forests

MDPI

Article

A Participatory Approach to Evaluating Strategies for Forest Carbon Mitigation in British Columbia

Guillaume Peterson St-Laurent [1,*], George Hoberg [2] and Stephen R. J. Sheppard [3]

1 Institute for Resources, Environment, and Sustainability, University of British Columbia, 2202 Main Mall, Vancouver, BC V6T 1Z4, Canada

2 School of Public Policy and Global Affairs, University of British Columbia, 6476 NW Marine Drive, Vancouver, BC V6T 1Z2, Canada; george.hoberg@ubc.ca

3 Faculty of Forestry, University of British Columbia, 2900–2424 Main Mall, Vancouver, BC V6T 1Z4, Canada; stephen.sheppard@ubc.ca

* Correspondence: peterson.guil@gmail.com; Tel.: +1-778-828-7968

Received: 26 March 2018; Accepted: 19 April 2018; Published: 23 April 2018

Abstract: To be successful, actions for mitigating climate change in the forest and forest sector will not only need to be informed by the best available science, but will also require strong public and/or political acceptability. This paper presents the results of a novel analytical-deliberative engagement process that brings together stakeholders and Indigenous Peoples in participatory workshops in the interior and coastal regions of British Columbia (BC) to evaluate a set of potential forest carbon mitigation alternatives. In particular, this study examines what objectives are prioritized by stakeholders and Indigenous Peoples when discussing forest carbon mitigation in BC's forests, as well as the perceived effectiveness of, and levels of support for, six forest-based carbon mitigation strategies. We start by describing the methodological framework involving two series of workshops. We then describe the results from the first round of workshops where participants identified 11 objectives that can be classified into four categories: biophysical, economic, social, and procedural. Afterwards, we discuss the second series of workshops, which allowed participants to evaluate six climate change mitigation strategies against the objectives previously identified, and highlight geographical differences, if any, between BC's coastal and interior regions. Our results effectively illustrate the potential and efficacy of our novel methodology in informing a variety of stakeholders in different regions, and generating consistent results with a surprising degree of consensus on both key objectives and preference for mitigation alternatives. We conclude with policy recommendations on how to consider various management objectives during the design and implementation of forest carbon mitigation strategies.

Keywords: climate change mitigation; forest management; forest carbon; preferences; deliberative-analytical process; British Columbia

1. Introduction

The management of forests has great potential to reduce greenhouse gas emissions and/or increase carbon removals from the atmosphere [1,2]. The way we manage our forests, the types of wood products we produce, and how we use and ultimately dispose of those products, can significantly influence the carbon balance of our forest sector. As with many other jurisdictions, the government of British Columbia (BC), Canada, envisions an important role played by forest management in reaching their climate change mitigation targets [3,4]. BC's 55 million hectares of forests (more than any European country except Russia), 95% of which are publicly owned, have an important role to play in the global carbon cycle [5]. Nevertheless, while the province has ambitious climate policies (e.g., the first revenue neutral carbon tax in North America), a recent study indicates that the province has few effective policies targeting forest carbon management [6]. In addition, BC's forest carbon offset program, which is arguably the most significant policy dealing with climate change mitigation in the forests to date, faces important barriers and limitations [7,8]. While the Climate Leadership Plan announced by the province in 2016 promised a Forest Carbon Initiative, very little concrete information has been provided as to how this will translate into on-the-ground actions other than one general funding announcement [4,9].

To be successful, actions for mitigating climate change will not only need to be informed by the best available science, but will also require political and social acceptability, particularly since forest management entails a diversity of multifaceted, interconnected, and competing values [10]. In effect, sustainable forest management necessitates an integrated approach that balances economic (e.g., timber harvesting, forage), environmental (e.g., biodiversity, erosion, carbon sequestration), social (e.g., recreational, employment), and cultural (e.g., well-being, spiritual) uses, values, and interests that all need to be considered [10–12]. Because of this complexity, decision-making on forest management benefits from involving interested or affected actors "to ensure that all relevant information is included, that it is synthesized in a way that addresses the parties' concerns, and that those who may be affected by a risk decision are sufficiently well informed and involved to participate meaningfully in the decision" [13] (p. 30). Such a participatory approach ensures not only that all values are considered, but also that the resulting strategies benefit from public acceptability, legitimacy, and credibility.

