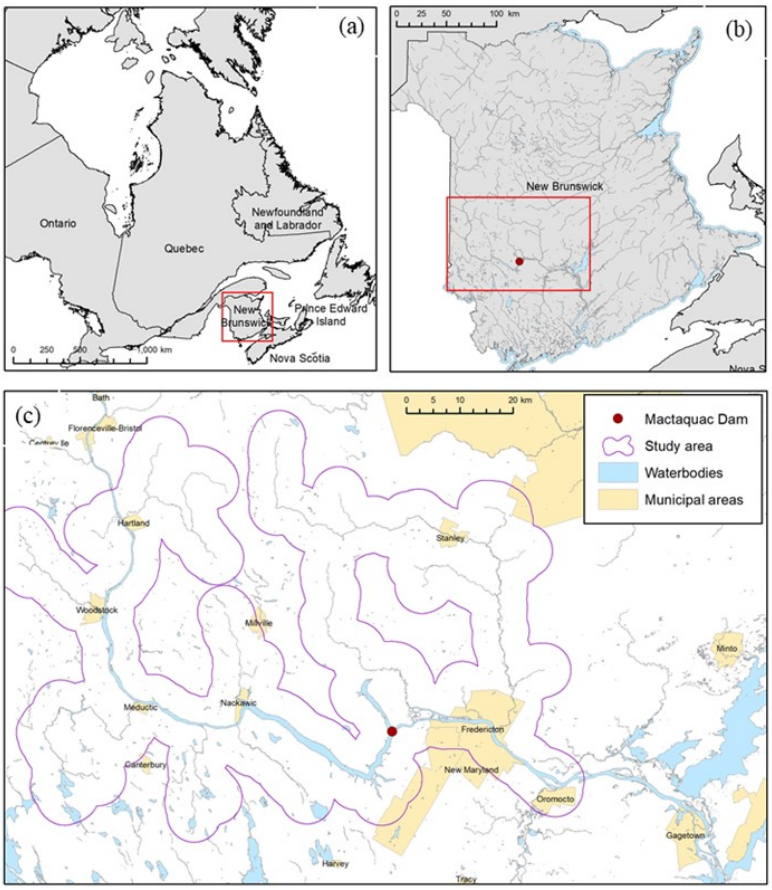

Figure 6.2. Location of the study area in Canada (a) and New Brunswick (b). Boundaries of the study area shown in (c) and defined as a 5000 m buffer around the reach of the river most hydrologically affected by the dam (approximately Hartland to Oromocto) and its tributaries. Produced in ArcGIS 10.4 (ESRI 2016) and contains information licensed under the GeoNB Open Data Licence and under the Open Government Licence – Canada, as well as data from Natural Earth**.** (Reilly et al. 2018)

6.4.2. The Mactaquac Dam and its influence on the Saint John River and its population

The Mactaquac Dam has been in operation since 1968 and currently supplies approximately 12% of New Brunswick's electricity (New Brunswick (NB) Power 2016). It was built to provide energy for the economic development and industrialisation of the province (Bourgoin 2013). A park close to the dam, a historical museum of original buildings relocated for the creation of the headpond, and a pulp and paper mill were also built, as part of an associated rural development project (Si 1993, Bourgoin 2013).

Flooded productive fertile farmland and churches and graveyards were flooded to create the headpond, and 900 - 1100 people (estimates vary) were displaced (Si 1993, Bourgoin 2013). The residents' objections focused on the impacts of these material losses on their aesthetic, cultural and historic attachments to the river. The loss of churches and graveyards represented both a rupturing of the connection to previous generations and to the area's British settler heritage more generally (Bourgoin 2013). These arguments were labelled 'sentimental' by the dam planners, and thus were easily dismissed (Kenny and Secord 2010, Bourgoin 2013).

Now, the headpond is a popular local destination for recreational activities, including boating and fishing, which support local businesses and tourism (Dillon Consulting 2015, Stantec 2015, Reilly and Adamowski 2017a). Numerous other ecosystem services are important, including the intrinsic value of ecosystems and aesthetic appeal (Reilly and Adamowski 2017a, Reilly et al., 2018). On the other hand, the dam forms an impassable barrier to migrating fish, including the economically-valuable Atlantic salmon, the population of which has declined in recent years (Stantec 2015). The river flow downstream of the dam fluctuates by one metre on a daily basis, as water is released through the dam in response to energy demands. This is a stressor to aquatic species in this reach of the river and complicates its recreational use. Overall, therefore, the dam has had both advantages and disadvantages for the area and for the province.

At the time of study, the dam's owners, New Brunswick Power (NB Power), were in the process of evaluating options for its end of life, which was foreshortened due to a structural problem. The options under consideration included rebuilding the affected concrete electricity generating structures, which would allow the dam to continue functioning as a hydropower producer and maintain the headpond. The second option was to retain the earthen dam that maintains the headpond and decommission the electricity generating structures, and the third was to remove the dam entirely and return the river to its free-flowing state (NB Power 2016).

At the time of data collection, the environmental and social impacts of each of the three options had been reviewed and communicated to the public. A consultation process was underway, in which NB Power requested submissions and responses to an online survey from New Brunswickers and held community meetings in the affected reach of the river (NATIONAL and CRA 2016).

The decision on the dam's future was controversial. The outcomes of NB Power's consultation process, reported after field work was completed, revealed that although a majority of respondents preferred to retain the dam, others wanted to remove it (NB Power 2015, NATIONAL and CRA 2016). The strong local interest and divergent opinions about the options for the dam's future made the case an ideal opportunity to study how sense of place in and around a river environment varies amongst stakeholders with different opinions about a possible change to that environment. The dam is one of the largest in the world to ever be considered for removal, making it an important test case for other large dams reaching the end of their lifespans.

Since the data collection was completed, NB Power decided to enhance maintenance, replace critical components and install a fish ladder to allow the dam to reach its originally-planned 100-year lifespan (NB Power 2017). This essentially preserves the status quo, but a similar debate will have to take place in 30 years' time when the decision has to be made again. Therefore, this study will still be useful both as a reference for the future decision-making process and in guiding management of the dammed river in the present.

6.5. Methods

6.5.1. Sampling and data collection

We used a qualitative approach to identify the range of locally-specific place meanings present in the study area (Davenport and Anderson 2005, Devine-Wright 2011). This enabled us to understand people's reasons for their deeply personal relationships with places and identify how a potential change to the physical space would impact their sense of place (Gunderson and Watson 2007). We used qualitative semi-structured interviews, which were combined with a participatory mapping exercise, the results of which are reported in Reilly et al. (2018).

To select interviewees, we used non-proportional quota sampling to understand how sense of place varies between individuals with different characteristics (Gunderson and Watson 2007). We aimed to include the main interest groups, as well as interviewees located throughout the affected area (Figure 6.2). We invited representatives from a list of stakeholder groups in the

study area developed from an earlier phase of the study (Reilly and Adamowski 2017a), and contacted others recommended to us in a snowball sampling approach. We continued inviting stakeholders and conducting interviews until no new themes were introduced in the interviews, i.e. theoretical saturation was reached (Strauss and Corbin 1998). The final sample included 32 individuals, which included three family members of invited interviewees, of which 12 had participated in the earlier phase. It included small business owners, representatives of environmental and watershed groups, municipalities, recreation groups, students, farmers, heritage groups, and upstream and downstream residents. Notable groups that were missing included Maliseet First Nations and industry, who had declined to participate in an earlier phase of the study.

The interviews began with questions on what the participants thought should happen to the dam and why, and how they thought each option for the dam would affect them. We then proceeded with a series of questions on places in, near or around the river within the study area that were important to them (Appendix 6.1). We first asked participants to identify places that were important according to their own criteria. We then used prompts on cultural ecosystem services adapted from an interview protocol designed by Klain and Chan (2012) and Gould et al. (2015), which used broad, plain-language questions to elicit use of the ecosystem services that were identified as locally important in an earlier phase of the study (Reilly and Adamowski 2017a) (Appendix 6.1). We chose this protocol to encourage participants to reflect on a range of ways in which the environment and specific locations may be important for them. For each question, we asked what was important to the participant about each place and why they liked it. We used closed probing questions as needed to follow up on ideas and check understanding (Patton 2005, Gould et al. 2015). The participants were also asked to mark on a map the places they identified, the results of which are reported in Reilly et al. (2018).

The interviews lasted between 40 and 90 minutes, and took place in locations of participants' choosing, including their home, workplace and local cafes. We conducted all interviews between May and June 2016.

6.5.2. Qualitative data analysis

All recorded interviews were transcribed, and the main themes collated into a short summary document, which was returned to participants to check our interpretation. Nine participants confirmed that the summaries were accurate and five requested changes to minor details; the remainder did not respond.

We used an iterative process of descriptive coding to identify the place meanings associated with the locations mapped, and with the study area in its entirety (Miles et al. 2013). To identify meanings, we looked for pieces of data that described how a person valued a place and then coded the data according to those values.

Using this coded dataset, we removed all tangible place meanings (Table 6.1), including all references to ecology, aesthetics, economic value and recreational experiences, unless they were linked to community or personal identities in some way. We retained all intangible meanings, i.e. community meanings and individual expressive meanings. For example, if a person expressed that being able to walk in a rare and biodiverse forest helped them feel fulfilled, the idea of fulfilment was retained as an intangible meaning.

We then proceeded with further iterations of coding the intangible meanings, which involved entering each code into a codebook with a description and example, then comparing codes, and refining the coding and codebook (Appendix 6.2). We grouped codes into sub-categories of meanings (or pattern codes (Miles et al. 2013)) using an inductive process of looking for similarities and differences between codes. Lastly, we sorted the meanings sub-categories into the two broad categories of community meanings and individual expressive meanings (Table 6.1).

We then summarised the coded data into several display tables organised by participants' roles and their position on the dam (Miles et al. 2013). The tables had a line for each participant and a column for each meaning, grouped into the meaning sub-categories. Each participant's intangible place meanings were entered into the corresponding cell with a representative example from the coded data. This allowed us to compare the types of meanings within categories, between individual participants, and between the groups of participants.

6.6. Results

6.6.1. Intangible place meanings and their variations between people

We present here the range of community and personal identity meanings in summary tables and illustrated with quotes from the participants' interviews.

Community identity meanings focused on individual villages/towns, the region or the province (Table 6.2). They included reflections on what maintains a community, such as shared activities and sufficient population (sub-category 1): '*the dam is essential for our pulp industry here. The community was created too from this place* [the mill]' (Participant 04). Maintaining what was done in the past (sub-category 3) and what should continue into the future (sub-category 4)

were important in defining a community: '*what would happen is that whole boating recreational thing would disappear. So kids in the future wouldn't get a chance to experience what kids experience today*' (Participant 01). The past was also important in terms of its traces that can still be seen today, which act as reminders of the region's history (sub-category 5): '*At Kings Landing, there are homes there that I visited as a child that were actually homes that families that I knew were living in here in the community. And when the dam came through, those homes would have been destroyed, so they were moved to Kings Landing. And that's just part of the heritage of this place*' (Participant 05W). The distinctiveness of communities and the region was frequently mentioned as a key component of identity (sub-category 2), by differentiating them from other areas. Lastly, many participants emphasised the importance of the river for the identity of various villages/towns, regions, the province and the Maliseet First Nation (sub-category 6).

Table 6.2. Place meanings associated with community identities.

