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Public perception of forest assisted migration (FAM): a useful approach which requires cautious implementation?

Felipe Jovani Tavares Moreira[1]*, Jean-François Bissonnette[1], Patricia Raymond[2] and Alison Dale Munson[3]

[1]Département de Géographie, Université Laval, Québec, QC, Canada, [2]Direction de la Recherche Forestière, Québec, QC, Canada, [3]Département des Sciences du bois et de la Forêt, Université Laval, Québec, QC, Canada

Forest Assisted Migration (FAM) emerges as a promising strategy of adaptation to climate change (CC) in the forestry sector. This method integrates various sources of knowledge to identify optimal locations for future tree species establishment through human intervention. As climate change presents numerous challenges to Quebec's forests, including shifts in suitable habitats for tree species, the FAM recommends a proactive approach to adapt to these changes. Recognizing the importance of addressing risks and following international resolutions, such as the Paris Agreement on Climate Change (COP21) and Convention on Biological Diversity (CBD), social perception becomes a critical consideration in the decision-making process regarding FAM. To investigate this issue, we conducted semi-structured interviews with 18 key stakeholders in Quebec, including officials from the Ministry of Natural Resources and Forestry, employees of private forestry technical companies, forestry researchers, private forest owners, non-governmental organizations (NGO) members, and other forest stakeholders. We analyzed the data collected in this phase through thematic discrimination, focusing on (i) acceptability (ii) risk perception (iii) feasibility, and (iv) purpose. Then, we compared the discourses with data from other publications addressing the social aspects of FAM. To develop this reflection, we found it important to use a conceptual framework that encompasses the articulation among some concepts of intervention through FAM vs. non-intervention, public trust in government authorities, risk perception and scientific knowledge. The interviews revealed a general inclination among stakeholders to support FAM, dependent upon cautious implementation with pilot projects and studies serving as references for future large-scale applications. Concerns raised by stakeholders included seed production, adequate experimental monitoring, and careful species selection. While some stakeholders were more knowledgeable about current FAM research, others emphasized the importance of economic viability, public participation in decision-making, and transparency in forestry processes. We identified communication and public involvement as fundamental aspects for advancing the perspective of FAM implementation in Quebec; it is crucial to recognize the presence of humans in FAM target areas and their potential contributions to implementation. Moving forward, forest authorities

responsible for FAM should prioritize stakeholder engagement at all levels to ensure a socially inclusive strategy of adaptation that respects a wide range of considerations.

Introduction

Among the strategies for responding to climate change, Forest Assisted Migration (FAM) has gained prominence in the past decade. Being more specific than the Assisted Migration (AM) concept, FAM seeks to intentionally move individuals or populations of trees to more suitable areas according to expected future climate conditions (Aitken and Whitlock, 2013; Royo et al., 2023).

The FAM strategy presupposes proactive human action to facilitate ecological transition and forest adaptation. However, this raises a set of questions about the relationship between humans and nature because this relationship varies depending on the values held by different social groups, thereby raising ethical considerations (Aubin et al., 2011). This research is conducted in the areas of social forestry and human geography to better understand the perceived potential and shortcomings of FAM. FAM is considered an emerging approach to adaptation to climate change that raises complex concerns and hopes that require interdisciplinary attention between natural and social sciences.

Amidst this discussion, it is important to emphasize the concept of three intensities of displacement models in FAM that are already addressed in the scientific literature. The first model, Assisted Population Migration is defined as the tree movement within the distribution area of a species (Benomar et al., 2016), which is the least intensive modality, presenting a low risk of maladaptation, forest disease spread, and other undesirable situations for forest health (Ste-Marie, 2011). In addition, studies indicate greater social tolerance for this modality (Pelai et al., 2021a; St-Laurent et al., 2018).

The second model, Assisted Range Expansion, is considered riskier than the Assisted Population Migration. In this case, the movement of species outside and around the current zone of occupancy facilitates natural expansion (Ste-Marie et al., 2011). In this situation, scientists seek to stimulate natural migration to limit the risks of maladaptation because favorable climatic niches are expected to migrate much faster than plant species (Champagne et al., 2021; Iverson et al., 2008; Périé et al., 2014).

The third model, Assisted Species Migration/Exotic Translocation, is the most dangerous modality because it involves the movement of species outside their natural range over distances greater than those accessible by natural dispersal (Charles and Stehlik, 2021). In this case, the use of exotic species would be possible.

Although not typically cited as a model for FAM intensity, Assisted Genetic Migration is an important strategy to highlight.

This method facilitates the movement of organisms between populations within a species' existing range to preserve genetic diversity. It also involves the movement of species beyond their historical distribution, bringing individuals from other sources (McLaughlin et al., 2022), such as the white spruce (*Picea glauca*) brought from the United States to Quebec (Benomar et al., 2022a). This approach aims to introduce genetic diversity and resilience into populations of native species, improving their adaptation to changing environmental conditions.