This paper presents the results of a novel analytical-deliberative engagement process that brings together stakeholders and Indigenous Peoples in participatory workshops across the province to evaluate a set of potential forest carbon mitigation alternatives. By doing so, we answer two main research questions:

1. What main objectives do stakeholders and Indigenous Peoples prioritize when discussing carbon mitigation in BC's forest sector?
2. What are BC's stakeholders and Indigenous Peoples' preferences for, and perceived acceptability, credibility, and effectiveness of, climate change mitigation options in BC's forest sector?

Importantly, Indigenous Peoples in BC and in Canada have distinct legal rights and title to the land and natural resources and do not view themselves as normal stakeholders (for more details, see [14,15]). We will therefore make a distinction between Indigenous Peoples and non-indigenous stakeholders throughout the paper. Importantly, this distinction is only used in the manuscript—Indigenous People participants were included and treated as all other participants during the engagement process.

This engagement is part of a larger research project, the Forest Carbon Management Project (hereafter "larger research project"; this project is funded by the Pacific Institute for Climate Solutions), which aims to generate recommendations for regionally specific forest carbon mitigation activities for BC's forests, while maximising the environmental, economic, and social benefits. We begin by providing an overview of forest carbon management in BC, followed by a presentation of our methodological framework with detailed summaries of analytical-deliberative processes in general, and our analytical-deliberative province-wide engagement process specifically. Subsequently, we discuss the results of the engagement process, revealing the values that should be considered when developing and evaluating forest carbon management strategies, as well as the outcomes of the multi-criteria evaluation of six mitigation strategies, highlighting key trade-offs and geographical differences between BC's coastal and interior regions. Finally, we present individual participants' levels of support for the different strategies, including regional and sectoral discrepancies, and discuss implications for forest carbon management.

2. Forest Carbon Management in British Columbia

The forest carbon cycle comprises various pools amassing or releasing carbon, including components of forest ecosystems, such as biomass (e.g., plants and trees), soil, dead organic matter and litter, and pools from the forest product sector (e.g., wood in construction) [1,2]. A forest's net » (GHG) emissions result from the difference in the transfer of carbon between these pools. While a forest can represent a carbon sink when it removes more carbon than it emits into the atmosphere, it can also act as a carbon source when it emits more carbon than it removes. Taking into account all carbon pools, BC's forests acted as a carbon sink between 1990 and 2002, but became a net carbon source in 2003 and have emitted more than they sequestered ever since [5]. This shift from sink to source is mainly due to an increase in wildfires and the large number of trees killed by the mountain pine beetle outbreak [16,17].

Incremental activities that reduce GHG emissions from forests or increase removals of carbon from the atmosphere compared to business-as-usual activities are considered forest carbon mitigation actions. The evaluation of an action's net effect on GHG emissions or removals requires a systems perspective that accounts for its impact on: (1) forest ecosystem emissions and removals; (2) storage of carbon in wood products; and (3) substitution effects, which are the impact of substituting wood products for other products (e.g., cement, steel) and fossil fuels (e.g., natural gas, coal) that are more emissions-intensive on a life cycle basis [18–21]. From a climate perspective, there are therefore important alignments and trade-offs between increasing carbon storage in forest ecosystems and seeking to obtain mitigation benefits through the use of wood.