Meaning sub-category	Meaning	Example
1. Community is based around a shared lifestyle and livelihood	Towns cannot readapt if the headpond changes	'Culture and infrastructure has evolved around the way it is, and it would be extremely disruptive to change that.' Participant 44
	The headpond reduces community isolation	'It's recreational yes, but it's also a main throughfare to get to, community to community is right, so you're not isolated in this area.' Participant 40
	Jobs associated with the headpond keep people in the area	'It's a farming, agricultural and tourism area. Yeah, and the headpond's the major link to it all.' Participant 40
	Recreation brings people in	'With the boating, and the sledding and the communities. I mean Nackawic, certainly, they're going to be happy to see [the fishing tournament] on the weekend.' Participant 23
	Community celebrations and rituals bring people together	'We have the regatta once a year on Canada Day. So that's very important.' Participant 02
2. This place is like no other	It is superlative (the best, the prettiest, the most visited)	'It's one of the premier boating areas in the province also. Because you're not running up on sandbars or anything. So it's recognised worldwide for its boating recreation.' Participant 40
	It has aspects that are rare	'It's a nice inland population of things like black terns, which are quite rare.' Participant 35

Meaning sub-category	Meaning	Example
	It has unusual features for its context	'We have a beach and it's usually also something you would see… on the ocean you would find a beach. Not so much in the rivers'. Participant 04
3. Connectivity with past generations	Place of family heritage	''[Island Park] had been the place where most of the soldiers were mobilised in New Brunswick, were mobilised to that park [during World War II]. And so a lot of people had a connection with someone who never came back.' Participant 42
	Sharing the same experience as previous generations	'Now there's three generations of children that have gone to camp. Everyone that we've talked to knows, either they've gone or they know someone, their brother has, or their... you know. They know people who have gone.' Participant 41
4. Connectivity with future generations	Preserve opportunities for learning, exploring, self-efficacy	'What I'd really love to see is that each child have the opportunity to experience something in this river valley that shapes their life forever.' Participant 35
	Maintain current uses of the headpond	'I hope that the kids, my kids and other kids in the future can experience kind of exactly what it is.' Participant 22
5. Our history is close to our present	Farming way of life preserved at Kings Landing Historical Settlement (museum).	'It's part of our history and it reminds us that that's what the farming looked like before the dam was built.' Participant 31
	History can still be seen in the present	I think the landmarks on the river. That you can look in to see that, you see that there was a bridge here. And the log booms that go across here. […] I think it reminds us of what used to, which was logging, which drove the area' Participant 36
	Particular features that were lost are still remembered	'Historically and culturally the re-emergence of the historic Fort Meductic site, which would be just above Eel River somewhere, which was probably never properly looked at and artefacts removed from prior to the dam's construction.' Participant 15
6. The river and nature are who we are	The relationship between humans and nature here is unusual	'I would say that it's a great thing to have a city that's by a river like this' Participant 38
	Nature is more important than human heritage	'In terms of New Brunswick, if there's a sense of a need to conserve anything within a particular community I think it's going to often be the, perhaps the most significant or important natural feature within that community.' Participant 15
	History is centred around the river	'There's a reason why the Fredericton hub is where it is. To my historical knowledge that's

Meaning sub-category	Meaning	Example
		where they decided that the colonisers were up river enough that it wasn't salty.' Participant 37
	The area and its people are defined by rivers	'When it impacts us negatively, we say, "well, we're not happy about this and I wish there wasn't a river there", or almost that thought. And yet my goodness, we couldn't do anything without it. It's fundamental to the province.' Participant 47
	To be Maliseet means to be people of the beautiful river	'To be Maliseet means to be Woolastookyuk. People of the beautiful river. Like, that's the people. So that's beyond significant.' Participant 37

The personal identity meanings (Table 6.3) had some thematic similarities with the community meanings, including the importance of continuity between past, present and future, and the importance of activities and experiences in contributing to identity. For individuals, those activities produced a sense of accomplishment and stimulated emotions, both of which were considered important for a person's idea of who they are (sub-categories 1 and 2). A very commonly cited meaning involved the contribution of places, activities and experiences to forming and maintaining relationships with others (sub-category 3): '*because of* […] *the fact that we use the river, we've a larger circle of friends than some of my sisters who have lived here all their lives'* (Participant 01W).

Many participants described either water in general or the river itself as feeling like home and inspiring a sense of belonging (sub-category 4): '*I know it's from the activities that I do and I could do those activities somewhere else. But I think it's not just the activities, it's* [the river is] *like your home*' (Participant 22). Others incorporated the river and places around it directly into their sense of who they are by feeling rooted in that place through being born there or it being where their ancestors were from (sub-category 5). Memories and stories from earlier phases of people's lives were also important in maintaining a sense of continuity, including, for some, past the end of their lives (sub-category 6). The accumulation of time spent in the area and activities experienced there allowed some participants to develop a deep knowledge of locales and how they behaved (sub-category 7). Lastly, for some participants, interactions with the river over a period of time may have been enjoyable but did not contribute to their identity (sub-category 8): '*But as far as would I send somebody to go see this or go see that, something that I would identify with, nope*' (Participant 30).

Table 6.3. Place meanings associated with personal identities.

Meaning sub-category	Meaning	Example
1. Enables accomplishments	Has enabled life's work	'It was poor land, but we did land improvements and we farm it. We use it today mainly for growing fruit crops.' Participant 32
	Builds confidence	'I just got in the boat and out I went. Spent all afternoon playing up and down the river between here and Meductic, and came back in, docked myself and hit nothing, and it was fine. I was there waiting for the bad part but no, it was fine. So it just gave me confidence again that you can do it.' Participant 02
	Taught me what I know	'Years ago, a man lived here and he was the sort of the top birder […]. Came to Fredericton in 1955 and he was, I learned a lot from him' Participant 26
2. Inspires emotions	Water feels relaxing	'Why am I drawn to water… I dunno […]. It's just one of those calming, soothing things to me.' Participant 39
	Joy at being in nature	'I see a little chickadee or a troop of chickadees, and they're so energetic and they're happy to be out, and it's -40 and they don't care. And, you know, I'm shivering away and then…. It just makes me feel better about myself and better to be part of the world, because there are other things that are there that seem to invoke a sense of joy.' Participant 35
	Peacefulness	'I pursue my main hobby there. I guess I sort of find some peace there.' Participant 15
	Other aspects of places feel relaxing	'There's a lot of people that love the outdoors just because it's there. And they may not do anything with it but just the ability to see a lush habitat is really, just like relaxing for a lot of people. Therapeutic in that way.' Participant 37
3. Builds and sustains relationships	Geographical proximity	'The reason that we moved here was because we wanted to move to New Brunswick to be closer to [wife]'s family.' Participant 01
	Shared experiences	'We're not crazy four wheelers but it's a social aspect. You go out and go up to the cabin, maybe have a little fire or something. Have a drink and then go back home again.' Participant 23
	Memories of time spent together	'I certainly enjoyed my time with my late wife and the kids every summer. At Mactaquac Park.' Participant 30

Meaning sub-category	Meaning	Example
	Group rituals	'At Thanksgiving we always go picking apples with the kids who are now thirty-something.' Participant 18
	Show places to others	'I just recently took a new family to Canada down to the campground and the girls went ballistic over the beach.' Participant 04
	Relationships keep me here	'We actually bought that house as a temporary residence until we could find somewhere that we wanted to build. And we liked the people so much we stayed there.' Participant 23
	Know people in the area	'That's the other thing about living here. It's that, and I'm kinda rediscovering it, it's that people from here are amazing.' Participant 18
4. Feels like home	Water feels like home	'When I moved here I feel inland but I've been here for three years now. And I realised, like, oh my gosh I'm so glad I can live in a city where I can see the water.' Participant 37
	This place feels like home	'We both used to live up there. So, it's kind of visiting the home town.' Participant 31
5. Who I am	Multiple generations in a place	'I'm six generations here. My family came here in 1785. To this land. Well, just next door. […] So, you know, I got deep roots.' Participant 32
	Growing up here makes me who I am	'I identify with this, this has made me who I am certainly, being on this river and growing up right there and working and living on it.' Participant 36
	The river is part of me	'The river runs through me. It, I don't know.' Participant 44
6. Continuity in my life	This is where I belong	'When I first came in sight of the Saint John up around Hartland, just all of a sudden I felt where I belonged again. I just reconnected at some level with the river.' Participant 44
	Stories from childhood	'I grew up right about here on the water, and I would just go over to these islands and camp. Oh, it was fun. I mean you're 16 years old so, great way to spend the summer.' Participant 21
	Part of something bigger	'That stream goes over the falls and goes right down to this pond of water and out into the river. And away to the sea. I don't know, there's something about the continuity of that thought that I like.' Participant 44
	Stories from adulthood	'So when I go back to that place, I think, oh ten years ago or 20 years ago, I saw such and such

Meaning sub-category	Meaning	Example
		here and I wonder if I'll ever see it again' Participant 35
7. I know it	Knowing helps with activities	'Living beside the headpond for, well, 55 years, you even know the yard lights. When you leave Nackawic and come down that headpond, you can tell where you are by the yard lights, and like whether you're in Kings Landing or whether it's the yard light of the gas station in Prince William' Participant 40
	Knowing helps to feel connected	''There's magic about the water. And about this area. And coming to know the water and the river.' Participant 32
	This is my place	'Growing up in the area, I have a lot of private little places.' Participant 40
8. Doesn't define me	This is just land	'It's just a piece of property that we decided to build a home on' Participant 04
	No deep connection to the river	'I don't think I have a sense of an identity with the river, particularly. It's really nice that it's there, I'd take advantage of it. But I wouldn't climb a mountain to find it, sort of thing.' Participant 04

While there was individual variation in which community identity meanings were present, there were few obvious patterns between the participants who preferred to retain the dam ('the retainers') and those who preferred to remove it ('the removers'). However, the majority of removers did not refer to the community being defined by shared livelihoods and lifestyles (sub-category 1). While retainers expressed meanings in sub-category 6 about the river and nature defining the community, it was less common than amongst the removers.

6.6.2. Relationships between intangible meanings and the biophysical environment

The intangible meanings demonstrated by participants were closely related to the biophysical environment. This may be expected, since participants were asked to focus on important places in, near or around the river, which would have led them to consider the biophysical environment in their answers. Despite this, we investigated the range of ways in which the biophysical environment contributed to intangible meanings (Table 6.4).

Table 6.4. The role of the biophysical environment in contributing to intangible meanings.

Category	Role of biophysical environment	Example features	Quote
Allows experiences	Enables current and past economic activities that define a community	- Fertile soil permitted farming, which the community was built around, before the dam was built. - Abundant water supplies maintain a pulp and paper mill, a major local employer.	And Nackawic, [...], are they prepared because this mill only has x number of years of life left anyway. [...]. But it still would certainly, the town would I guess, would lose the taxes, the base and all that. So Nackawic could well become what it was back in the sixties which was a dying town.' Participant 04
Physical reminders	Has features that remind current generations of history	- Kings Landing historical settlement preserves houses relocated when the dam was built and the previous farming culture	[Kings Landing] would be a prime location of interest for anybody coming here and wanting to know about how people lived in New Brunswick back in the 1800s, I think is really, really a significant, a significant site' Participant 43
Allows experiences	Enables recreational activities that define a community	- Easy recreational boating and fishing for smallmouth bass and muskellunge attract visitors and residents.	'Right along here the population of eagles here has started growing so. And a lot of people especially from foreign countries that are overpopulated they like to see stuff like that.' Participant 34
Is distinctive	Is particularly unusual	- Geographical location and climate allow rare habitats and species	'It's a sheltered valley where lots of plants are persistent at the northern limit of their range in North America. And they're not found elsewhere in North America' Participant 35
Enables existence	Defined/shaped how a community came into existence	- The river was wide and deep enough to allow boat transport from the ocean	'Everywhere that has history and who we are and where we came from, it was the waterway. Because that's how we got there.' Participant 32
Allows experiences	Enables recreational activities that contribute to self-identity, and can be shared with past and future generations	- Presence of particular species and habitats allows birding and species discovery - Easy recreation, including fishing and boating, can be	I really hope to take my son and paddle the upper stretch again, which I did a few years ago with a group of students, and show him that.' Participant 36

Category	Role of biophysical environment	Example features	Quote
		passed on from generation to generation'	
Allows experiences	Enables professional activities that contribute to self-identity	- The river underlies local culture and art, which is a source of personal artistic expression	'[I make art] because I want young people to be aware of that, the importance of the river, and the importance of, it's had on the history and our development.' Participant 47
Allows experiences	Has features and enables activities that inspire emotions and feel like home	- The presence and accessibility of water is seen as peaceful - The river and/or headpond are considered to be part of a person's home	'It's for relaxation. I will take a book and a cup of coffee and go paddle out in the middle of the river and just sit there and read my book and drink my coffee' Participant 04
Allows experiences	Enables activities that help to form and maintain relationships, both currently and in the past	- Accessible recreation on the river, including boating and fishing, is often a shared experience	'When you're out there in a boat you're meeting totally different people in the community' Participant 40

In many cases, the biophysical environment allowed or promoted experiences to which intangible meanings are attached, whether for community identity or personal identity (Table 6.4). For example, many of the economic activities in communities, such as tourism, farming and the paper and pulp mill, directly rely on certain biophysical conditions. This is considered a goal-directed tangible meaning (Table 6.1) related to economic importance. However, the role of these activities in sustaining and defining the community then is considered an intangible meaning, as participant 40 describes: '*that's what the community's built of, is people that have moved to Mactaquac to work at Mactaquac Dam, and build their life around the headpond and Mactaquac Dam*'. Therefore, in this case the biophysical environment relates to intangible meanings with goal-directed tangible meanings as an intermediary.

