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REGISTERED REPORT STAGE 1: STUDY DESIGN

# A systematic mapping protocol for understanding knowledge exchange in forest science

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## Abstract

1. When making decisions about forest and environmental management, managers and policymakers often rely upon scientific knowledge. There is a well-documented 'knowledge–integration gap' where often the production of knowledge and its use are not aligned. Though there are several theoretical frameworks that conceptualize how knowledge is exchanged between producers of scientific knowledge and users of that information, there has been little attention to documenting knowledge exchange practices and their effectiveness, especially about forests.
2. In the systematic map, we will examine the peer-reviewed academic and grey literature to document and classify the knowledge exchange techniques suggested and adopted by knowledge producers and users in the forest sciences globally. Characterizing this knowledge exchange landscape will provide new information about which techniques are used and their frequency, if there is evidence of effectiveness for particular techniques, and recommendations for best practices. This map will also show whether approaches to knowledge exchange differ between sectors (e.g. academia, government).
3. We will create a systematic literature map as defined by the Collaboration for Environmental Evidence to capture case studies of, or theories about, knowledge exchange related to forest science. The search of peer-reviewed academic and grey literature will be conducted in English and French in two academic databases (BASE and Scopus) and one specialist database (ResearchGate). Candidate search strings will be evaluated against a test list of documents to determine strings with maximum sensitivity and specificity. Eligibility criteria will be applied to items at two screening stages: (1) title and abstract and (2) full-text. All screening decisions will be recorded in a database with 15% of full-text screening decisions validated. Items retained for inclusion will have data extracted according to a standardized strategy. Each reviewer conducting data extraction will have at least three of their extractions validated.

4. The systematic map will employ a narrative synthesis approach that includes descriptive statistics, tables, and figures which describe the types and frequency of knowledge exchange techniques theorized or described, a network map displaying the institutions within and between which knowledge exchange occurs, as well as summarizing any available evidence of effectiveness for particular knowledge exchange techniques.

**KEYWORDS**
forest management, forest science, forestry, knowledge exchange, knowledge mobilization, knowledge production, science transfer, science–policy interface

## 1 | INTRODUCTION

Management of natural resources and the environment, including forest management, requires tackling problems that are becoming increasingly complex and involve growing levels of risk (Cvitanovic et al., 2015; Engels, 2005; Lubchenco, 1998). To make decisions about such problems, natural resource managers and policymakers (henceforth 'knowledge users') must identify and choose between possible outcomes while weighing potentially competing evidence and trying to fulfil their environmental, social and economic objectives (Douglas, 2012). In forest management, there have been calls to increase the effectiveness of communication between scientific knowledge producers (which for the purposes of this protocol we consider as inclusive of natural and social scientists and researchers) and prospective knowledge users (Guldin et al., 2005; Kleine, 2009; Parrotta & Campos Arce, 2003). These knowledge users may include governments, Indigenous land stewards and/or rights-holders, industrial managers, landowners, educators, non-governmental organizations and others with a role and interest in the management, conservation and restoration of forest ecosystems.

Many of the world's forests are managed for a variety of values, which include conservation, food, natural and industrial resources, tourism and cultural values and climate risk management (Dhar et al., 2018; Eriksson, 2018). The needs and constraints felt by communities reliant on forest resources vary based on global and cultural context, norms, cultural values and the hierarchy of actors involved in forest management (Elliott, 2018). The complexity of resources, values, stakeholders and governments involved in forest management necessitates understanding into what evidence is used to make decisions and by whom as well as how knowledge about forests is transferred between actors (D'Eon & MacAfee, 2016). Knowledge exchange, generally, describes the interchange between producers of scientific knowledge (in our case, scientists) and users who apply this knowledge.[1] Knowledge exchange activities can improve the integration of scientific knowledge into policies and management activities, particularly if the knowledge is credible, salient and legitimate (Hering, 2016; Nguyen et al., 2017; Posner & Cvitanovic, 2019).

Scientific evidence about natural resources, including forests, is linked to policy and management outcomes in many ways. These outcomes include (but are not limited to) raising awareness, issuing warnings, defining problems, assessing policy and management options before and/or after implementation and monitoring implemented policies (Douglas, 2012; Engels, 2005). Science can also be used to legitimize or justify policy or management decisions (Engels, 2005; Girling & Gibbs, 2019). However, science is often unused or underused in policy and management processes (Cvitanovic & Hobday, 2018; Hisschemöller et al., 2001; Sutherland & Wordley, 2017), including forest science (Parrotta & Campos Arce, 2003).