In this way, our study argues that exploring perceptions about forests is essential to better understand the potential use of FAM in forest management strategies in the context of climate change (Foladori and Taks, 2004; Hicks et al., 2010). This would deepen the understanding of the complex human relationship with forests (Moshofsky et al., 2019). This study specifically targeted tree migration in forest environments. To avoid any confusion with the migration of animal species or the planting of exotic species on a small scale, for ornamental or personal use, we opted to include the term "forest" in the designation of this strategy.

The emergence and proliferation of strategies such as FAM can be justified by the current state of climate change, which jeopardizes the reproduction and thus the sustainability of certain tree species. Forest ecosystems may consequently face threats to their composition and structure. The inadequacy of measures implemented in recent decades to mitigate climate change at the global scale, coupled with forecasts of its acceleration (IPCC, 2022), has motivated the formulation of more ambitious projects in Canada, such as FAM (Williams and Dumroese, 2013).

From this perspective, studies in the field of social sciences are crucial for the effectiveness of socioecological management projects, as they provide vital support for cooperation and exchange with populations (Bernard et al., 2020; Lambini et al., 2019). Understanding the perceptions of the actors involved is fundamental and essential according to the principles of participatory democracy that guide the management and development of natural environments (Hajjar and Kozak, 2015).

Therefore, broadening decision-making processes related to the environment to encompass all sectors of society is crucial for incorporating diverse areas of knowledge and epistemological perspectives (IPBES, 2019; Lenoir, 1995). Consequently, it can be affirmed that expanding public participation to include various actors (such as environmental organizations, engaged citizen groups, and indigenous communities) in democratic societies has yielded beneficial effects (Bouthillier and Roberge, 2007; IPBES, 2019; Tardif et al., 2017).

Along these lines, the growing interest in FAM has generated a series of ethical reflections due to the distinct values that are challenged by this forest management approach to CC (Aubin et al., 2011). Thus, from a broad perspective, studies often present biocentric, ecocentric or anthropocentric positions as determining factors in the choices of the actors involved (Hajjar and Kozak, 2015; Mcfarlane and Boxall, 2003). In essence, ecocentrism emphasizes the importance of entire ecological systems, recognizing the interdependence of all life forms, while biocentrism focuses on the intrinsic value of individual organisms beyond humans. Despite these differences, both views stand in contrast to the anthropocentric perspective, which prioritizes the utilization and alteration of nature and forests to meet human needs and improve well-being (Hajjar and Kozak, 2015; Sena, 2019).

The difficulty of accurately predicting the outcomes of forestry interventions such as FAM poses a dilemma that is the subject of discussion (Park and Talbot, 2012). Decision-makers are faced with two situations: wait or act. "Acting" would imply risks of poor adaptation or "maladaptation" of species that are artificially migrated, which would thus increase exposure to epidemics, competition and stress (Hewitt et al., 2011). However, the alternative of "waiting" presents its own set of challenges. Delaying action may lead to missed opportunities for intervention, potentially exacerbating existing issues within forestry ecosystems (Davidson and Simkanin, 2008). Additionally, the longer the delay, the more uncertain decision-makers become about the effectiveness of future interventions (Park and Talbot, 2012). This means that they face not only the immediate risks of taking action but also the potential downsides of waiting, including missed opportunities and heightened uncertainty (Park and Talbot, 2012; Schlaepfer et al., 2009).

Ultimately, FAM is a social and political project that is based on a particular conception of the potential of forest science and human capacities for forest management. A treatment of the subject within the field of social sciences renders it possible to identify more specific aspects not covered by the natural sciences (Guan et al., 2019). This leads to the following question: what are the main values and beliefs that determine the perceptions of social actors toward FAM? The values and beliefs associated to FAM are often formulated as specific considerations, caveats, or proposals associated with a person's own experience with forest management. In summary, the term "perception" involves understanding how people read various aspects of the environment. However, for this study, we define "values" as beliefs in ideas that influence the attitudes and behaviors of the concerned social actors (Batellier, 2016).

As key elements in perception studies, we highlight (i) public cognizance, reflecting the level of knowledge about assisted tree migration; (ii) public opinions, encompassing attitudes, feelings, and behaviors regarding assisted tree migration; and (iii) social acceptance measured by the degree of community support for assisted tree migration.

FAM has been the subject of scientific debate for three decades, generally reflecting the risks (competition, maladaptation, epidemics, fires, etc.) and benefits of its use in the environment (Keel, 2007; McLachlan et al., 2007; Peters and Darling, 1985; Royo et al., 2023). Despite the favorable development of tree species in certain experiments carried out in recent decades in

Canada (Klenk, 2015), there is still no consensus in the scientific literature regarding the adoption of FAM as an adaptation strategy against large-scale climate change impacts (Park and Talbot, 2012; St-Laurent et al., 2018). Additionally, there is some uncertainty regarding the ability to implement this strategy on a large scale, given the limitations in nursery production capacity, the scarcity of seeds, the large size of the territory, and the lack of labor (Palik et al., 2022).