The biophysical environment also contributed to intangible meanings by being a physical reminder of a community's history and enabling the community to exist in the first place. Lastly, the community's distinctiveness was closely related to the rarity of elements of the biophysical environment: '*people that come from away, they could not believe that we're on a river with hardly any boats. But lots of eagles and stuff like that. So that is again starting to get this river, as it is now, more recognised*' (Participant 05W). In this case the relationship

between the biophysical environment and intangible meanings is mediated by inherent tangible meanings, notably its ecological importance (Table 6.1).

6.7. Discussion

6.7.1. The role of intangible meanings in opposition and support of dam removal

The results of the study demonstrate the wide range and importance of intangible place meanings in the study area. For many of the participants, places in and around the dammed river environment were highly significant in determining their community's identity and their own personal identity. Most individuals held multiple place meanings, and the participant group as a whole did not hold one common place meaning.

The intangible meanings identified are the product of a complex system of community and personal history, future hopes, social networks, self-perceptions, biophysical characteristics, and emotions (Smaldone et al. 2008, Stedman 2008, Nash et al. 2010, Urquhart and Acott 2014). However, we focused here on the role of the biophysical environment in the intangible meanings, since that is what would most obviously be affected by dam removal. If the dam were removed, the headpond would revert to a shallower and narrower river, with low-lying riparian land and islands being exposed (Stantec 2015). It would be expected that these morphological changes and the removal of the dam as a barrier would change the ecology of the river, such as by improving fish migration (Hart et al. 2002, Stantec 2015). An earlier phase of this study showed that these changes were perceived to both restrict and expand people's ability to benefit from ecosystem services (which can be cross-linked to tangible meanings) in several ways. For example, the shallower river was perceived to reduce access to recreational boating and fishing from boats, while facilitating fishing from shore (Reilly et al., 2018). It would therefore be expected that the intangible meanings, such as a feeling of relaxation or fulfilment, that participants derived from these experiences would also be affected (Davenport and Anderson 2005).

It is less clear how such changes to the biophysical environment would affect the intangible meanings that are less directly linked to recreational, economic and ecological tangible meanings. Some intangible meanings identified in the study were associated with places that do not anymore have the biophysical characteristics that were the source of the meaning, suggesting that the meaning can remain in place when the characteristics change. Two notable examples are the value attributed to salmon pools, which were present in several locations

before the dam was built but have now been flooded, and Fort Meductic, a site of historical importance that is also now underwater. Similarly, other studies of retainers in the area showed that individuals who had had deep emotional connections to the undammed river were able to adapt to appreciate the dam in place (Keilty et al. 2016, Sherren et al. 2016). However, this does not mean that all identified intangible meanings would survive this transition or would be perceived to survive this transition. Indeed, some participants explicitly stated that they would not feel the same way if the headpond was no longer there. This issue deserves further study, possibly in the form of a longitudinal study that investigates place meanings both before and after a change in biophysical conditions.

The lack of considerable differences in intangible meanings between the participants who would accept or support dam removal (the removers) and those who would oppose it (the retainers) was somewhat surprising. It could have been expected that the two groups would have different sets of meanings that were perceived as compatible or incompatible, respectively, with dam removal. Several other studies of the role of place meanings in conflict around natural resource management found that conflict occurs between stakeholders with strong place attachment but different place meanings, which would be affected differently by management decisions (Stedman 2003, Anderson et al. 2013, Masterson et al. 2016). Others found that opposition to energy projects occurred amongst those who held place meanings that were perceived to be incompatible with the impacts of the project (Smith et al. 2011, Jacquet and Stedman 2014). Therefore, we would have expected to see a clear difference in meanings between those that supported retaining the dam and those that supported removing it.

There are several possible explanations for the inconsistency between our finding of little difference between individuals holding different positions on the dam's future and studies of other similar decisions. Firstly, we suggest that in some cases tangible place meanings may be more important or easier for participants to assess as compatible with a project than intangible meanings. We identified here that tangible meanings may form the link between the biophysical environment, which would be altered by dam removal, and intangible meanings. Furthermore, earlier phases of this study found clear differences in tangible meanings, expressed using ecosystem services, between the two groups (Reilly and Adamowski 2017a) (Reilly et al., 2018). This is consistent with other studies that found that perceived compatibility of a project with aesthetic appeal, ecological meanings and economic meanings was related to whether stakeholders oppose or accept a project (Devine-Wright and Howes 2010, Devine-Wright 2011, Anderson et al. 2013). Therefore, it may be the case that stakeholders diverge in

their tangible place meanings, leading them to assess compatibility differently, but that those different tangible place meanings contribute to the formation of similar intangible meanings.

Another possible explanation relates to the one identified difference in community meanings – that the community being defined by shared livelihoods and lifestyles was more common amongst retainers, and the river and nature defining the community was more common amongst removers. This difference in community identity may be more significant than it appeared to be in this exploratory study with a relatively small sample size. If that were the case, the two groups would then differ in at least one form of intangible meaning, several tangible meanings (Reilly et al., 2018) and their perceptions of the project's impacts. We recommend that further research with a larger sample size aims to further explore the relative importance of the shared and contested meanings. For example, a Q methodology exercise that involves ranking the importance various meanings identified in this study could be conducted (Anderson et al. 2013).

The existence of subjective and emotional place meanings may have the potential to heighten emotions in general around the decision and exacerbate conflict arising from diverging tangible meanings (Cheng et al. 2003, Buijs and Lawrence 2013). Emotional responses to an issue can escalate conflict and produce a vicious cycle of increasing emotion worsening the conflict, which in turn increases emotion (Buijs and Lawrence 2013, Sandström et al. 2013). In particular, intangible meanings are based around identity, both at a personal level and a community level. People can respond strongly when they feel an infrastructure project threatens their identity (Wondolleck et al. 2003, Gray 2004). It may also shift the balance of power in a conflict – those parties who respond emotionally can find themselves delegitimised on the basis that they are not engaging in a constructive manner (Buijs et al. 2011, Buijs and Lawrence 2013).

To take account of the potential for divergences in meanings and for the presence of intangible meanings to escalate conflict, we therefore suggest that the meanings-mediated model by which place attachment influences opposition to projects (Devine-Wright 2009, 2011) could benefit from tangible and intangible meanings being differentiated. Tangible meanings are more clearly linked to the biophysical conditions that would be changed by an infrastructure project and therefore may be more likely to be assessed as compatible or incompatible with the project. It may be more challenging for a stakeholder to determine how a project would affect intangible meanings directly, but if they are affected by the project via tangible meanings, conflict and/or

opposition may be heightened. However, this study was only intended to be exploratory, and therefore the relevance of a differentiated model should be further investigated in other contrasting cases and tested in quantitative studies of randomly sampled stakeholders.

6.7.2. Decision making sensitive to intangible place meanings

People's relationships with the dammed river environment cannot be described with one single place meaning. For each individual, and for the participants collectively, each place is important and valued in several ways. It is therefore impractical for decision makers to attempt to preserve a singular sense of place when considering projects that would alter certain characteristics of the locale (Yung et al. 2003, Nash et al. 2010). Indeed, efforts to do so may risk excluding other, equally important, place meanings and by extension the people who hold them (Nash et al. 2010, Masterson et al. 2016).

Decision makers should therefore aim to be sensitive to the multiple meanings that people hold in the affected area (Davenport and Anderson 2005). Firstly, it is important to understand the place meanings that prevail within the affected area, including how they are complementary and conflicting (Yung et al. 2003). The act of gathering information specifically on the multiple dimensions of place meanings, including taking into account the more emotional and subjective intangible meanings, can help to build trust between stakeholders and decision makers (Farnum et al. 2005). This can ultimately be expanded into a participatory decision-making process focused on place, which has been found to allow a greater range of stakeholders to be involved and perspectives to be elicited then non-place-based processes (Cheng et al. 2003, Wheeler et al. 2016).

Secondly, understanding place meanings can help to understand conflicts around potential dam removals and other similar infrastructure questions (Stedman 2008). Shared intangible place meanings can serve as a point of agreement between parties that may strongly diverge in their interests (Nash et al. 2010). Furthermore, a shift in debate away from interests towards place meanings has been found to help the involved parties feel heard and respected and to allow for different issues to be addressed (Yung et al. 2003, Cheng et al. 2003, Wheeler et al. 2016).

Thirdly, mitigation measures for tangible place meanings that may be lost, such as access to recreation, employment (economic meaning), and ecological meanings, may be relatively simple. In this case, for example, the loss of boating in the headpond by removal of the dam could be compensated by enhancing facilities on other lakes, facilitating a transition to boats that draw less water, or signing deeper channels in the free-flowing river. Impacts on wildlife

could be minimised through careful dewatering and active restoration of the exposed land post removal. However, these measures fail to take account of the intangible meanings that would be threatened by the change in biophysical and/or social conditions that result from such a project. These are less easy to compensate or mitigate, deriving as they are from a combination of social and personal factors developed over time. While the particular method of accounting for intangible meanings will be very context specific, the current situation in this case may be informative. Kings Landing Historical Settlement was widely valued by participants for its preservation of the area's farming culture that existed before the dam was built. Creative solutions such as this should be considered as ways to reduce the impact of disrupted place meanings.

6.8. Conclusion

This study investigated intangible place meanings attributed in and around a dammed reach of the Saint John River, New Brunswick, Canada, which was the location of a controversial decision around whether to rebuild or remove the dam in question. The participants held a range of intangible meanings, and expressed place-based community and personal identities. Many of these meanings were closely linked to the biophysical environment and the experiences and activities that it allows. There were few clear distinctions in intangible meanings between participants who preferred to remove the dam and restore the reach to its natural free flowing conditions and those who wanted to keep the dam in place. This suggests either that tangible meanings, including experiential, economic and ecological meanings, may be a more significant source of disagreements between stakeholders in this case, or that one difference in community identity meanings between the two groups is highly important. Further studies can distinguish these possible explanations and test the resulting model in a larger sample of the affected population.

REFERENCES

Anderson, N. M., K. J. H. Williams, and R. M. Ford. 2013. Community perceptions of plantation forestry: The association between place meanings and social representations of a contentious rural land use. *Journal of Environmental Psychology* 34:121–136.

Beckley, T. M., R. C. Stedman, S. M. Wallace, and M. Ambard. 2007. Snapshots of what matters most: using resident-employed photography to articulate attachment to place. *Society & Natural Resources* 20(10):913–929.