Though the mismatch between produced evidence and its use in policymaking is often referred to as the 'science–policy gap' (Bradshaw & Borchers, 2000; Snow, 1959), we generalize this concept to the 'knowledge–integration gap' to be inclusive of management uses. There are multiple suggested causes for this gap, with a predominant one being that scientists and knowledge users operate in different cultures, with different timelines, expectations and motivations (Cash et al., 2003; Engels, 2005; Girling & Gibbs, 2019; Guston, 2001; Nguyen et al., 2018). Knowledge users often lack scientific training, whereas scientists often lack understanding of policymaking or management styles, including how and when to share their work (Brisbois et al., 2018; Fazey et al., 2014; Girling & Gibbs, 2019). Communities of scientists and knowledge users alike have called for bridging the knowledge–integration gap (Lubchenco, 1998). In light of this, Cvitanovic and Hobday (2018) called on researchers to go beyond identifying barriers to knowledge integration and to instead focus on available solutions to integrating science into decision-making.

We are not aware of an existing taxonomic classification of terms and models for knowledge exchange in science, but we identified four a priori categories based on existing literature and our prior experience. These include (1) 'One-way exchange', where scientists independently produce a scientific report or paper and deliver it to

[1] Knowledge exchange is related to concepts such as knowledge mobilization, knowledge transfer, tech transfer, knowledge translation, knowledge brokerage, knowledge uptake, knowledge diffusion and knowledge dissemination (Fazey et al., 2014; Mitton et al., 2007). We chose 'knowledge exchange' rather than 'knowledge mobilization' because our intent is to study the bidirectional transfer of knowledge between knowledge producers and knowledge users rather than the transfer of knowledge to a wider range of recipients than targeted users (Nguyen et al., 2016; Social Sciences and Humanities Research Council, 2019).

knowledge users. Included under this model are the 'loading dock' (Cash et al., 2006) or 'deficit' (Fernández, 2016) approaches to knowledge translation. (2) 'Solicited exchange', in which a knowledge user expressly invites knowledge producers to tackle a pre-identified knowledge gap, which is sometimes done through contracts to researchers or competitions for research funding or opportunities. (3) 'Network exchange', whereby two or more actors come together for the explicit purposes of exchanging knowledge generated independently by each. This is often done through workshops, conferences or professional networks. Finally, (4) 'participatory exchange', in which prospective users of scientific information are engaged and involved in its generation. This is sometimes termed 'coproduction' or 'cocreation' (Beier et al., 2017; Norström et al., 2020; Wall et al., 2017). Participatory exchange is sometimes considered an intrinsic part of 'transdisciplinary research' (Lang et al., 2012), 'community-based research' or 'community science' (Grant, 2015; Lang et al., 2012), 'social-ecological systems' (Balvanera et al., 2017) or, when related to ecology, 'translational ecology' (Enquist et al., 2017; Safford et al., 2017; Schlesinger, 2010). However, the aforementioned terms are also conceptualized without explicit or implicit inclusion of knowledge exchange.

Whereas one-way exchange has been considered relatively ineffective (Cash et al., 2006), integrative/participatory models have been proposed to increase effectiveness of knowledge exchange (Beier et al., 2017; Salomon et al., 2018; Westwood et al., 2020). Though there exists some theoretical guidance on best practices for knowledge exchange between scientists and knowledge users in the natural sciences (e.g. Gibbons et al., 2008; Nguyen et al., 2017; Westwood et al., 2020), it is not grounded in empirical evidence. Overall, relatively little attention has been paid to characterizing existing approaches to knowledge exchange, their commonness and their effectiveness. It is not known what knowledge exchange techniques are commonly employed in the forest sector, with what frequency or if evidence of effectiveness has been previously collected for any of these techniques.