In Canada, research on social perceptions of forest management strategies, such as FAM, is limited, with a dozen studies published (Hajjar and Kozak, 2015; Pelai et al., 2021a; St-Laurent et al., 2018). In Quebec specifically, this scarcity is particularly evident. In the context of social participation, this is alarming, especially considering that approximately 92% of Quebec's forests are publicly owned and administered by government bodies (Boulanger et al., 2023).

Materials and methods

Ethical procedures and authorizations

This study was approved by the Ethics Committee for Research with Human Subjects at Laval University (approval number 2021-187).

Study area

The focal region of the studies is the province of Quebec in Canada. Thus, all interviewees were based in Quebec, albeit from different regions (e.g., Capitale-Nationale, Abitibi-Témiscamingue, Outaouais, Estrie, and Maurice). The selection of individuals presented some challenges, first given the specificity of the subject. As very few people are aware of the application of FAM, the recruitment of participants was complex and limited.

Participants were recruited in different areas, from boreal forests in the north to temperate forests in the south. The extensive boreal forest is crucial for carbon storage and biodiversity and the temperate forest is located closer to urban areas. The chosen regions have significant water resources, including numerous rivers and lakes. In turn, climate change threatens Quebec's forests with more frequent forest fires, pest outbreaks and changes in weather patterns that affect forest health and productivity. In the socioeconomic sphere, Quebec is strongly associated with natural resource industries such as forestry, mining and agriculture. Industrial logging is significant, economically vital for some communities and heavily subsidized. However, there is a growing demand for conservation and sustainable practices. This dynamic creates a scenario of challenges and opportunities for the application of FAM.

Interview selection

In this study, semi-structured interviews were essential for identifying nuances and clarifying details regarding the way in

which the groups (researchers, stakeholders, forestry workers and private forestry owners) treat the potential of FAM today.

Survey participants were recruited using the snowball sampling method (Audemard, 2020; Leighton et al., 1995), where university or government researchers previously nominated potential interviewees. Additionally, purposive sampling was based on survey profiles of organizations and individuals and their supposed knowledge about forest management. For this second method, 12 organizations involved in forest management, public park management, forest research, representatives of private owners, the timber industry, and non-governmental organizations were included.

Considering the limited number of researchers specializing in the topic, we chose not to specify their region when presenting the results, to guarantee confidentiality and anonymity. The selection of interviewees prioritized subject specialists, particularly those affiliated with government ministries and forestry research institutions. However, we also conducted interviews with forest managers, private landowners, and ecologists. For this latter group, the criterion was a fundamental grasp of the subject matter, though not necessarily an advanced level of expertise in the current research.

During the research preparation phase, we identified a list that pointed out the main organizations and profiles of interviewees that we should contact. The preparation of this list included the participation of professors at Laval University and discussions with researchers associated with the Quebec government. On the other hand, members of the industrial sector, some managers of forestry companies and NGOs were contacted, but did not express interest in discussing the project.

To ensure the rigor, validity, and relevance of the research, sociological principles were integrated throughout all stages of the study. These principles included reflexivity, contextualization, interaction, interpretation of meanings, consideration of subjectivity, theorization, and generalization (Lune and Berg, 2016; Reed et al., 2018). Given that the production of knowledge on social perceptions are subject to change over time and sensitive to the social and cultural context, we examined other studies already carried out in Canada to validate our methodology (e.g., Findlater et al., 2022; Hajjar and Kozak, 2015; Pelai et al., 2021a; St-Laurent et al., 2019). These procedures were crucial to correspond to the principles of qualitative research in social sciences (Baribeau and Royer, 2012; Bertrand et al., 2006).

One advantage of the semi-structured interviews was the possibility of greater proximity and greater interaction with the interviewees (Savoie-Zajc, 2021). This made it possible to address more precise subjects, referring to the actors interviewed and their areas of intervention. In this way, we were able to spontaneously guide the course of the research, producing the best analysis of the responses of research participants.

The interviews encompassed a diverse group of respondents, totaling 18 individuals categorized into five distinct groups, with 29 categories of respondents, as one individual may belong to more than one category. These groups included three (3) private forestry company staff (PFC), five (5) private forest owners (PFO), eleven (11) forestry researchers (FR), four (4) members of NGOs/other forestry stakeholders (FS), and six (6) members of a government ministry (MM). This approach ensured a comprehensive representation of perspectives and expertise

TABLE 1 Category and quantity of actors interviewed.

Category of respondent	Number of people per category
Staff of private forestry companies (PFC)	3
Private forest owners (PFO)	5
Forestry researchers (FR)	11
Ministry employees or government institutions (MM)	6
Members of NGOs (FS)	4
Total	29

within the forestry sector, enriching the insights gathered from the interviews (see Table 1 for details).

Development of the interviews

The interviews took place between June 2021 and May 2023. Each respondent received both written and verbal versions of the questions and was allowed 4 to 5 min to respond to each question. Approximately 15 questions were addressed during the interviews. Additionally, follow-up questions were posed to delve deeper into specific aspects based on the responses or to provide further elucidation of certain topics, which is a common strategy in semi-structured interviews (Savoie-Zajc, 2021). The interviews were conducted in French and translated to English by the main author for the purpose of this article.