Bourgoin, S. 2013. Disregarded sentiments: Discovering the voices of opposition to the Mactaquac Dam. St Mary's University.

Brehm, J. M., B. W. Eisenhauer, and R. C. Stedman. 2013. Environmental concern: Examining the role of place meaning and place attachment. *Society & Natural Resources* 26(5):522–538.

Brummer, M., B. Rodríguez-Labajos, T. Thanh Nguyen, and D. Jorda-Capdevila. 2017. 'They have kidnapped our river': Dam removal conflicts in Catalonia and their relation to ecosystem services perceptions. *Water Alternatives* 10(3):744–768.

Buijs, A. E., B. J. M. Arts, B. H. M. Elands, and J. Lengkeek. 2011. Beyond environmental frames: The social representation and cultural resonance of nature in conflicts over a Dutch woodland. *Geoforum* 42(3):329–341.

Buijs, A. E., and A. Lawrence. 2013. Emotional conflicts in rational forestry: Towards a research agenda for understanding emotions in environmental conflicts. *Forest Policy and Economics* 33(September 2015):104–111.

Cheng, A. S., L. E. Kruger, and S. E. Daniels. 2003. 'Place' as an integrating concept in natural resource politics: propositions for a social science research agenda. *Society & Natural Resources* 16(2):87–104.

Davenport, M. A., and D. H. Anderson. 2005. Getting from sense of place to place-based management: An interpretive investigation of place meanings and perceptions of landscape change. *Society & Natural Resources* 18(7):625–641.

Devine-Wright, P. 2009. Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. *Journal of Community & Applied Social Psychology* 19:426–441.

Devine-Wright, P. 2011. Place attachment and public acceptance of renewable energy: A tidal energy case study. *Journal of Environmental Psychology* 31(4):336–343.

Devine-Wright, P. 2013. Explaining 'NIMBY' objections to a power line: The role of personal, place attachment and project-related factors. *Environment and Behavior* 45(6):761–781.

Devine-Wright, P., and Y. Howes. 2010. Disruption to place attachment and the protection of restorative environments: A wind energy case study. *Journal of Environmental Psychology* 30(3):271–280.

Dillon Consulting. 2015. Social Impact Comparative Review.

Doyle, M. W., E. H. Stanley, D. G. Havlick, M. J. Kaiser, G. Steinbach, W. L. Graf, G. E. Galloway, and J. A. Riggsbee. 2008. Environmental science. Aging infrastructure and ecosystem restoration. *Science* 319(5861):286–287.

ESRI. 2016. ArcGIS Desktop version 10.4. Environmental Systems Research Institute, Redlands, CA.

Farnum, J., T. Hall, and L. E. Kruger. 2005. Sense of place in natural resource recreation and tourism: An evaluation and assessment of research findings. *USDA Forest Service - General Technical Report PNW*(660):1–59.

Gould, R. K., S. C. Klain, N. M. Ardoin, T. Satterfield, U. Woodside, N. Hannahs, G. C. Daily, and K. M. Chan. 2015. A protocol for eliciting nonmaterial values through a cultural ecosystem services frame. *Conservation Biology* 29(2):575–586.

Gray, B. 2004. Strong opposition: Frame-based resistance to collaboration. *Journal of Community & Applied Social Psychology* 14:166–176.

Greider, T., and L. Garkovich. 1994. Landscapes: The social construction of nature and the environment. *Rural Sociology* 59(1):1–24.

Gunderson, K., and A. Watson. 2007. Understanding place meanings on the Bitterroot National Forest, Montana. *Society & Natural Resources* 20(8):705–721.

Hart, D. D., T. E. Johnson, K. L. Bushaw-Newton, R. J. Horwitz, A. T. Bednarek, D. F. Charles, D. a Kreeger, and D. J. Velinsky. 2002. Dam removal: Challenges and opportunities for ecological research and river restoration. *Bioscience* 52(8):669–681.

Jacquet, J., and R. Stedman. 2014. The risk of social-psychological disruption as an impact of energy development and environmental change. *Journal of Environmental Planning and Management* 57(9):1285–1304.

Johnson, S. E., and B. E. Graber. 2002. Enlisting the social sciences in decisions about dam removal. *BioScience* 52(8):731.

Jorgensen, B. S., and R. C. Stedman. 2001. Sense of place as an attitude: Lakeshore owners attitudes toward their properties. *Journal of Environmental Psychology* 21(3):233–248.

Jorgensen, B. S., and R. C. Stedman. 2006. A comparative analysis of predictors of sense of place dimensions: Attachment to, dependence on, and identification with lakeshore properties. *Journal of Environmental Management* 79:316–27.

Keilty, K., T. M. Beckley, and K. Sherren. 2016. Baselines of acceptability and generational change on the Mactaquac hydroelectric dam headpond (New Brunswick, Canada). *Geoforum* 75:234–248.

Kenny, J. L., and A. G. Secord. 2010. Engineering modernity: Hydroelectric development in New Brunswick, 1945-1970. *Acadiensis* 1(1):3–26.

Kil, N., S. Holland, and T. Stein. 2014. Place meanings and participatory planning intentions. *Society & Natural Resources* 27(5):475–491.

Klain, S. C., and K. M. A. Chan. 2012. Navigating coastal values: Participatory mapping of ecosystem services for spatial planning. *Ecological Economics* 82:104–113.

Kyle, G., K. Bricker, A. Graefe, and T. Wickham. 2004. An examination of recreationists' relationships with activities and settings. *Leisure Sciences* 26(2):123–142.

Lejon, A. G. C., B. M. Renöfält, and C. Nilsson. 2009. Conflicts associated with dam removal in Sweden. *Ecology And Society* 14(2):4.

Lewicka, M. 2011. Place attachment: How far have we come in the last 40 years? *Journal of Environmental Psychology* 31(3):207–230.

Low, S. M., and I. Altman. 1992. *Place attachment*. Springer US.

Manzo, L. C. 2003. Beyond house and haven: Toward a revisioning of emotional relationships with places. *Journal of Environmental Psychology* 23(1):47–61.

Masterson, V., R. C. Stedman, J. Enqvist, M. Tengö, M. Giusti, D. Wahl, and U. Svedin. 2016. The contribution of sense of place to social–ecological systems research: a review and research agenda. *Ecology and Society* 22(1):49.

Miles, M. B., A. M. Huberman, and J. Saldana. 2013. *Qualitative data analysis: A methods sourcebook*. 3rd Edition.

Nash, N., A. Lewis, and C. Green. 2010. 'Not in our front garden': Land use conflict, spatial meaning and the politics of naming place. *Journal of Community & Applied Social Psychology* 20:44–56.

NATIONAL and CRA. 2016. *What Was Said Final Report*. Fredericton, Canada.

New Brunswick (NB) Power. 2015. Your feedback: What we heard at our Mactaquac Project open houses. Fredericton, Canada.

NB Power. 2016. *Considering the future of Mactaquac*. Fredericton, Canada.

NB Power. 2017. Backgrounder, Mactaquac Generating Station Life Achievement Project. Business Case and Technical Considerations. Fredericton, Canada.

Patton, M. 2005. Qualitative Research. Pages 1633–1636 *in* B. S. Everitt and D. C. Howell, editors. *Encyclopedia of Statistics in Behavioral Science*. John Wiley & Sons, Ltd, Chichester, UK.

Perlaviciute, G., and L. Steg. 2014. Contextual and psychological factors shaping evaluations and acceptability of energy alternatives: Integrated review and research agenda. *Renewable and Sustainable Energy Reviews* 35:361–381.

Reilly, K. H., and J. F. Adamowski. 2017a. 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.

Reilly, K. H., and J. F. Adamowski. 2017b. Spatial and temporal scale framing of a decision on the future of the Mactaquac Dam in New Brunswick, Canada. *Ecology and Society* 22(3): 21.

Reilly, Kate H., Adamowski, Jan F., & John, Kimberly. (2018). Participatory mapping of ecosystem services to understand stakeholders' perceptions of the future of the Mactaquac Dam, Canada. Ecosystem Services, 30: 107-123.

Rickard, L., and R. C. Stedman. 2015. From ranger talks to radio stations: The role of communication in sense of place. *Journal of Leisure Research* 47(1):15–33.

Sandström, C., K. Eckerberg, and K. Raitio. 2013. Studying conflicts, proposing solutions - Towards multi-level approaches to the analyses of forest conflicts. *Forest Policy and Economics* 33:123–127.

Sherren, K., T. M. Beckley, J. R. Parkins, R. C. Stedman, K. Keilty, and I. Morin. 2016. Learning (or living) to love the landscapes of hydroelectricity in Canada: Eliciting local perspectives on the Mactaquac Dam via headpond boat tours. *Energy Research & Social Science* 14:102–110.

Si, Z. 1993. A theoretical framework for social impact analysis with special reference to population relocation at the Mactaquac Dam project on the Saint John River. Dalhousie University.

Sidaway, J. 2005. Resolving Environmental Disputes: From Conflict to Consensus. Earthscan.

Smaldone, D., C. Harris, and N. Sanyal. 2008. The role of time in developing place meanings. *Journal of Leisure Research* 40(4):479–504.

Smith, J. W., M. A. Davenport, D. H. Anderson, and J. E. Leahy. 2011. Place meanings and desired management outcomes. *Landscape and Urban Planning* 101(4):359–370.

Stanley, E. H. H., and M. W. Doyle. 2003. The ecological effects of dam removal. *Frontiers in Ecology and the Environment* 1(1):15–22.

Stantec. 2015. Mactaquac Project Comparative Environmental Review Report.

Stedman, R. 2016. Subjectivity and social-ecological systems: a rigidity trap (and sense of place as a way out). *Sustainability Science* 11(6):891–901.

Stedman, R. C. 2002. Toward a social psychology of place: Predicting behavior from place-based cognitions, attitude, and identity. *Environment and Behavior* 34(5):561–581.

Stedman, R. C. 2003. Is it really just a social construction?: The contribution of the physical environment to sense of place. *Society & Natural Resources* 16(8):671–685.

Stedman, R. C. 2008. What do we 'mean' by place meanings? Implications of place meanings for managers and practitioners. Pages 61–82 *in* L. E. Kruger, T. E. Hall, and M. C. Stiefel,

editors. *Understanding Concepts Of Place In Recreation Research And Management*. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Stedman, R. C., T. Beckley, S. Wallace, and M. Ambard. 2004. A picture and 1000 words: Using resident-employed photography to understand attachment to high amenity places. *Journal of Leisure Research* 36(4):580–606.

Stokowski, P. A. 2002. Languages of place and discourses of power: Constructing new senses of place. *Journal of Leisure Research* 34(4):368–382.

Strauss, A., and J. Corbin. 1998. Basics of Qualitative Research Techniques and Procedures for Developing Grounded Theory. 2nd edition. SAGE Publications, London.

Tonitto, C., and S. J. Riha. 2016. Planning and implementing small dam removals: Lessons learned from dam removals across the eastern United States. *Sustainable Water Resources Management* 2:489–507.

Tuan, Y. F. 1977. *Space and Place: The perspective of Experience*. University of Minnesota Press, Minneapolis.

Urquhart, J., and T. Acott. 2014. A sense of place in cultural ecosystem services: The case of Cornish fishing communities. *Society & Natural Resources* 27(1):3–19.

Vorkinn, M., and H. Riese. 2001. Environmental concern in a local context: The significance of place attachment. *Environment and Behavior* 33(2):249–263.

Wester-Herber, M. 2004. Underlying concerns in land-use conflicts — the role of place-identity in risk perception. *Environmental Science & Policy* 7:109–116.

Wheeler, M. J., A. J. Sinclair, P. Fitzpatrick, A. P. Diduck, and I. J. Davidson-Hunt. 2016. Place-based inquiry's potential for encouraging public participation: Stories from the common ground land in Kenora, Ontario. *Society and Natural Resources* 29(10):1230–1245.