For the purpose of simplicity, possible mitigation strategies in BC's forests can be classified into three main categories (inspired by [19,20]). The first category refers to activities targeting the preservation of existing forest areas through reduced deforestation or the increased expansion of forest areas through afforestation. The second category involves maintaining or increasing forest carbon density (i.e., the quantity of carbon sequestered in a given area of forest). To do so, various sustainable forest management strategies can be implemented, including conservation approaches, silvicultural activities that increase growth rates and carbon uptake of trees, harvesting practices that reduce carbon losses (e.g., avoided slash burning), and efforts to reduce the impacts of natural disturbances. The third set of strategies relates to the use of wood products to generate off-site carbon stocks and replace energy-intensive products and fossil fuels.

3. Methods

3.1. Analytic-Deliberative Processes

Public and stakeholder engagement and participatory processes in environmental and natural resource management have become increasingly prominent over the past several decades [22,23]. Accordingly, a variety of tools and methods have been developed to incorporate the perspectives of various groups in the decision-making process [24]. Of particular interest here are methods combining quantitative, scientific, and analytical methods with deliberative and participatory components, known as analytic-deliberative processes [13,25]. By "reconcil[ing] 'technocratic' and 'citizen-centric' approaches" [26] (p. 300), analytic-deliberative methods offer attractive alternatives to traditional participatory processes. The analytic component implies the use of precise, reproducible, reliable, and agreed upon procedures, enabling the structuring and resolution of factual problems. In contrast, deliberation involves a process of discussion, debate, and rational argumentation where participants share their positions, try to convince each other, and improve their understanding. Within analytic-deliberative, the two components complement each other: the analysis provides information, knowledge, and structure to deliberation, which in turn informs what type of analysis is needed.

One such analytic-deliberative process, multi-criteria decision analysis (MCDA), represents an appealing approach that facilitates and structures the decision-making process. Primarily conceived as technical approaches to be used by a single decision maker [24], MCDA methods have evolved to integrate stakeholder inputs and concerns in the field of forest management [11,27,28]. Insights for developing structuring processes can also be acquired from Structured Decision Making (SDM) [29–31]. One of the main differences between SDM and conventional participatory MCDA is the emphasis put by the former on the problem structuring process, whereas the latter often focuses on finding a prescriptive (and often quantitatively supported) solution. By focusing on the structure rather than the outcome, SDM proposes a transparent, inclusive, and methodical approach that prioritizes participants' identification and in-depth understanding (and sometimes transformation) of their values and how they relate to the problem at stake. While both methods have already been used in Canada and globally to tackle diverse forest management problems [11,27,28], they are not currently in wide usage for decision-making on complex trade-offs for forest carbon solutions.

In general, participatory MCDAs and SDM share at least five steps, although their names and order of occurrence vary:

1. Clarification of the decision context: The main objective is to identify the problem or question being addressed and who should be involved in the process.
2. Structuring of the decision problem: This step involves the identification of evaluation criteria (also termed values, objectives, or points of view) with which the alternatives will be assessed.
3. Identification and outline of alternatives: The objective of this phase is to produce and describe a set of alternatives that can be evaluated and compared by the participants.
4. Elicitation of preferences: The goal of this step is to elicit participants' preferences, that is the evaluation of the importance of the criteria and alternatives.
5. Trade-offs among alternatives: In this final step, the preferences or weightings elicited both for criteria and alternatives are pooled together to rank the alternatives and highlight trade-offs.

3.2. Data Collection

The engagement process presented in this study is separated into three phases based on the five steps of MCDA and SDM (Figure 1), including two cycles of workshops. All the workshops were led and moderated by the first and second authors of this paper.