To validate the collected data during the research period, we employed triangulation by gathering data through various methods and sources. This included observations, inquiries, and specific concerns that were thoroughly discussed not only with fellow students, researchers, and university professors but also through interactions during regular meetings, conferences, symposiums, and field visits. Our engagement extended to on-site experiences, such as visits to the Berthier nursery and two excursions to experimental FAM plantations in Portneuf, Quebec. These plantations were developed as part of the DREAM project (Desired REgeneration Through Assisted Migration), which has been ongoing since 2018 (Royo et al., 2023).

Data analysis

Given that this study adopts an inductive approach, we examined local data to derive references, draw inferences, and gain relevant perceptions in association with other studies. This data collection technique enables an interpretive and constructivist research perspective. It was selected because such an epistemological stance aims to gain a comprehensive understanding of a phenomenon while exploring the perspectives and meanings that social actors attribute to their reality (Savoie-Zajc, 2021). In essence, engaging in joint reflection on FAM through interviews with individuals who are interested or curious about its implementation fosters a dynamic of co-constructing meaning between the researcher and the participants. Consequently, this methodology facilitates the emergence of new discourse and insights into the studied phenomenon (Gauthier, 2009).

The interviews were recorded in both video and audio formats, and a transcription was produced with editing. This editing process aimed to maintain the essence of the recorded narrations and speech while improving readability and understanding. It included grammatical corrections, the elimination of repetitions, and the removal of non-essential elements. Next, contextualized thematic analysis (de Souza, 2019) was conducted to examine the qualitative data. This process was carried out manually. During the analysis, we focused on extracts that highlighted four key concepts: (i) Social participation and acceptance; (ii) Trust in government authorities; (iii) Intervention through FAM vs. non-intervention; (iv) Technical capacity and scientific feasibility of FAM.

Results

Different degrees of FAM and acceptability

Exploring different intensities of FAM and its acceptability sheds light on crucial considerations in this field. Assisted population migration, involving movements within the species' range, has gained general support as a relatively safe and practical approach. On the other hand, the assisted expansion of distribution, which involves the movement of species beyond their current zone of occupation, was considered more daring and appropriate in specific circumstances. Assisted species migration, although emblematic, has faced skepticism due to its higher risk and logistical challenges.

According to these models, most interviewees expressed a preference for the first model, which involves migration within the distribution area using native species. However, some mentioned that they support the second model in specific cases. The third option was deemed unfeasible due to the high level of risk and impracticality, especially when considering systemic issues.

> The discussion about acceptability was extensive, with interviewees expressing optimism about the proposal's chances of acceptance. However, many stakeholders emphasized that the process must continually account for public perceptions of the species involved. I believe that assisted migration is a necessary and inevitable strategy given that climate change is occurring rapidly and that forest ecosystems must adapt quickly. However, the importation of species must be managed carefully to minimize impacts on local ecosystems (FR 1).

Hence, the evolution of acceptability could be attributed to the transparency exhibited in projects. Several interviewees raised concerns regarding the opacity surrounding projects and the heightened centralization, as some interviewees stated, "It is super important to be truly honest when it comes to the level of knowledge we have, the degree of certainty we have. We must accept, we have to say, there are many things we do not know" (FS3).

The discourse surrounding acceptability is highlighted a nuanced picture, where FAM is generally favored but requires an ongoing dialogue between public perception and the species being introduced. Project transparency emerged as a key factor influencing acceptability, as interviewees expressed concerns about opacity and centralization of decision-making.

Finally, although assisted migration is seen as an inevitable strategy in the face of rapid climate change and the urgent need to adapt ecosystems, careful management and transparency are key. The balance between innovation and risk mitigation must be carefully explored to ensure the long-term sustainability of forest ecosystems amid evolving environmental challenges.

Operability and indigenous participation

During several interviews, two themes were raised by the interviewees while assessing the forestry sector's situation, even before we posed specific questions: (i) the risk of a scarcity of technical conditions for large-scale forestry interventions and (ii) indigenous participation in decision-making within this sector. Although this topic extends beyond our focus, these elements play a crucial role in social dialog regarding FAM.

Nearly all the interviewee reports highlighted at least one type of worker shortage in the forestry sector, such as in logging, planting, seedling management, processing, handling, and transportation of materials, along with the subsequent aging of the current workforce. "We are struggling to attract students; their numbers are decreasing. During the summer, there used to be a large workforce. Why are students interested in working in the forest decreasing annually?" (PFO 4). This decline in young people's involvement in forest management activities, particularly students, is considered critical during the planting period. Numerous interviewees expressed concerns about this tendency, emphasizing its potential impact on the viability of FAM, as it would require more workers, especially in northern Quebec, the region far from urban centers and services.