Williams, D. R. 2008. Chapter 2 — Pluralities of place: A user's guide to place concepts, theories, and philosophies in natural resource management. Pages 7–30 *in* L. E. Kruger, T. Hall, and M. Stiefel, editors. *Understanding concepts of place in recreation research and management, PNW-GTR-744*. USDA Forest Service, Pacific Northwest Research Station.

Williams, D. R., and M. E. Patterson. 1996. Environmental meaning and ecosystem management: Perspectives from environmental psychology and human geography. *Society & Natural Resources* 9(5):507–521.

Williams, D. R., and M. E. Patterson. 1999. Environmental psychology: Mapping landscape meanings for ecosystem management. Pages 141–160 *in* H. K. Cordell and J. C. Bergstrom, editors. *Integrating Social Sciences and Ecosystem Management*. Sagamore Press, Champaign, Illinois.

Wondolleck, J. M., B. Gray, and T. Bryan. 2003. Us versus them: How identities and characterizations influence conflict. *Environmental Practice* 5(3):207–214.

Yung, L., W. A. Freimund, and J. M. Belsky. 2003. The politics of place: Understanding meaning, common ground, and political differnce on the Rocky Mountain Front. *Forest Science* 49(6):855.

APPENDIX 6.1

Interview protocol

The purpose of the study was explained to participants, along with confidentiality procedures, and consent was requested.

Section 1: General questions

For new participants:

- Are you aware of the process to decide what should happen to the Mactaquac Dam when it reaches the end of its life? (Show pictures of the three options if necessary.)
- What do you think should happen to it?
- What are your reasons for that?
- How do you think removing the dam would affect you?
- And rebuilding it?
- Have you read any of the information that New Brunswick Power has published about the decision on the dam?
- Have you participated in any of the consultation activities they've been doing, like the meetings, the online comments, etc.?

For returning participants:

- Have you read any of the information that NB Power has published about the decision on the dam?
- Have you participated in any of the consultation activities they've been doing, like the meetings, the online comments, etc.?
- I'm going to ask you the same question again that I asked you last time: what do you think should happen to the dam?
- What are your reasons for that?

Section 2: Ecosystem services and place meanings

Personal – general

- Now we're going to think about how you use places around the river in your personal life.
- What are the places that you use most or that are particularly important to you on the map? Think about all the seasons as well, not just where you use in summer.

- Can you tell me what you do at place number [x]? And what is it about that place that you like? What's important about it? Are there any other reasons that you go to that place in particular? How often do you go there?
- Now we're going to go through some more specific questions to see if there are any other places you'd like to add. It's ok if some of these questions make you think of places you've already drawn, just point out the number to me. It's also fine if as we're going through the questions you think of a place that answers a previous question – just draw it and then we'll talk about it.

Personal – recreation, relaxation and wellbeing

- Are there any other activities that you do or experiences that you have around the river that we've missed?
- What is it about [doing activity/having that experiences] in those particular places that you like? What's important about those places? Are there any other reasons that you go to that place in particular? How often do you go there?

Personal – non-use values

- Now I'd like you to think about any other places that you think are important but not because of anything that you directly or personally you get from them (Gould et al., 2015).
- Why are those places important?

Personal – identity and social and community connections

- Now if we think about a person's identity, it comes from their relationships, ideas, sense of belonging, and all these shape who they are (Gould et al., 2015; Klain and Chan, 2012).
- Are there any places that are important for your sense of identity? How would you describe the link between that place and your identity (Gould et al., 2015; Klain and Chan, 2012)?

Personal – heritage and memories

- Are there places that remind of you of things that happened in the past that were important for you or for your community (Gould et al., 2015; Klain and Chan, 2012)?

Personal – intergenerational/bequest

- Are there any places or experiences in and around the river that you hope that your kids or the kids around here will experience in the future (Gould et al., 2015; Klain and Chan, 2012)?
- What is it about those places that you hope they will experience?

Personal – provisioning

- I'd like you to think about if you get any physical things, like resources, food or materials from in and around the river in your work or personal life. I mean here things that you're involved in getting for yourself. Your water supply wouldn't count unless you personally are involved in collecting water.
- If you haven't already, can you draw any of the places that you get those things from? What do you get at each place? How often do you go there to get those things?
- Is it important to you to be able to get those things yourself? How?

Personal – movement

- Do you use the river to get around? Where do you go? Can you describe the difference between using the river for that and using a different way to get around, like by car? How often do you do that?

Regulating – flood control and water quality

- Are there places that you think are important for your environment more generally, like for maintaining water quality, flood control, and soil fertility?

APPENDIX 6.2

Codebook for intangible meanings

Code/dimension	Category	Example
Attachment to water	Personal identity	'As a little boy I was very close to the river, and for some reason it just kind of gets embedded in you.'
Belonging	Personal identity	'When I first came in sight of the St John up around Hartland, just all of a sudden I felt, I felt where I belonged again'
Celebrations	Community identity	'What happens is when the ice breaks and comes down and jams, and then there's just this crunching and moving, and it can get really loud. I mean, it's really amazing. And so there's sort of a community ceremony, sort of community ritual'
Childhood memories	Personal identity	'Growing up we canoed, kayaked, motorboated. Just, that was, we'd play on the water, it was part of the backyard'
Community Connection/ Reduced Isolation	Community identity	'It's recreational yes, but it's also a main throughfare to get to, community to community is right, so you're not isolated in this area'
Community History	Community identity	'The [name] was put together by a number of people who are interested in seeing Kings Landing continue and flourish for generations to come. Because the older it is, the more important it is for people to look back on.'
Community Relationships	Community identity	'Used to be I knew everybody from here to Fredericton. 25 miles that way. And to Woodstock, which is 30 miles that way. Because they were all farmers.'
Cultural activity	Community identity	'Fiddleheads is something that you know, we New Brunswickers we harvest them. A lot of places don't, even where they grow, I don't think they even harvest them'
Didn't grow up here	Personal identity	'I never lived there in the past. Yeah. We're transplants. So I have no connection to what the river used to be'
Familiarity	Personal identity	'You know, there's a magic about that river and knowing where to fish and knowing where the rocks are'
Family ancestry	Community identity	'We migrated and came up the Saint John River valley. And the King of England promised us land, and we got land. So here we are. We're still here'
Family relationships	Community identity	'At Thanksgiving we always go picking apples with the kids who are now thirty-something. My daughter's coming back for thanksgiving this year, so we'll pick apples. And there's apples at a beautiful place.'

Code/dimension	Category	Example
First nature experiences	Personal identity	‘There are kids like my nephews, my great nephews, the one who was here Saturday and the others who’ve been here before, who would never get out on this river in a boat with our marina gone.'
Fishery history	Community identity	‘We’ve lost the salmon population in the river. And that’s directly because of two dams, not just Mactaquac but, you know. Or three dams. Yeah. so I think we need to do more to protect the fishery and the history of the river.'
Friend relationships	Community identity	‘It’s a social gathering. It’s a protected creek and I think that if, on a weekend there’s all kinds of boats in there'
Fulfilment	Personal identity	‘For me, I get more of my energy and fulfilment from being around things in nature'
Grew up here	Personal identity	‘I grew up right along the Mactaquac headpond. I was born in 1961, the dam was built in 1967. I stuck my feet in it every summer, and it’s just part of my lifestyle'
Had to leave for work	Personal identity	‘I would go away and work places but I’d come back.'
Home	Personal identity	‘I missed the river. I used to sit and try to think why I felt so homesick. I missed my folks but I missed the river'
Houses on river	Personal identity	‘I know a lot of people who live up here and I would certainly sympathise with them. It’s a tough decision. You know, when you build up in a place like that, That’s the risk you take.'
I'm part of a bigger system	personal identity	‘That stream goes over the falls and goes right down to this pond of water and out into the river. And away to the sea. And I like the, I don’t know, there’s something about the continuity of that thought that I like.'
Industry legacies	Community identity	‘They cut them all down. Or most of them. The only ones left are not on crown land. Out through this Pokiok country, they devastated it.'
Intimacy with river	Personal identity	‘You lose the islands and you lose the intimacy of the smaller river, the smaller body of water, the current kind of pushing you along'
Joy	Personal identity	‘It’s the coldest, bleakest day of winter, and then I see a little chickadee or a troop of chickadees, and they’re so energetic and they’re happy to be out and it’s -40 and they don’t care. And you know I’m shivering away and then, it just makes me feel better about myself and better to be part of the world because there are other things that are there that seem to invoke a sense of joy'

Code/dimension	Category	Example
Learning	Community identity	‘We take our grandsons there when we can, for the simple fact that they can go there and they can touch an animal and they can. And if we can keep them quiet enough, you know they can watch people make butter. They can see how people dressed. They can see that people, there’s a piece of history that they can visualise that you can’t get from your history teacher'
Leave things for kids	Community identity	‘…but what we’re hoping is that our grandsons will go there sometime when they get older and have that as a camping spot or whatever'
Life's work	Personal identity	‘My husband said that when I die he’s going to have me cremated and sprinkle the ashes at [name]. Because I’ve never left it since I was 19!'
Maintains community	Community identity	‘All that area’s been settled by a lot of people that have worked and do work at Mactaquac Dam. So, so, you’d be losing, you’d be destroying quite a community.'
Maliseet culture	Community identity	‘Which marks the Meductic Fort, which was, which was a settlement of the Maliseet people of great historic and prehistoric significance.'
Maliseet sacred lands	Community identity	‘Hawk Island up here, 5B where we fiddlehead, that was the meeting place of all the Maliseets that were, you know, all the tribes that were, you know, covered the Acadia area. That’s where they met in the summertime. And everybody was allotted their, you know, the areas that each tribe is going to hunt'
Memories as adults	Personal identity	‘Every place where I have encountered something interesting in nature, I recall. So when I go back to that place, I think, oh ten years ago or 20 years ago, I saw such and such here and I wonder if I’ll ever see it again. So, I can’t go anywhere without getting that kind of memory evoked.'
My land	Personal identity	‘When the dam came up the government bought all of the rest of the farm. But there was a small parcel there that they didn’t take. And a lot of what they did take was sold back to people other than ourselves. But that’s important because we own a small piece of the old farm.’
My spot	Personal identity	‘And so many things that I value, more than any other place on the planet, happened for me right in this area, of course. So this stream, and that pond, and the falls. Very important to me'
Nature as community heritage	Community identity	‘If there’s a sense of a need to conserve anything within a particular community I think it’s going to often be the perhaps the most significant or important natural feature within that community'

Code/dimension	Category	Example
Neighbour relationships	Community identity	‘I live on a street with 15 houses, or 12 houses and 18 kids under five. So there’s lots of good neighbours and things like that. So it’s interesting.'
No identity because not indigenous	Personal identity	‘If I understand the question no. I’m not a native or anything'
No identity with headpond	Personal identity	‘The dam’s obviously a reference point as you’re travelling along the TransCanada highway. But as far as would I send somebody to go see this or go see that, something that I would identify with, nope.'
Nostalgia	Personal identity	‘This would be my mother-in-law’s farm. At number 4. And that has a lot of, if you want to…sentimental, nostalgic value to my wife and to our children as well.'
Notable/selling point	Community identity	‘When I travel, to find a place that is as nice as our walking trail, and to be able to take advantage of it, I would have thought “oh my gosh, I found a treasure here!”’
Part of life	Personal identity	‘The river runs through me. It, I don’t know. My life’s just tied to it'
Part of me	Personal identity	‘As a little boy I was very close to the river, and for some reason it just kind of gets embedded in you'
Partner relationship	Personal identity	‘I didn’t learn to fish until I met my husband. And now I love it.'
Peaceful	Personal identity	‘When I’m out in my boat by myself, especially by myself, I find it’s like therapy. I just get so excited and when I get out there it’s like this sense of relief. And I don’t know I just love the peacefulness.'
Personal accomplishment	Personal identity	‘There’s a little plant called the prototype quillwort, which was a species I helped describe as new to science about 15 years ago.’
Proud of what we've done here	Community identity	‘I don’t want people from other areas coming here and sort of justifiably criticising us for things we’ve done. I like to be proud it. So you know whatever we do here, I hope I can be proud of that'
Relaxed	Personal identity	‘It’s a stress reliever right there. When you run three businesses, it’s… it’s nice. Talk about something else, have some thoughts of your own.'
Remember what it was like	Personal identity	‘Keep in mind that those that have been around post dam, particularly those that front the river and look at it, who can’t remember the beauty of a free-flowing river you know may have their own commitment to the current status quo'
Retain connection to previous generations	Community identity	‘I come from an old farm family that’s farm was over in Devon there, the old farm. And I, I never worked on that farm. My, my ancestors come from there, and they used