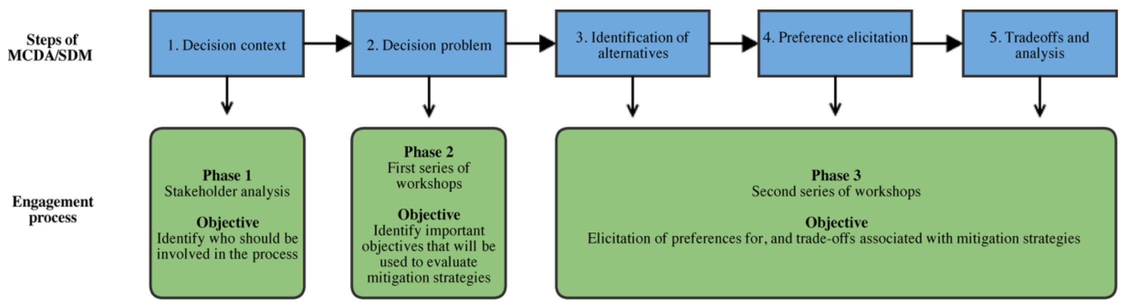

Figure 1. Overview of three phases of engagement process and how they integrate the five steps of multi-criteria decision analysis/Structured Decision Making.

In order to identify regional divergence, the engagement process focuses on four locations in two main forestry regions of the province: the coast (Vancouver and Nanaimo, BC, Canada) and the interior (Kamloops and Prince George, BC, Canada, Figure 2). While variations exist within these two regions, the coastal region is principally composed of older mild temperate rainforests characterized by infrequent disturbance patterns and a high carbon density; the drier and cooler interior region is typically the home of younger forests that face a higher frequency of fires and pest outbreaks that often prevent landscapes from reaching and maintaining the maximum carbon storage characterizing old-growth forests [32,33]. For the purpose of this paper, we will compare the combined results of the coastal (Vancouver and Nanaimo) and interior (Kamloops and Prince George) forestry regions.

Figure 2. Map showing the locations where the engagement process was carried out.

3.2.1. Stakeholder Analysis

Carrying out a stakeholder analysis [34,35] is a key step in ensuring that all concerned parties are considered during the consultation process [28]. We first created a list of categories of potential forest users and/or individual/groups that may be interested in or affected by mitigation activities in BC's forests: (1) forest industry; (2) other forestry professionals (community forests, consultants); (3) regional/local government; (4) Indigenous People; (5) non-government organizations (NGOs); (6) academia; (7) carbon offset companies; and (8) bioenergy companies. We then identified and classified potential organizations and individual participants in each category for the four areas previously identified areas. To do so, we used a variety of sources, including demographic information, previous government and other agency consultation processes, forest companies, and NGOs. We selected additional participants with the help of iterative identification—when previously unknown individuals contacted for the purpose of this study point out other potential participants [36]. While efforts have been made to ensure representativity (i.e., we made sure that we had at least five invitees for each groups of actors in each region), we did not exclude any potential participants, meaning that invitations were unevenly distributed between categories of actors (i.e., there are more NGOs and forest professionals than carbon offset and bioenergy representatives). Furthermore, final participation strongly depended on participants' availability. Consequently, it is important to acknowledge that unequal sectoral representation may have affected the dynamics of the workshops and the results.

3.2.2. First Series of Participatory Workshops: Objective Identification

The second phase of the engagement process involved a first round of participatory workshops with the goal of identifying a list of important objectives to be considered when generating and evaluating climate change mitigation strategies for BC's forests. In this first round, we held five 3.5-h workshops between February and March 2016 in the two pre-identified regions: coast (two workshops in Vancouver, one in Nanaimo (because of the larger number of interested participants, two workshops were held in Vancouver) and interior (one workshop each in Kamloops and Prince George). A total of 76 participants from different groups of actors with interest in, and knowledge of, BC's forests participated in these workshops (Figure 3). While the different groups of actors were not equally represented in the workshops, the format of the workshops (i.e., deliberation rather than voting model) ensured that all groups were able to state their views.