We examine the integration of science into policies and management practices regarding forests from the lens of knowledge exchange. The aim of this paper is to create a systematic map that provides a better understanding of existing theories and practices regarding knowledge exchange in forest science. To do so, we will record and categorize the knowledge techniques identified in articles related to forest science and compare them to our a priori taxonomy. We will generate a network map to describe the institutions that use each knowledge exchange technique, their sector and their relationships with each other. We will also document whether the authors collected evidence of effectiveness of presented techniques (or if evidence is absent, elucidate gaps in knowledge about technique effectiveness). We present our methods in this protocol as part one of a registered report. Our methodology will be equally useful for characterizing the knowledge exchange landscape in other scientific disciplines, the vast majority of whom are also plagued by the knowledge–integration gap.

## 1.1 | Objective

Our proposed systematic map will examine the published peer-reviewed academic and grey literature to describe the techniques used to exchange forest science knowledge between producers and users. We aim to describe the type and frequency of techniques used and/or theorized, the distribution of these techniques within and among institution types as well as reported evidence of their effectiveness. In doing so, we will provide a first-ever characterization of the global knowledge exchange landscape in forest sciences (in English and French). We hope this work enables researchers and practitioners to move towards a shared language for knowledge exchange endeavours, highlight lessons learned in implementation of knowledge exchange as well as provide a typology which can be used in future to test and compare the effectiveness of different models for knowledge exchange.

## 1.2 | Primary question

The question guiding the systematic map of techniques used to exchange knowledge in forestry is: What techniques have been used and/or theorized by those producing new knowledge about forests, forest ecology, forest policy, forestry and silviculture to engage in knowledge exchange with potential knowledge users?

Our *population of interest* includes cases of knowledge exchange in forestry and forest sciences and reported in English or French and our *approaches of interest* are the ways that knowledge exchange methods are categorized, described and evaluated.

# 2 | MATERIALS AND METHODS

This systematic map will follow the Collaboration for Environmental Evidence's guidelines (CEE, 2018) and the ROSES reporting standards (Haddaway et al., 2018; Appendix S1).

## 2.1 | Search strategy

The search intends to capture all available peer-reviewed journal articles, reports, presentations, policy briefs, white papers, conference proceedings, book chapters and other peer-reviewed and grey literature in English and French relevant to the research question. We limited the search to English and French as these are languages read fluently by the authors. Preliminary searches were used to identify search strings and databases with the best performance (see below), and the final search to inform the systematic map will use three databases focussed on peer-reviewed publications and/or grey literature.

We compiled an initial set of 55 unique search terms (24 in English and 32 in French; Appendix S2). Terms were combined using Boolean operators to generate a set of eight candidate search strings for preliminary testing (four English strings and four French strings; Appendix

S2). The test list of documents known to be relevant to the research question consisted of 15 documents (Appendix S2) and was compiled based on author knowledge of the field. We initially identified 10 potential databases to search for peer-reviewed studies and grey literature. We rejected five of these for one or more of the following a priori reasons: heavily biased towards Canadian content; behind paywall; does not allow full use of Boolean operators and/or parentheses; and/or redundant as it is indexed by a retained database (Appendix S2).

To further narrow down the search strings and databases, we conducted preliminary searches to evaluate the specificity and sensitivity for search strings in each database. 'Specificity' reflects the proportion of the sample returned by the search that is relevant to the research question, whereas 'sensitivity' reflects the proportion of the test list returned by the sample in a given search (CEE, 2018). Preliminary searches included the testing of eight search strings in five databases (Appendix S2). For each string in each database, we recorded how many of the items were relevant as well as how many of the 15 test list items were returned in the first 100 results. We used this information to calculate specificity and sensitivity of each string in each database per first 50 and first 100 returned results, using the following formulae:

$$\text{Specificity for first 50 results}:$$

$$\#\text{ of relevant items in first 50 returned results}/50 * 100,$$

$$\text{Specificity for first 100 results}:$$

$$\#\text{ of relevant items in first 100 returnedresults}/100 * 100,$$

$$\text{Sensitivity for first 50 results}:$$

$$\#\text{ of items from the test list returned in first 50 results}/15 * 100,$$

$$\text{and Sensitivity for first100 results}:$$

$$\#\text{ of items from the test list returned in first 100 results}/15 * 100.$$

We also recorded which keywords were returned in relevant results (Appendix S2). Of the eight search strings tested, we selected the two strings in each language showing the highest specificity and sensitivity at both the 50-item and 100-item stages. We then modified these strings to remove keywords that were not returned in any relevant results during preliminary searching (e.g. *arbor*; Appendix S2), resulting in our four final search strings for executing the search strategy (Table 1).