However, even in more southern regions, this issue is highlighted. In connection with this, the requirements extend to the operational absence of studies and workers in nurseries.

> There is a need for considerable knowledge to set it up [FAM], but there is no longer anyone who works in tree nurseries; it is not very interesting for people who prefer to work in ecology, in development software, artificial intelligence, etc. However, the concrete, the ground, there is no one left (MM 2).

Another argument was the importance of integrating native communities into the decision-making process. Among the stakeholders consulted, there was a strong understanding of the unique circumstances of First Nations, with a consensus in favor of collaborative efforts.

> It is certain that it would require consultation specifically to indigenous people; then, the consultations must be consultations where there is a certain power of recommendations (PFO 2).

> If these indigenous populations are not only consulted but also integrated into the process, it is better. We see projects such as

> "Paix des Braves" [territorial agreement signed in 2002 between Quebec and the Cree nation] or successful partnerships with other First Nations; these are projects where they are integrated and allies, and the same should be true for private landowners. They must be in the game, they need to (PFO 1).

Given the historical process of territorial occupation in Quebec, indigenous status is officially recognized by the State (Teitelbaum, 2015). This scenario was constructed through a reinterpretation of the role of the First Nations in the development of Quebec and a new understanding of the presence of different indigenous nations in the province (Dabin, 2022). Due to this shared vision about the importance of First Nations and their role in the province's environmental debate, the importance of indigenous participation in the decision-making process was highlighted by several interviewees (PFO 5; FS 3; PFC 1, 3; FR 1, 2, 4, 7, 10, 11).

Risk perception: intervention vs. non-intervention

Risk perceptions were discussed along with examples, such as the intensity of FAM (inside or outside the distribution area), as well as biological factors (species competition, epidemics and uncontrolled fires) and social factors (economic interest, social participation and technical-scientific capacity). The imperative to intervene in forests amidst climate change was upheld by all parties consulted in our study. Nevertheless, there is broad acknowledgment of the risks inherent in large-scale forest interventions.

The divergences among the actors occurred in the type of intervention to be carried out, with FAM being the subject of discussion and recognized as an option, although not exclusive or a priority for the majority. "The big problem is uncertainty (...). That is why we cannot just depend on FAM; we're not going to replant 100% of our forests in Quebec; we must put a lot of effort into natural regeneration" (FR 2).

All respondents were in favor of implementing pilot projects in the province, and they emphasized that this would mitigate risks if large-scale interventions were necessary in the future (PFC1; FR 11). "I think these are technologies that deserve to be analyzed with pilot projects, which we try on a smaller scale to see a little how they behave" (FS 1).

> For me, invasive species are something that I worry about, competition, particularly with global warming, so that worries me and assisted migration. The secret risk revealed by the migration of an exotic species is a significant topic for discussion in the scientific community (PFO 4).

The reduced large-scale quantitative experience of FAM and the uncertainties about the viability of the strategy (FS 2) contribute to a skeptical view of this strategy. At the technical level, we identified greater uncertainties regarding seed production, adequate knowledge and the choice of species. Regarding seed production, one researcher highlighted the potential difficulty in providing seedlings for assisted migration.

> (. . .) in the boreal forest, we mainly have species that we can dehydrate and preserve in a seed bank. However, the target species for Quebec-assisted migration into temperate forests are species that generally produce seeds that do not survive well or have a short shelf life. These are seeds that do not grow well, which is why we harvested them in the fall. We do not sow them in the spring. Therefore, this difficulty in supply due to the non-conservation of seeds will also influence the choice of essences to be used in migration because if seeds cannot be collected, crops cannot be planted (MM 5).

Therefore, even though they advocate field trials with FAM, some researchers highlight that these probable obstacles need to be carefully analyzed.

In the social sphere, the most recurring reservation pointed to the objectives of FAM in the province. Many interviewees criticized the current utilitarian perspective on forests. In this scenario, ecological priorities might be sidelined, while financial considerations heavily influence decisions about natural environments (FR 4, 5, 9, 10; FS 3, 1). This viewpoint suggests that the ongoing FAM strategy might overshadow alternative reforestation proposals or divert focus from pressing issues related to forest regeneration.

> (...) I have difficulty considering assisted migration in restoration. We invest a lot in economic value. However, we're not doing as much for ecological restoration, which is why I think assisted migration is currently sold as insurance, an insurance policy for timber yield (FR 9).

> The problem is that we always want to provide the same amount of wood supply, when we must at some point find a way to slow down, and for that, I think diversified strategies are needed. (. . .) maybe we should also find a way for the next few decades to slow down harvesting and try to find diversification (FS 1).

Finally, the interviews highlighted that challenges such as uncertainties in the production of seeds for assisted migration, the risks of invasive species and the utilitarian perspective of forests point to the need for careful consideration and diversified strategies in forest management. Balancing economic value with ecological restoration is a significant concern among actors, emphasizing the importance of finding sustainable solutions that prioritize the long-term health and resilience of forests.