Code/dimension	Category	Example
		to, they used to actually graze their cattle down there in the summertime'
River culture	Community identity	'It seems to me that the river itself has a certain aspect that arguably there would be no New Brunswick without the St John River.'
River history	Community identity	'We are of a different time, a different generation, and a different product. But this river's been here forever. Long, long time. Nope. And who the hell are we to mess it up'
Show visitors	Community identity	'I just recently took a new family to Canada down to the campground and the girls went ballistic over the beach, you know. And being able to run in the water'
Socialising with strangers	Community identity	'There's a total social network. When you're, when you're out there in a boat you're meeting totally different people in the community.'
Source of art	Personal identity	'And, and so a lot of my [art] has been about water and rivers.'
Stands out/unique	Community identity	'So you can walk right from that convention centre and right there, mark that number 4, you can catch any one of ten species of fish and you can take those fish home, back to the convention centre and have them cook them and eat them for dinner. And that's a very special, that's a different kind of city'
Taken for granted	Community identity	'They're undervalued by people who take them for granted because people live here all the time.'
What I know	Personal identity	'I came here to this country in 83 and it was built in 64 or something. So, like I don't know any different'
What it means to be from here	Personal identity	'I think the river basically from the dam down has been, is what I really associate and really relate to as far as being from, Fredericton is and what it means to be, you know, situated on this beautiful river.'
Why we live here	Personal identity	'I always wanted to live here. I guess I've always enjoyed nature and being at the woods or being at the water'
Will travel to be here	Personal identity	'My family's chosen to work out west and make the money, but make their house and life in the Mactaquac area'
Wonder	Personal identity	What I'd really love to see is that each child have the opportunity to experience something in this river valley that shapes their life forever. And that they never forget that.'

7. SUMMARY AND CONCLUSIONS

In this thesis, research into the role of social demand for ecosystem services in a conflict over a possible dam removal was presented. As large dams built in the mid-20th century in North America continue to age, decision makers will increasingly have to navigate the complex context of energy demand, increasing concern about ecological impacts of dams, climate change, and demand for ecosystem services to decide on their future. For some such dams, the balance of negative to positive impacts may be such that removal is considered a viable option. When potential dam removal creates differential impacts for stakeholders, conflicts are likely to arise. Understanding the roots of such conflicts, particularly in how the resulting hydrological and ecological changes affect people, will be crucial for effective and equitable decision making, and for conflict resolution. The concept of ecosystem services provides a useful method of linking biophysical changes to the differences in stakeholders' interests, values, and perceptions that may contribute to conflict.

The overall aims of this research, therefore, were to:

1. Identify and analyse the social demand for ecosystem services in and around a dammed river environment.
2. Analyse the extent to which social demand for ecosystem services underlies stakeholder conflict and identify how the concept of ecosystem services can be used for its resolution.

To assess how social demand for ecosystem services could contribute to conflict around a potential dam removal, a conceptual framework (Figure 2.1) was developed, based on literature on dam removals, ecosystem services, and conflict around water resources, biodiversity and the environment in general. The assessment of social demand for ecosystem services, elicited through interviews and participatory mapping, allowed an understanding of stakeholders' interests in and around a dammed river that could potentially be affected by removal of the dam. Frame theory, meaning how people perceive an external event based on their prior knowledge and experiences, allowed identification of stakeholders' perceptions of the impacts of dam removal and how they varied with ecosystem service benefits. In particular, scale frames, meaning how stakeholders perceived the boundaries of a problem in space and time, were analysed. This revealed the strategic implications of framing, in terms of how arguments and stakeholders were legitimised and delegitimised in decision making. Lastly, emotions were

brought into the analysis through the literature on place meanings, specifically how they can affect whether a project, such as dam removal, is supported or opposed.

Being an exploratory study, the conceptual framework was applied and refined in a single case, the Mactaquac Dam on the Saint John River, New Brunswick, Canada. The Mactaquac Dam is something of an extreme case (Gerring 2004), being the largest dam ever considered for removal, which would create the greatest change to the river environment of the dams removed to date. It might be expected, therefore, that the potential removal of the dam would generate stakeholder conflict or opposition beyond the magnitude of that which has occurred in conflicts around smaller dams. However, the little research done to date on conflicts around dam removals focuses on small dams with much less biophysical change anticipated, although these can also generate intense opposition (Lejon et al. 2009, Jorgensen and Renofalt 2012, Fox et al. 2016). The single case in this research allowed the dynamics of conflict around a potential dam removal to be explored in more detail than would have been possible in a multi-case study (Gerring 2004). This was especially important in the context of large dam removals, which are still rare, and for which social responses are not yet well understood.

The concepts of stakeholders' issue frames, scale frames and place meanings have not, to date, been studied in the context of dam removals, while only a small number of studies in other regions have assessed social demand for ecosystem services in dammed river environments (Darvill and Lindo 2014, Brummer et al. 2017). Therefore, because little is known about how social demand for ecosystem services, frames and place meanings could be of relevance to decision making about a dam, a qualitative research approach using interviews and interview-based participatory mapping was used. This allowed an in-depth exploration of stakeholders' opinions and experiences in relation to the conflict, as well as of the context in which it occurred. A combined inductive-deductive approach to analysis of the qualitative data allowed all locally-important ecosystem services to be captured, for variations in demand within a given category of service to be identified, and for nuances in frames and sense of place to be incorporated.

To enable such an in-depth investigation, the research focused on a small sample of stakeholders selected using non-proportional quota sampling to attempt to represent the widest possible range of experiences and perceptions. In total, 50 participants were interviewed across two phases of data collection, with 12 of those participating in both. They were located throughout the affected reach of the river – in all major towns, around the reservoir,

downstream of the dam, and on several major tributaries. They represented a range of interest groups, with many individuals holding multiple interests in the area, including residents, environmental groups, watershed groups, municipalities, heritage organisations, small businesses, students and researchers. The two notable groups not included were First Nations representatives and community members and industry. Both were invited to participate in the first phase of data collection, but declined and did not respond, respectively. Discussions were held with the decision maker, New Brunswick Power, but they were not formally interviewed.

The conceptual framework and data collected were analysed to address several specific objectives to explore the two main components of the overall aims of the research – social demand for ecosystem services and stakeholder conflicts:

1. Social demand for ecosystem services in and around a dammed river environment
    a) To identify the range of ecosystem services from which stakeholders benefit in and around the dammed river, and how they vary between stakeholders.
    b) To identify spatial patterns in the distribution of the ecosystem services that are socially demanded, particularly in relation to the location of the dam, and how it varies between stakeholders.
    c) To determine if stakeholders are able to map the spatial distribution of the ecosystem services from which they benefit.
    d) To determine if stakeholders can map the spatial distribution of ecosystem services that they anticipate benefitting from under various future scenarios and to identify stakeholders' perceptions of the causal mechanisms for a change in the spatial distribution of ecosystem services under different scenarios.
2. Sources of stakeholder conflict around a potential dam removal
    a) To explore the divergence in opinions on the future of the dam between stakeholders with different interests and locations in relation to the dam.
    b) To explore the variation between stakeholder groups in how the problem at the centre of the conflict is framed, and how those frames relate to social demand for ecosystem services, in order to investigate the role of diverging experiences and interests in the conflict.
    c) To develop a conceptual framework for analysing how the problem at the centre of the conflict is framed using spatial and temporal scales, and how these scale frames match and mismatch between stakeholders.

d) To assess the role of scale framing in exacerbating the conflict around the future of the dam.
e) To identify the place meanings in and around the dammed river and how they relate to the biophysical environment that is affected by the dam.
f) To explore the role of place meanings, and therefore, emotion in the conflict around the dam.

Underlying the research design was the assumption that ecosystem services were locally important and that social demand for ecosystem services was linked, positively or negatively, to the existence of the dam. This assumption was tested in chapters 3 and 4 through an inductive analysis and participatory mapping of the extent to which local stakeholders benefitted from ecosystem services in the dammed river environment (objective 1(a)). This assessment created a foundation for the research by highlighting the ways in which stakeholders benefitted from the ecological processes and functions that may be affected if the dam were removed.

Given that the impacts created by dam removal would vary spatially, it was important to understand where stakeholders currently benefitted from ecosystem services and how they perceived that the spatial distribution of services might change. Interview-based participatory mapping of current social demand for ecosystem services was conducted to understand the spatial distribution of services with the dam in place, which was considered to be largely similar to if the dam were rebuilt, and how that differed between stakeholder groups (chapter 3; objective 1(b) and (c)). Participants were subsequently asked to map how they expected the spatial distribution of their demand for services to change if the dam were removed (chapter 3; objective 1(d)). While many participants had difficulty mapping specific changes to ecosystem services, the interviews uncovered their perceptions of the impacts of the various options for the dam on their lives, wellbeing, and important places. The data produced was analysed inductively to ascertain the assumptions people made in considering those impacts, in terms of the biophysical changes to the river that would be caused by removing the dam (chapter 3; objective 1(d)).

How participants benefitted from ecosystem services in and around the dammed river was subsequently linked to how they framed the potential dam removal in terms of whether it was a loss or gain and their preferences for the dam's future (chapter 4; objectives 2(a) and (b)). It showed the potential for divergences in ecosystem services demand to be exacerbated by how the decision is framed, with people being less willing to experience a loss than forego a gain.

This analysis was extended to identify how stakeholders framed the problems and solutions involved in the decision-making process in terms of scale (chapter 5; objectives 2(c) and (d)). The scale frame analysis showed the implications of scale frames for legitimising arguments and stakeholders, and highlighted how they can be used strategically to argue for a particular option.

Lastly, the role of emotion in conflicts over dam removals was incorporated through the concept of place meanings (chapter 6; objectives 2(e) and (f)), focusing on intangible meanings, since the tangible, experiential, economic and ecological meanings were already assessed through the ecosystem services framework. The intangible place meanings were categorised into personal identity and community identity and used to show the importance of emotional connections to place that build up over time and are anticipated into the future.

Overall, then, the social demand for ecosystem services in the case study area was strong, with a range of services demanded across all four categories of services of the Millennium Ecosystem Assessment (MA, 2005). Although similar services were demanded between the two groups, those who preferred to retain the dam and those who preferred to remove it differed in how particular services were used. There were also clear differences in the spatial distribution of those services, with retainers primarily demanding services around the dam's headpond, and removers using services downstream of the dam and on its tributaries. These differences in ecosystem service demand resulted in different positions on what should be done with the dam through two major routes, namely through changes to stakeholders' interests, reinforced through how those changes are framed, and through disruptions or enhancements of emotional connections to locations in the affected area.

The following sections outline the conclusions drawn from the four manuscripts presented in this thesis in relation to the specific objectives.