Of the five databases used during preliminary searching, two were eliminated after showing specificity below 10% and sensitivity below 1% (unable to return any of the test list) after 100 hits (Table 2; Appendix S2). The three retained databases are Bielefeld Academic Search Engine (BASE), ResearchGate and Scopus. These three will be accessed using the following entry points: BASE is free for any user to search, ResearchGate will be searched with personal registration accounts and Scopus will be searched using library access via Carleton University.

**TABLE 1** Proposed search strings for the execution of the search strategy

| String # | String |
|---|---|
| 1 | (forest* OR silvicultur*) AND (knowledge trans* OR knowledge exchang* OR knowledge mobiliz* OR knowledge shar* OR "knowledge broker" OR "knowledge uptake" OR extension) |
| 2 | (forest* OR silvicultur*) AND ("science-policy integration" OR science policy integration OR science-policy interface OR coproduction OR co-produc* OR coprod* OR co-creat* OR cocreat* OR "forest information") |
| 3 | (forêt* OR forest* OR sylvicultur*) AND (utilisation de connaissances OR trans* de connaissances OR échange de connaissances OR fusion de connaissances OR trans* du savoir* OR échange du savoir*) |
| 4 | (forêt* OR forest* OR sylvicultur*) AND (intégration des sciences et des politiques OR "Politique forestière" OR co-construction) AND (connaissance* OR savoir* OR information) |

*Note*: The asterisk (*) can represent any characters (e.g. forest* can represent forestry, forests, forested).

**TABLE 2** Preliminary searching of candidate databases to test for average specificity and sensitivity across eight search strings for the first 100 hits

| Candidate database | Average specificity (%) | Average sensitivity (%) | Final status |
|---|---|---|---|
| Bielefeld Academic Search Engine | 18 | 1 | Retained |
| Google Scholar | 8 | 0 | Rejected |
| JSTOR Life Sciences Collection | 2 | 0 | Rejected |
| ResearchGate | 28 | 5 | Retained |
| Scopus | 21 | 7 | Retained |

## 2.2 | Item screening and eligibility criteria

Eligibility screening of returned results will occur in two stages: (1) title and abstract and (2) full-text. Each of the three databases will be searched with all four search strings (with the exception of Scopus which does not allow searching in French) for a total of 10 unique searches to screen results. Each search will be conducted by one individual. The title, author and year of each result will be copied into a Google Sheet and the title and abstract screened for relevance according to the eligibility criteria. All title and abstract screening decisions will be recorded in the Google Sheet, and the full results and summary statistics will be included in an appendix to the final published report.

Given that part of the study objective is to determine the most appropriate keywords for use in this developing field of inquiry, it is necessary to use general terms to capture relevant results. Due to the generality of many keywords and their high use in English and French (e.g. 'forest', 'transfer'), we are expecting high numbers of returned

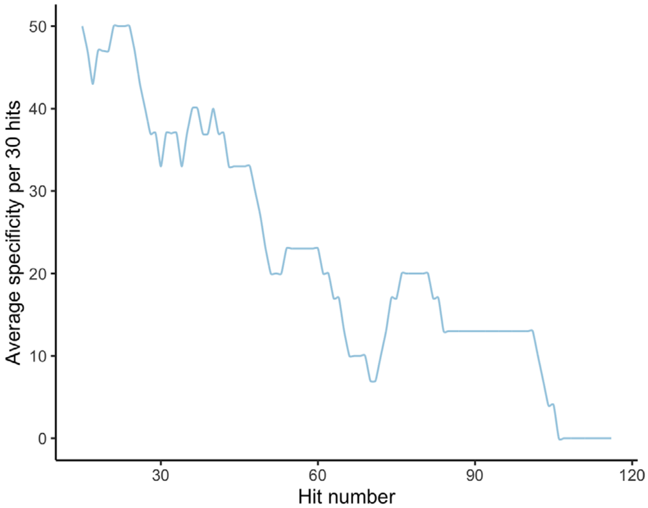


**FIGURE 1** Example graph of rolling average specificity, showing average specificity (% of retained results per 30 hits) at each hit number. In this case, the stopping condition has been met (25 consecutive hits were deemed not relevant and average specificity remained below 20% over the 25 final hits)

hits from each search with relatively low total specificity. Preliminary search strings retrieved hit numbers in the thousands, but specificity declined sharply within the first hundred results (Appendix S2). Therefore, it is necessary to provide stopping criteria to maximize search effort. To determine the number of hits to be screened for relevance, the assessor will stop screening the title and abstract additional hits once one of the following conditions is met:

Stopping condition 1: All returned hits have been screened.