Trust and transparency

Regarding trust in the Quebec government, questions were raised regarding current management in the face of climate change and the possibilities for managing assisted migration. Despite occasional criticisms from certain respondents, the majority are optimistic about the possibility of public organizations in Quebec promoting the implementation of FAM (MM 2, 6; PFC 1; PFO 1; FS 2, 4). Among the criticisms, some interviewees questioned

the lack of transparency of projects and excessive centralization because "(...) a small group of people should not be responsible for the final decision without consulting other experts" (FS 1).

The interviews revealed that centralization is linked to the extent of decision-making authority and the transparency of the process. Participants frequently expressed a desire for increased social participation, emphasizing the need for transparency and trust in decision-making. While a few suggested that Quebec's current structure requires radical changes (FS 1, 3; FR 8; MM 2, 4), the consensus was that only minor adjustments are needed (FS 2, 4; PFO 2, 3; MM 2, 5).

Another interviewee expressed distrust regarding the way in which the proposal has spread, perhaps without due precautions: "So we replant based on economic profitability, but which does not consider the risks. Therefore, it's a big project that's underway, but it's happening very quickly" (MM 5).

Thus, the concept of transparency was emphasized in all the groups that were interviewed, with unanimous support for clear procedures as a means of upholding acceptance, engagement, and democracy in decision-making.

> It is super important to be honest regarding the level of knowledge we have, the degree of certainty we have. We must accept, we have to say, there are many things we do not know (...). I believe that stakeholders can collaborate more effectively, but concrete plans are needed. As mentioned earlier, transparency is key. If the plan is clearly outlined and communicated well, stating exactly what actions will be taken and where they will occur, for example, "We plan to implement this strategy across 25% or 2% of the territory," stakeholders will be more receptive. (FR 4).

In line with statements against centralization, interviewees highlighted that trust is proportional to different actors in the forestry environment when discussing FAM. In other words, the actors understand that there is a direct relationship between communication, participation and trust that must be discussed in the FAM development process in the province.

> (...) When engaging in direct dialog with those on the ground, such as professionals, the conversation becomes much more interesting, rich, and complex, fostering a greater level of trust. Professionals often have more influence over individuals than politicians do. It is easier to communicate directly with the people who will be doing the work, such as fixing the roof of your house. If you express a dislike for the color of the roof, it is a straightforward conversation. However, when the government dictates all roof colors, this becomes a different matter altogether. (PFO 5).

Discussions surrounding trust in the Quebec government in relation to forest management, especially in the context of climate change and assisted migration, have led to the need for a deeper assessment. Although there is optimism about the potential of public organizations to implement FAM, there are specific concerns related to the implementation of the strategy.

Overall, trust in government initiatives such as FAM depends on transparent communication, inclusive participation and collaborative efforts among diverse stakeholders, ensuring a balance between ecological priorities, economic interests and public trust in forest management strategies.

Purpose and values in a multifaceted context

In the final segment of our interviews, we asked participants to reflect on the purpose of FAM, considering the key factors discussed earlier, with emphasis on uncertainties, participation, trust in government, and operability. Reflecting on the core purpose of FAM provided some specific insights.

Consequently, the analysis of the interviews showed that despite the different experiences and particular roles of the actors in the forestry sector, the interviewees were similar in terms of priorities, needs and expectations. As we shall see, the understanding of how much the short-term effects of climate change echo in the sector and determine almost the entirety of action plans "Climate change is directly affecting the survival and growth of trees, making them more susceptible to pests and diseases" (FS 6).

The most cited concern is that the strong economic and financial interests in the sector could suggest an inappropriate purpose for FAM. While all interviewees acknowledged the forest's importance to the province's economy, they also emphasized the social and environmental values that serve as pillars of contemporary sustainability (Purvis et al., 2019):

> The companies' interest is now this: they want cheap wood, which, when processed, brings good dividends and provides good value to the shares. Reducing costs would mean having more cheap wood in the factory, and that does not match my vision of sustainable forest management (PFO 1).

With respect to the purposes of the FAM and other measures for adaptation to climate change, the actors noted that another plan must be developed to address the challenges of climate change, prioritizing the protection of biodiversity and social participation.

> More biodiverse ecosystems tend to be more resistant to disease, climate change and even fires. (...) I see this [CC strategies] as a proposal that is still in the early stages of study and discussion, especially regarding the possibility of assisted migration to trees. (...) However, for me, the most crucial aspect is the semantics of the discussion and the diversity of policies that promote popular participation, democratize knowledge and encourage open debates on how to improve and preserve our forests. This is vital not only for the economy but also for the health of local communities and forest ecosystems (FS 1).

The discourse in favor of biodiversity was frequently highlighted. Some recalled the importance of considering biodiversity studies in line with assisted migration research. In

TABLE 2 Attitudes toward FAM.

Favorable values	Values against
Benefits greater than impacts	Uncertainties
Risk of inaction	Natural resilience
Scientific capacity	Overly favorable to the forest industry
Biodiversity conservation	Precautionary principle

TABLE 3 Behavior toward FAM.