7.1. Conclusions: Social demand for ecosystem services and its variation between stakeholders (chapters 3 and 4; objective 1(a))

The analysis of social demand for ecosystem services and how it differed between stakeholder groups formed the foundation of the remainder of the research. Interview-based methods were used to elicit how stakeholders benefitted from services in, near or around the river. The first period of data collection used semi-structured interviews, which included an open-ended question on how stakeholders used the river in their personal and professional lives. The second period, a year later, used a structured set of plain language prompts to elicit ecosystem services

as part of a participatory mapping exercise to analyse the spatial distribution of ecosystem services demand. The purpose of using these two methods was not to compare the social values uncovered, but to reveal the full range of services, enhanced by their spatial distribution as identified using participatory mapping (Santos-Martín et al. 2016).

For each phase of data collection, a sample of stakeholders was selected using non-proportional quota sampling. Thirty stakeholders participated in the first phase and 32 in the second, of whom 12 participated in both phases. They represented a range of interests, including anglers, headpond residents, downstream residents, businesses, environmental non-governmental organisations (NGOs), watershed organisations, heritage groups, and recreational groups, and were located both up and downstream of the dam.

The participating stakeholders benefitted from a wide range of ecosystem services across all categories in and around the river reach affected by the dam. There were few notable differences in the types of ecosystem services recognised by the two groups of participants – the retainers and the removers – as elicited by the interviews. However, bequest value, food provision and water filtration were only mentioned by removers, while disease regulation and wildlife watching were only mentioned by retainers. In the participatory mapping elicitation, hunting, motorised boating, sailing and transportation were not mentioned by removers, and hydropower and several regulating services were not mentioned by retainers.

The more notable differences between the groups, the retainers and the removers, were in how they benefitted from the same service. For example, fishing was popular with both groups, but retainers preferred to fish for species such as smallmouth bass and muskellunge from a boat, while removers preferred to fish for salmon and trout from shore. These two activities have very different biophysical requirements, with the former requiring water deep enough to be navigable and the latter requiring the fast-flowing streams that provide habitat for such species and an accessible shoreline.

Based on the findings of this study, the following conclusions can be identified:

- The differences between the two methods in terms of ecosystem services identified is likely to be due to the different prompts used and the different biases of the methods (Santos-Martín et al. 2016). In particular, the more targeted prompts used in the interviews for the participatory mapping exercise more consistently identified a wider range of services, while the open-ended interview question allowed stakeholders to

focus on the services most important for them. A combination of complementary methods therefore reveals a fuller picture of ecosystem services demand than one alone.

- Some ecosystem service interests, including concern for ecosystem protection, were shared by both groups involved in the conflict, possibly representing common ground that could be the basis of conflict resolution.
- Within a given type of ecosystem service, such as recreational fishing, there can be wide variations in how it is accessed and benefitted from. Therefore, in decisions that would affect such services, it is prudent to understand the range of ways in which they are used and how those uses would be affected.
- The wide range of cultural services demanded in this case, which do not necessarily have a monetary value, reinforces the need for non-monetary methods of ecosystem services valuation, alongside traditional economic and biophysical assessments.

7.2. Conclusions: The spatial distribution of ecosystem services under different scenarios (chapter 3; objectives 1(b), (c) and (d))

A methodology for eliciting the spatial distribution of current ecosystem service benefits was adapted from that used in similar studies, based on inductive identification of ecosystem services identified during a semi-structured interview combined with participatory mapping. The methodology was extended to assess the extent to which it was possible to map perceptions of future distribution of ecosystem services under various scenarios, notably dam removal. A sample of stakeholders to conduct the participatory mapping was selected using non-proportional quota sampling, including representatives of a wide range of interests located throughout the dammed river reach.

The stakeholder-produced maps were digitised and analysed using the Getis-Ord Gi* statistic to identify significant hotspots of current ecosystem service benefits. Perceptions of the consequences of hydrological and ecological change under the dam removal scenario were identified using causation coding of the interview transcripts. Hotspots were located at several locations in the reservoir and downstream of the dam. Those who preferred to retain the dam primarily mapped services around the reservoir, whereas those who preferred to remove it mostly mapped places on unaffected tributaries and downstream of the dam. Changes to ecosystem service provision if the dam were removed were perceived to be caused by removal of the dam as a barrier, the lower water level in the current headpond and the faster streamflow in the same reach.

Based on the findings of this study, the following conclusions can be identified:

- Participatory mapping of ecosystem services using an interview-based approach is appropriate for capturing the full range of services demanded and for identifying nuances in benefits from the same category of service. It also allowed ecosystem services that could not be mapped, including those that were not linked to specific places or those for which the location was not known, to be identified during the interview.
- Stakeholders demanded services in all categories of the MA (2005), although cultural services were most commonly mapped. Stakeholders who preferred to retain the dam mostly mapped places around the headpond, while those who wanted to remove it mostly mapped places downstream of the dam and on unaffected tributaries.
- Participants were able to describe their perceptions of ecosystem services under future scenarios, including dam removal, but were not able to map them. Therefore, participatory mapping can be a useful prompt to discuss those perceptions but is unlikely to produce useful maps of future scenarios.
- When considering diverging interests of relevance to dam removals, their spatial location should also be taken into account. Differential impacts on services demanded can be exacerbated by differential impacts on the locations in which those services are demanded.
- Mitigation measures for loss of ecosystem service provision should include facilitating access to remaining areas, such as for boating, and restoring the character of locations that are currently valued. These measures should be focused on hotspots to provide the greatest benefit, but locations that were not mapped should not be neglected, as this would risk disrupting service provision elsewhere.

7.3. Conclusions: Stakeholders' frames of ecosystem services and potential dam removal (chapter 4; objectives 2(a) and (b))

This study linked a qualitative assessment of the ecosystem services from which stakeholders benefitted to how they perceived the decision on the future of the dam. A sample of 30 stakeholders, selected using non-proportional quota sampling, participated in this component of the research, which was based on interviews.

The semi-structured interviews consisted of questions on how they used and benefitted from the river as individuals and/or as representatives of their organisations, as well as what they

wanted to happen to the dam and how they perceived each option would affect them. The transcribed interviews were inductively coded in an iterative process of coding, entering codes into a codebook, comparing within and between codes, and recoding. The interview data was triangulated with data from documents, including blog posts and editorials, that were coded in the same way. Participants' frames were developed from the coded data by creating a table of their perceptions of the problems and solutions inherent in the decision and clustering participants with similar views.

The two groups framed the decision differently, with retainers arguing for preservation of social and economic stability and a desire to avoid disturbance of the current ecosystem. Removers instead saw the decision as an opportunity to improve the current situation, while those who were neutral were waiting for more information before making their decision. Those who perceived dam removal as a loss were more strongly attached to their positions.

Based on the findings of this study, the following conclusions can be identified:

- In benefitting from ecosystem services, people interact with the ecosystem affected by a decision. Those interactions are then a source of the knowledge and experiences that inform frames of the decision and attitudes towards it.
- Frames of the decision on dam removal reflect the loss aversion tenet of prospect theory, namely that people are less willing to experience a loss than to give up a potential gain. Therefore, those who perceive dam removal as a loss are more likely to hold their position more strongly.
- Analysis of frames reveals both biases that can be corrected with improved information from the decision maker, and areas of convergence between groups in conflict that can inform conflict resolution.

7.4. Conclusions: Spatial and temporal scale framing of potential dam removal (chapter 5; objectives 2(c) and (d))

The aim of this study was to develop a conceptual framework for assessing stakeholders' scale frames and their implications for decision making and conflict, and to apply it to empirical data on stakeholders' frames of the decision on the Mactaquac Dam. The conceptual framework was developed from the literature on frames of environmental conflicts and the politics of scale. It differentiated frames of the problems and the solutions involved in the decision, since they are likely to be treated differently in terms of scale framing. Scale framing strategies were identified from the literature on politics of scale, which involved manipulation of scale frames,

whether conscious or unconscious, to achieve certain political ends. Strategies included upscaling, downscaling, rescaling, scale coupling, projecting into the future and emphasising levels. The outcomes of those strategies in terms of how arguments and stakeholders were legitimised or delegitimised in the debate were also identified.

The conceptual framework was used as the basis for a hybrid deductive-inductive analysis of the transcribed data from semi-structured interviews with a sample of 30 stakeholders, selected using non-proportional quota sampling. The interviews involved discussion of how the stakeholders benefitted from the river, what their preferred option for the dam was, and how they thought the various options would affect them. To code the data, a codebook was developed of the problem and solution frames and the scales used, as derived from the conceptual framework. The codebook was then refined as the data was coded. The finalised coded data was entered into a comparative table of how the problems and solutions were framed using scales, from which the scale framing strategies were identified.

The stakeholders identified different problems and solutions in the decision according to their position, as would be expected. For example, those who wanted to retain the dam viewed dam removal as a problem, whereas those who wanted to remove it viewed the dam itself as the problem. What was more interesting, however, was how the problems were scale framed to strengthen their argument. The retainers scaled up the problems associated with dam removal from the property level to the headpond and province, while the removers scaled up problems caused by the dam to the river. The two groups also diverged in how they framed problems on the temporal scale. The retainers framed the period since the dam's construction as a stable state that should be sustained in the future, while the removers framed the period before the dam was constructed as the ideal state that should be returned to.

These scale frame mismatches can prevent a shared understanding of the situation from being reached between groups and can obscure the interests and needs at stake. Which levels on spatial and temporal scales are used to frame the problem includes and excludes certain arguments, and dismisses some stakeholders as being irrelevant to the decision making. For example, in upscaling property level problems to the headpond level, retainers assumed those problems would be shared throughout the headpond area and that others were not relevant to the decision. Stakeholders also attempted to frame the problem such that it matched the level at which the solution could be found, to enhance legitimacy of their interpretation.

Based on the findings of this study, the following conclusions can be identified:

- The conceptual framework developed in this study, which included sub-types of issue frames, scales, and scale framing strategies, allowed a systematic identification of scale frames and their consequences. In particular, the differentiation of the problem and solution sub-types allowed matches and mismatches between stakeholders to be easily identified by comparing like to like.
- The importance of temporal scale frames, in addition to the spatial scale frames usually studied, was affirmed. Interpretation of the past was identified from the data collected in this study as a scale framing strategy that had not been previously identified in the literature. Interpretation of the relevance of the past to decision making in the future allows some solutions to be seen as desirable and others as unjust.
- The scale frames had political functions, in that they included or excluded certain arguments from being valid in the decision-making process and deemed certain groups of people as relevant or irrelevant to the decision. This process has the potential to further reinforce differences between stakeholders beyond those that arise from non-scalar framing of issues.
- The scale frames used by the two stakeholder groups included several mismatches, including which levels on the temporal scale were considered relevant to the decision, and the use of upscaling to the provincial level by retainers and to the river level by removers.
- Decision makers should keep potential scale frame mismatches in mind to avoid appearing to prioritise some issues or groups of people in their scoping of impact assessments or stakeholder consultations.

7.5. Conclusions: The role of place meanings in opposition to potential dam removal (chapter 6; objectives 2(e) and (f))

This study focused on the emotional dimensions of environmental conflict through the lens of sense of place. Specifically, it aimed to identify the range of intangible place meanings that participants attributed to locations in and around the dammed river environment and how they varied between people based on their preferences for the future of the dam. The relationships between meanings and the biophysical conditions of those locations and how they might be changed if the dam were removed were also assessed.

To account for the role of the varying intangible place meanings and their biophysical underpinnings in the wider conflict, a conceptual framework was developed from the literature on place meanings and place-protective behaviour. This framework suggested that intangible

place meanings, tangible place meanings (chapters 3 and 4), place attachment, and perceptions of the impacts of infrastructure projects (chapter 4), such as dam removal, combine to affect whether a person accepts or opposes the project. The basis for this framework was a model that suggests that place meanings mediate the relationship between place attachment and project acceptance.