Stopping condition 2: Thirty consecutive hits were deemed not relevant 'and' the rolling average of specificity per 30 hits has been below 20% for those 30 hits. For example if hit numbers 1–31 return 15 relevant results, average specificity at hit 21 is 50%. If hit numbers 2–32 include 14 relevant results, average specificity at hit #22 is 47% (see Figure 1 for an example graph of rolling average specificity). Thus, the 'stopping point' for screening will be a different number of hits for each unique search.

If the item passes title and abstract screening, the full-text will be saved into a Mendeley (Mendeley Ltd., 2019) database and uploaded into the literature review program Covidence (Veritas Health Innovation, n.d.) for full-text eligibility screening. Covidence allows for (1) input of the literature database and automatic removal of duplicates, (2) guided screening according to user-specified settings (e.g. setting the number of screeners per item; forcing users to select from a list of reasons why an item is excluded and recording this decision), (3) data extraction by pairing a questionnaire alongside each document PDF, which the extractor must answer and (4) recording all screening decisions and data extraction, and outputting this as a spreadsheet. Covidence also tracks which reviewers have screened or extracted which documents and allows contentious items to be flagged for attention by additional reviewers.

Each item uploaded for full-text screening will be screened by one reviewer. If this reviewer is unsure about whether the document meets the eligibility criteria, they will flag it for attention by a second reviewer. If the second reviewer is still unsure, it will be discussed by the research team in full during bimonthly team meetings. Covidence generates a number for each entry, and the study lead (AW) will use a random number generator to validate 15% of full-text screening decisions. Four individuals will conduct full-text screening (including co-authors on this protocol). An output spreadsheet of full-text screening decisions from Covidence, with full results and their summary statistics, will also be included in an appendix.

### 2.2.1 | Eligibility criteria

*Population*

Included items will concern forest ecology, forestry, silviculture, forest informatics, dendroecology, dendrochronology or other natural or social sciences related to forests. Studies concerning natural resources or environmental studies in general will be excluded.

*Item content*

Items must include one or more of the following: (a) positing a theory or conceptual framework about knowledge exchange, or critically responding to such a theory or framework, (b) studying the use or effectiveness of methods in knowledge exchange, (c) presenting a case study of knowledge exchange or (d) presenting a plan of action for knowledge exchange. 'Knowledge exchange' is defined as per the definition given in Section 1.

*Geographical and language scope*

Studies may originate anywhere in the world and will be included if written in English or French.

## 2.3 | Study validity assessment

In this study, we do not intend to appraise the validity of research conducted in the items, nor the effectiveness of the knowledge exchange activity. Rather, we intend to capture descriptive information.

## 2.4 | Data extraction strategy

Each item which has passed full-text screening will be subject to data extraction by one reviewer. The reviewer will read the item in full and complete a questionnaire (Appendix S3) consisting of 18 questions. The questionnaire will capture information in four categories: (1) terms and approaches used related to knowledge exchange; (2) recommendations for effective knowledge exchange; (3) whether or not the item collected evidence about, or empirically tested, the effectiveness of knowledge exchange; and (4) information about knowledge-generating and/or knowledge-using institutions. Missing information in any of these categories will be recorded as not reported, unspecified or not applicable, as warranted.