Support	Skepticism/rejection
Participation in pilot projects	Support for other measures
Trust in government	Disbelief in government
Participation and dissemination of studies	Disbelief in current science

short, many actors believe that FAM can be important for forest sustainability if the selection of species is not based solely on commercial factors.

Discussion

When carrying out this study, we identified common concerns among the actors, despite their functioning in different environments. In fact, it was possible to identify different degrees of knowledge among some, but everyone who was willing to talk to us already had a good basic knowledge about FAM. The greatest difference was the deeper level of knowledge of the ministry members, which allowed them to analyze the subject in more detail.

To understand the values derived, we outline in Tables 2 and 3 below the key differences between attitudes and behaviors concerning the topic. In this context, attitude signifies the inclination to act among the relevant stakeholders, whereas behavior pertains to the actual actions carried out. Essentially, attitudes influence behaviors (Batellier, 2016).

While there is variation in the interpretation of the assigned values, they can be either favorable or unfavorable to the FAM depending on the context. However, we have distinguished here how certain terms and values emerged in the interviews.

Despite the tables presenting the values fairly, the discussion does not seem polarized, meaning there are no extreme views on either side. Overall, there is a favorable inclination toward adopting the strategy, as long as it is performed cautiously and without neglecting other potential projects related to climate change adaptation.

We observed that the FAM in this study is associated with reflections regarding the notion of caution and the precautionary principle, crucial themes in environmental studies (Reed et al., 2018). In our approach, we consider risk management through the lens of the precautionary principle and caution, advocating for preventive actions in the face of scientific uncertainties, especially when there is the potential for serious or irreversible environmental damage (Myers, 2002; Newton and Oldfield, 2012).

Throughout the development of this study, we identified scientific uncertainty in environmental studies, including FAM,

as a crucial factor in guiding public policies. This observation was consistently highlighted by interviewees, scientific literature (e.g., Pelai et al., 2021b; St-Laurent et al., 2018), and government publications. In the qualitative data collected, the precautionary principle was frequently mentioned, particularly in the context of associated risks and the challenges of controlling long-term effects.

Challenges in terminology and communication

The challenges surrounding terminology and communication in the context of assisted migration strategies are multifaceted and require careful consideration. One of the primary issues identified in this study is the lack of universally accepted and clear terminology for assisted migration. This absence of standardized terms and scientific concepts has led to conceptual confusion and misunderstandings among both experts and stakeholders (Ste-Marie et al., 2011). Despite efforts over several decades to establish a cohesive terminology, variations persist. In this study, we adopted the term FAM, but there are other terms in use, such as "assisted tree migration," "assisted colonization," "managed relocation," and "assisted gene flow" (Benomar et al., 2022b). This lack of unity in presenting the strategy complicates communication efforts and can impede effective dialogue among researchers, policymakers and the public.

Moreover, communication challenges in Quebec are exacerbated by linguistic barriers between anglophone and francophone provinces (Sansilvestri et al., 2016). These linguistic differences can lead to misunderstandings and hinder the dissemination of information about assisted migration strategies. Additionally, weak intergovernmental relations among administrative authorities in forest management further complicate communication and decision-making processes (Gauvin, 2017).

> (…) the federal government does not truly have any influence on how provinces manage their forests [legally, in Canada the forest management is an area of provincial jurisdiction]. It is therefore more a matter of pressure exerted by different actors on the provincial government" (MM 5).

An important observation from our study is the limited participation of certain groups and associations, particularly among NGOs and representatives of private forest owners, due to their unfamiliarity with the FAM strategy. This highlights the critical need for enhanced communication efforts and social relations to bridge gaps in understanding and foster inclusivity in discussions about assisted migration.

Moving forward, we propose that addressing these challenges will require dedicated studies in the field of communication and social participation. By consolidating the terminology related to FAM and improving communication strategies, we can reduce barriers to public understanding, promote greater clarity, and facilitate successful dialogue regarding the objectives and implications of assisted migration strategies in Quebec and beyond.

The implementation of the FAM in Quebec

The implementation of FAM in Quebec is a topic that elicits mixed feelings among stakeholders. While there is a general trust in the capabilities of public authorities to carry out initiatives like this, it is not without reservations. Our studies have revealed that, overall, stakeholders appreciate the government's mobilization capacity, efficient organization, and access to technical resources, seen as crucial elements for the successful execution of intervention projects. However, these positive perceptions are accompanied by concerns regarding certain technical aspects of FAM implementation, such as seed production, proper species selection, and workforce availability.

Another concern involves uncertainties and hesitations regarding public participation in decision-making, raising questions about the effectiveness and social acceptance of the strategy. Although our study did not cover a large sample of stakeholders, the results align with broader trends observed in related topics (Yelle, 2013). Ultimately, for the success of the relationship between the state and society, it is crucial to address technical concerns, involve the interested population, and popularize the topic.