Intangible place meanings were identified from a qualitative inductive analysis of data from interviews with 32 participants. The interviews were semi-structured. Participants were asked which places in and around the river were important to them and why through a series of plain language prompts for cultural ecosystem services. This approach allowed participants to reflect on the range of ways in which their local environment was important to them, while also enabling them to add their own perspectives in response to open questions about how the river was important to them.

Several intangible place meanings that contributed to participants' community and personal identities were identified from this inductive analysis. The main themes emerged as community distinctiveness, continuity over time, both in the past and in the future, belonging, and meanings derived from activities and experiences. Although there was individual variation between participants, there were few clear differences in meanings between those that preferred to retain the dam and those that preferred to remove it. There were only two community identity meanings that clearly diverged. For most retainers, community was based in a shared lifestyle enabled by the headpond, while for most removers, community identity was defined by the river.

The intangible meanings were found to relate to the biophysical characteristics of the location in several ways. The environment enabled or encouraged particular activities that contributed to a person's sense of identity or to sustaining a particular type of community. It also offered physical reminders of the past, and for many people was considered as defining the community's very existence. While some of these meanings, particularly those related to activities or experiences, could be expected to be affected by removal of the dam, others appear to have already survived changes to locations that occurred when the dam was built. Whether they could be sustained post-removal would require further study.

Based on the findings of this study, the following conclusions can be identified:

- Intangible meanings are linked to biophysical characteristics, as well as personal and community history, personal emotions and desires, and social relationships.

- Despite variation between individuals, many meanings are shared even between those with diverging positions on the future of the dam. Therefore, either diverging place meanings and emotional connections to the river do not contribute to the development of conflict, or the role of the only two meanings that differed between groups is more important than it appears. This issue, as well as the role of emotion in amplifying other differences between groups, deserves further study.
- Given the different variation between groups and their tangible and intangible meanings, it is suggested that the model by which place meanings affect the correlation between place attachment and project acceptance differentiates the two types of meaning.
- Decision making should be sensitive to place meanings by considering the impact of decisions that threaten those meanings and in proposing mitigation measures. A shift to participatory and conflict resolution approaches centred around shared place meanings has the potential to allow stakeholders to be heard and to build trust.

7.6. Contributions to knowledge

This thesis made several contributions to knowledge related to the understanding of social demand for ecosystem services in and around dammed river environments and in how stakeholder conflict relates to that ecosystem service demand. These contributions were made in the context of the specific theories used to inform this research and of the case that was studied. Therefore, the studies presented in this thesis also contribute to understanding the emerging issue of stakeholder conflict around large dam removal. They are discussed in this section and categorised into theoretical, methodological and empirical contributions.

7.6.1. Theoretical contributions

1. Chapters 3 and 4 revealed that even highly modified landscapes, such as reservoirs, a context that has been little studied to date, provide a wide range of ecosystem services that can be locally highly important. In particular, the results implied that reservoir ecosystems and wildlife species are perceived as having high non-use or inherent value, despite being far removed from the natural ecology of free-flowing rivers.
2. Chapter 4 contributed to the literature on sources of frames by arguing that benefits obtained from ecosystem services make an important contribution to the framing of environmental decisions. Benefits from ecosystem services represent interactions with the river environment from which stakeholders develop the knowledge that they draw on when framing the decision.

3. Prospect theory was applied to a new context, that of understanding conflicts around the potential removal of a large dam, in chapter 4. Specifically, the study showed that stakeholders frame removal as a loss or a gain, depending on their reference points, with those who perceived it as a loss holding their position more strongly.
4. In chapter 5, a new conceptual framework for understanding the role of scale frames in the politics of scale in environmental decision making was developed by combining literature on frames and on the politics of scale. It was applied to the case of decision making around a large dam and revised based on empirical data. Interpreting the past was identified as an important strategy for scale framing, based on data analysis. It was added to the conceptual framework as a scale framing strategy that had not previously been identified. The framework was shown to be effective for identifying mismatches in stakeholders' scale frames that can hinder effective communication and development of a shared understanding, and can amplify divisions between them.
5. Scale framing using the temporal scale was found in chapter 5 to be particularly important in the new context of a possible dam removal, given the changes to the river environment caused by dam construction and removal.
6. Chapter 6 argued that intangible place meanings can be closely linked to the biophysical characteristics of a location. Changes to the biophysical environment would be expected to change the range of experiences and activities possible there, and therefore also change the intangible meanings that are linked to those experiences. Other intangible meanings appear to be linked to locations that no longer have the biophysical characteristics that were the source of the original meaning. This suggests that some meanings can persist despite biophysical changes.
7. It was suggested in chapter 6 that theory on the role of place meanings in explaining opposition to infrastructure projects in settings with strong social place attachment could benefit from tangible and intangible place meanings being differentiated. It was suggested that it may be easier for stakeholders to assess whether perceived impacts of a project would threaten their tangible meanings, and that intangible meanings may heighten emotion over the issue.
8. Chapters 3 to 6 cumulatively demonstrated that conflicts over proposals to change ecosystem service provision and demand occur in many dimensions. Perceptions of biophysical change are assessed as compatible or incompatible with biophysical provision of or ability to access the ecosystem services from which stakeholders benefit (chapter 3). This assessment contributes to how the decision as a whole is framed, in terms of its

problems and solutions (chapter 4) and using scale (chapter 5). In framing the issue, stakeholders extrapolated from how they benefitted from ecosystem services to develop an understanding of the issue as a whole, which incorporated assumptions and biases. Lastly, ecosystem service benefits also contribute to emotional connections to particular locations and to a sense of identity (chapter 6). While many of these intangible meanings are shared between participants involved in the conflict, they may nevertheless contribute to conflict escalation.

7.6.2. Methodological contributions

1. Chapters 3 and 4 demonstrated that eliciting stakeholder demand for ecosystem services through interview-based approaches, whether combined with mapping or not, allows nuances of demand to be distinguished even within the same overall category of service. This is particularly important in contexts in which cultural services are significant.
2. Chapter 3 established that participatory mapping of ecosystem service demand combined with an interview-based approach is feasible in the context of a dammed river environment.
3. The standard interview-based participatory mapping method was extended in chapter 3 to include mapping of stakeholders' perceptions of the spatial distribution of ecosystem services under future scenarios, specifically the removal of the dam in this case. The results suggested that this task is challenging for stakeholders and has the potential to produce results biased towards ecosystem service demand by those who can remember or who have experienced equivalent states. However, the combination of participatory mapping with interviews revealed perceptions of the causal mechanisms that change ecosystem service provision and demand, even if the resulting spatial distribution could not be mapped.

7.6.3. Practical contributions

1. The research as a whole identified several interests, needs and values that stakeholders express in relation to a dammed river environment and that may contribute to conflict around dam removal. These outcomes contribute to the emerging literature on this topic, particularly in the unique context of large dams with large reservoirs.
2. Methods for resolving or managing conflicts in this context were not tested in this research. Nevertheless, the results allow several suggestions to be made. The scalar design of impact assessments, consultations, and conflict resolution processes should take into account how stakeholders frame various scales, and decision makers should be aware of which arguments and stakeholders are therefore implicitly included and excluded. Biases and assumptions in stakeholders' frames of decisions around dam removal can arise and should be corrected by

effective communication of impacts and uncertainties. Where removal is expected to create negative impacts on provision of or access to ecosystem services, spatially-targeted mitigation measures should be considered. However, these should be place sensitive – mitigation measures that solely restore ecosystem services may do little to relieve the conflict if intangible place meanings are disrupted. Despite diverging goals, interests and positions, common ground may exist between groups in conflict – in this case, the widely shared non-use value of ecosystems could form the basis of collaborative actions to reduce conflict.

3. Although it was ultimately decided in this case to upgrade maintenance to prolong the dam's lifespan, the findings presented here are likely to be of relevance to other large dams being considered for removal, particularly those with a similar pattern of past and current ecosystem service demand. In particular, the conceptual framework and methods used here offer an example for analysing data collected during stakeholder consultations to identify the issues that are likely to underlie conflict. As described above, the findings suggest conflict resolution methods that may prove fruitful elsewhere.

7.7. Limitations

The study limitations that define the boundaries of its conclusions are as follows:

- The perspectives of two key groups, Maliseet First Nations and industry, were not included in the study. Both were approached during the first phase of data collection, and several efforts were made to include First Nations, which were not successful due, at least in part, to prior involvement with the power company's consultation and lack of resources. The Maliseet Nations are unique in their relationship to the river, their history, how they were affected by the dam, and in their status as nations with unceded territory. The Wolastoq Grand Council issued a press release stating their preference for removal of the dam, a position that was effectively sidelined in the decision-making process. It must be recognised that this research does not account for their views, and that the impacts of both the dam's construction and its retention disproportionately affect them.
- The data was collected during two periods – summer 2015, before the release of impact reviews, and summer 2016, during the decision maker's consultation. It therefore represents essentially two snapshots of the conflict and does not otherwise account for dynamics over time. None of the participants that were interviewed in both phases had

changed their opinion from one to the other, and indeed for many their positions had become entrenched. However, the process by which that entrenchment took place was not studied in real time. Similarly, the evolution of the conflict since the decision was taken is not accounted for. Future work could analyse the post-decision conflict dynamics and assess the potential for divisions to be healed.

- The analysis of stakeholders' perceptions of ecosystem services focuses on the benefits of which they are aware, such as their own demand for cultural services. It does not account for those services that stakeholders unknowingly benefit from, in particular the regulating services that are required to maintain certain conditions in relation to water quality and flood risk, for example. It is therefore possible that the nature of conflict changes after a decision is made that affects the biophysical provision of such services once those impacts become visible to the general population.

7.8. Recommendations for future research

- Being an exploratory case study, there is considerable scope to extend the research presented in this thesis. The qualitative, small *n* analysis allowed in-depth exploration of stakeholders' experiences and perceptions informed by several theories linked in the conceptual framework that informed this research. The first recommendation for future research, then, would be to determine if the themes identified in this research can be generalised across the population that would be affected if the Mactaquac Dam were removed. To do this, a quantitative survey to identify current ecosystem service benefits, framing of the decision, place meanings, and position on the dam's future should be developed. The survey would be informed by the themes identified in this qualitative research, in an exploratory sequential mixed methods approach. The survey should be distributed to a randomised sample of the population living in the municipalities surrounding the affected reaches of the river upstream and downstream of the dam.
- A similar approach could be taken to generalise the spatial distribution of social demand for ecosystem services using participatory mapping. The parameters identified in the qualitative research should be used to define the categories that a large *n*, randomised sample would be asked to map in a postal or internet-based survey. This would allow a more robust identification of hotspots that could be targeted for management or restoration under either of the options for the dam.

- The conceptual framework developed to analyse the links between ecosystem service demand and conflict over potential dam removals (Figure 2.1) should be tested for transferability to similar cases. The studies published so far have focused on diverging ecosystem service use (Jorgensen and Renofalt 2012, Darvill and Lindo 2014, Brummer et al. 2017) and have focused on the potential removal of relatively small dams. Therefore, the role of ecosystem services in frames and sense of place, and how that role varies by conflict, should be further explored in cases of other large dams with large reservoirs that are considered for removal. In this way, the role of contextual factors specific to removal of large dams in conflict dynamics can be identified (Fox et al. 2017).
- This research focused on divergences between individuals in how they benefitted from ecosystem services, framed the issues at the centre of the conflict, and attributed meanings to places, as the purpose was to explore variations between individuals. The research should be extended by explicitly considering the power dynamics between stakeholder groups involved in conflicts over potential dam removals, and how such groups exercise power to attain strategic ends. This latter issue was touched on in chapter 5 in relation to the politics of scale, but it should be extended by considering the role of power differentials in the politics of scale, as well as considering the politics of place and how issue frames can be used strategically for political ends in this context.
- The suggestions given here for conflict resolution or management were theoretically informed but should be tested empirically. Mediation, collaborative management, and mitigation of the negative effects of the final decision could be put in place in the study area and their impacts analysed.