To categorize knowledge exchange terms and approaches, we ask 'Would the approach to knowledge exchange in this item be best described as: (A) Coproduction: Knowledge producers and users were jointly involved in the design and execution of a project; (B) Loading dock: Knowledge producers initiated a project, generated knowledge, and then delivered it to potential knowledge users; (C) Solicited: Knowledge users requested and/or funded specific knowledge, which knowledge producers were contracted to generate; (D) Network: The formal or informal convening of knowledge producers and knowledge users for the explicit purposes of knowledge exchange; (E) Not applicable; or (F) Other (write in short answer)'. This question was based on our a priori taxonomy of knowledge exchange models, with the specific language being more general than presented in our taxonomy so as to be easily understandable for the reviewers extracting the data. Data extraction will be completed by nine reviewers, which include five co-authors from the present protocol and four additional experts in forest science and/or knowledge exchange. The data extraction questionnaire will be filled out for each item in Covidence, which automatically compiles extracted data into a tabular form for analysis. A 1-h training session on data extraction will be provided by the study lead (AW) to all reviewers, which will include completing an example extraction together. To ensure that data extraction meets quality standards, AW will validate the first three items extracted by each reviewer and rate their agreement with the reviewer's assessment as follows: full (all questions in agreement), good (validator has additions or adjustments to one to two questions), fair (additions or adjustments to three to eight questions), or poor (adjustments or additions to nine or more questions).

If a reviewer's first three extractions all score 'good' or above during validation, that reviewer will be given feedback on these extractions and asked to continue extracting items without further oversight. If any of the extractions score 'fair' or below, the study lead will provide detailed feedback, make corrections and instruct the reviewer to conduct two more extractions which will then be validated. If either of these validations scores 'fair' or below, this process will be repeated indefinitely until all extractions score 'good' or above. Reviewers may ask the study lead for validation at any time on any items for which they are unsure. By following the above procedures, data extraction will be validated for a minimum of 27 items.

### 2.5 | Study mapping and presentation

A framework-based synthesis (Carroll et al., 2011) will be used to structure the categorization of knowledge exchange techniques. The systematic map will describe and categorize knowledge exchange techniques used by institutions related to forest science and forestry. Following other systematic map examples (e.g. Alexander et al., 2019; McKinnon et al., 2016), this approach will be partly structured according to our categories defined a priori from existing conceptual literature about knowledge exchange. It will also be an unstructured approach in that additional categories that emerge through the extraction process will also be included. Data will be available in a tabular format as an appendix to the article. Descriptive statistics, including charts and tables, will be used to elucidate patterns of knowledge exchange categories in terms of their proposal and use frequency, time span, location and commonalities between and within institution types. A network map visually representing linkages between institutions and sectors in relation to the knowledge exchange categories used will be presented. If and where available, evidence of effectiveness for particular knowledge exchange approaches will be presented and summarized. We will also identify evidence gaps for future research.

The systematic map will be submitted as a Stage 2 article in Ecological Solutions & Evidence once complete.

## 3 | DISCUSSION

Despite the ongoing efforts of scientists to have their research reflected in forest management and policy outcomes, scientific evidence is often unused or underused in environmental policy and management processes (Hisschemöller et al., 2001; Lubchenco, 1998; Sutherland & Wordley, 2017). We seek to answer the call of many experts to move past identification of problems contributing to the knowledge–integration gap, and instead, focus on solutions (Cash et al., 2006; Cvitanovic & Hobday, 2018). Our provision of the first-known characterization of the knowledge exchange landscape in forest science will generate new insights about which knowledge exchange techniques are used in relation to forest science, report on evidence of their effectiveness, gaps in knowledge about the approaches and recommendations for best practices. This map will also elucidate whether models for knowledge exchange differ between sectors (e.g. academia, government). Our dissemination plan extends beyond the peer-reviewed literature and will leverage the interdisciplinary research networks of the co-authors. Our review will immediately inform the approaches of forest scientists and managers of forest resources by providing considerations for effective knowledge exchange, with the aim of ensuring that policy and management decisions about forests are better informed by scientific evidence.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## AUTHORS' CONTRIBUTIONS

The study was conceived by AW, VN and MF. Preliminary searching and database testing were conducted by AW, TK, JW and KK. JS developed Figure 1. The manuscript was drafted by AW. VN, MF, TK, JW, JH and KK provided comments and revisions on all manuscript drafts. Bimonthly project guidance meetings were facilitated by AW with MF, TK, JW, KK, JS, VBN and JH attending and providing direction and feedback. All authors have read and approved the final manuscript.

## DATA AVAILABILITY STATEMENT

There are no data associated with this Stage 1 article. The data for the Stage 2 article will be stored in Dalspace, Dalhousie University's publicly accessible official repository on Alana Westwood's collection page at https://dalspace.library.dal.ca/handle/10222/80512.

## PEER REVIEW

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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