Comparative perceptions, Quebec vs. other Canadian provinces

Species assisted migration, the most intensive modality, which involves long-distance migration, was rejected by most of the respondents we interviewed. This situation aligns with several studies published in British Columbia (Hajjar and Kozak, 2015; St-Laurent et al., 2018). The reason could be associated with the greatest risk of a radical change in forest ecosystems. Thus, the use of native species is safer given prior knowledge and the possibility of resilience.

Among the groups studied, the differences in discourse between (i) researchers and members of ministries and (ii) private sector representatives, members of NGOs and private forest owners were highlighted. The former were much more certain potentials, risks, and implementation processes of FAM, while the latter were aware of how the strategy worked but uncertain of its necessity in the face of other available options. Thus, the degree of knowledge of FAM studies in the province increases the acceptability of and confidence in the relevance of the FAM strategy.

One element that appears underdeveloped in thinking about FAM is broadening the discussion with relevant organizations within and outside the province. Despite the impact of researcher networks and data sharing in the academic field (Benomar et al., 2022b), the analyzed discourses show the absence or lack of relationships in the forestry sector among Canadian provinces or among ministries in Quebec, such as the *Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs* (MELCCFP) and the *Ministère des Ressources Naturelles et des Forêts* (MRNF), in the technical field. However, FAM turns out to be an interesting strategy for provoking reflections from different institutional and informal authorities. As it is a controversial strategy, it works as an invitation to debate

human action, as well as the management of uncertainty (Lidskog and Löfmarck, 2015; Millar et al., 2007).

According to the semi-structured interviews, in response to the problem raised, we noticed that the main determining values of the social perceptions of actors regarding FAM are trust in the government, public participation and good communication. However, a lack of interest in participating in the interviews was identified on the part of representatives of the forestry industry (large forestry companies). Despite initial contacts, we also encountered difficulties in conducting interviews with indigenous groups in Quebec.

Conclusion

This study aimed to provide a critical reflection on the perceptions of professionals and researchers in the forestry sector about FAM. Although conducted in Quebec, we believe this qualitative research can serve as a reference for similar studies in other regions. Our interview model and the topics discussed—such as governance, level of social participation, social communication, and uncertainty forestry management—are relevant and have been addressed in other recent studies on FAM.

Given its interdisciplinary nature, encompassing social geography, sociology, and environmental sciences, this research offers a broad spectrum of assessments. This breadth can pave the way for more specific studies in the future, enriching the understanding of FAM and its implications across different contexts. In summary, our discussion on the values associated with the Quebec Forest has highlighted fertile ground for future social science research concerning the forest environment. It is imperative to expand studies among indigenous communities and conduct quantitative assessments covering the general population to gain a comprehensive understanding of stakeholders' perspectives.

The interviews provided valuable insights into the perception of FAM in Quebec, showcasing broad acceptance among the consulted groups while also revealing significant concerns related to FAM and forest management. However, nuanced perspectives and considerations emerged during these discussions. While there is a general acknowledgment of the risks associated with large-scale forest interventions, divergent views on the most appropriate types and intensities of interventions were evident, with FAM being one option among others but not universally favored or prioritized.

A key takeaway is the necessity of balancing economic interests with ecological restoration efforts, underlining the importance of a holistic approach to forest management. Concerns raised about the utilitarian perspective on forests underscore the need for integrating environmental sustainability with economic considerations.

In the field of governance, this study proves highly relevant for comparison in broader contexts. We identified several similarities with other environmental studies, not only in FAM but also in forest restoration (e.g., Derak et al., 2018), mining, and the management of protected areas. The findings emphasize key debates regarding decision-making, including challenges related to centralization, transparency, trust in authorities, and the expansion of social participation. Although specific studies in the socio-environmental field may present varied situations, they are likely to encounter similar debates.

In summary, FAM is considered beneficial, but many uncertainties remain about the ability to implement the FAM strategy on a large scale. Additionally, challenges such as uncertainties in seed production for assisted migration, risks of invasive species, and the need for diversified strategies in forest management were identified, highlighting the complexity of managing forest ecosystems in a changing climate.

The study also revealed specific challenges in disseminating knowledge about FAM in the forestry sector, with many potential participants expressing a lack of confidence due to insufficient knowledge. Addressing these challenges requires strategic knowledge dissemination efforts, such as providing educational resources and conducting outreach programs.

Moving forward, collaborative efforts among policymakers, scientists, stakeholders, and local communities will be essential in developing and implementing sustainable solutions that prioritize the long-term health and resilience of forests. Continued research and evaluation of intervention strategies, including FAM, while addressing broader societal and environmental implications, are crucial for effective forest management.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Comités d'éthique de la recherche avec des êtres humains de l'Université Laval. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin because many interviews were carried out remotely. Consent was tacit after the interviewee's rights were explained via email and subsequently recorded during the interviews.

Author contributions

FM: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review and editing, Validation. J-FB: Methodology, Supervision, Writing – review and editing. PR: Funding acquisition, Supervision, Writing – review and editing. AM: Funding acquisition, Supervision, Writing – review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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