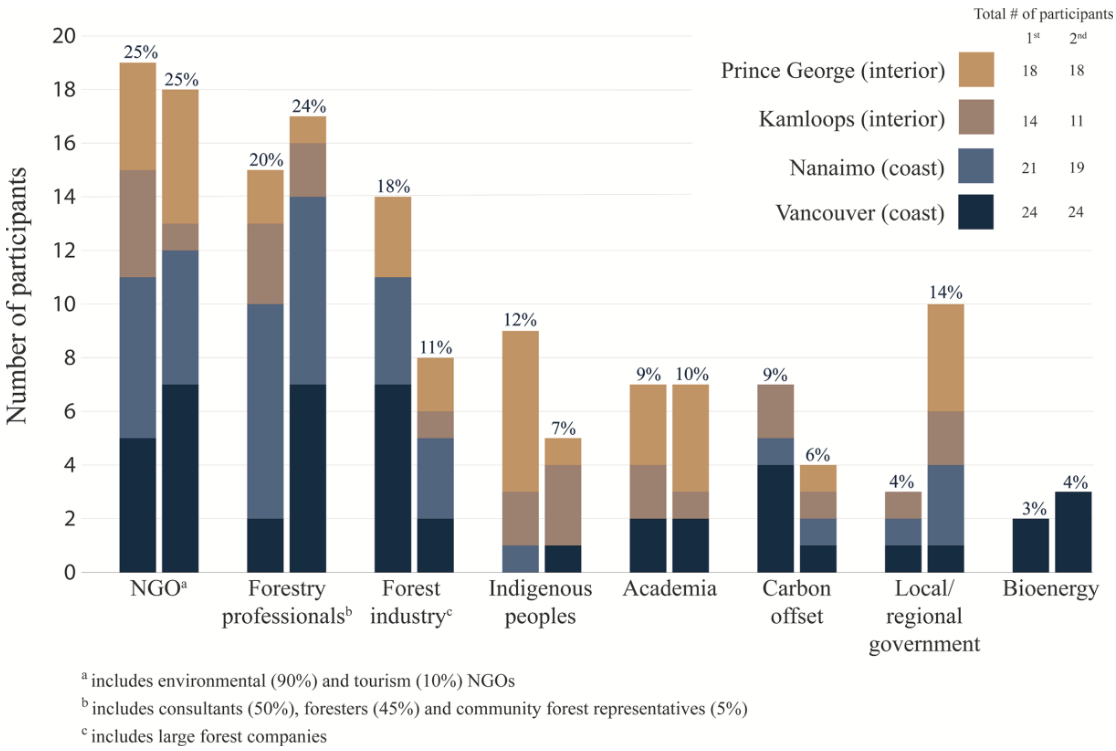

Figure 3. Representation (number of participants) by region of different groups of actors during the two series of participatory workshops: 1st round February–March 2016, 2nd round May–June 2017. Percent of total participants for each group and total number of participants at each series of workshops is also shown.

Since workshop participants had very different levels of knowledge of forest carbon management (i.e., some were experts working in the field while others had no previous experience with the subject), we started the workshops with a short presentation providing an overview of the different climate change mitigation options available in BC's forests to ensure that all participants had a basic understanding. An illustrated primer on forest carbon mitigation in BC, created for the purpose of this engagement process, was distributed to the participants one week prior to the workshop (supplementary material titled "Primer first series of workshops"). The primer provides a general overview of the carbon cycle, the role of BC's forests in mitigating climate change, and potential mitigation strategies. This primer does not specifically introduce the mitigation strategies evaluated in the second series of workshops.

We then asked participants to identify through deliberation the main objectives that should be considered when evaluating climate change mitigation strategies in BC's forests. Building on the methodology of SDM, objectives were defined as "what really matters" when evaluating forest carbon mitigation strategies [29]. Objectives are usually constructed with a verb that indicates the desired direction (e.g., increase, minimize, maximize) and should focus on "ends", that is the results that we want to achieve, rather than on "means", the actions to be undertaken. Participants were clustered into small groups of three to five individuals, making sure that each contained a diversity of groups of actors. We encouraged each group to reach agreement on a set of objectives and sub-objectives through discussions. Group results were then presented and discussed in plenary. An agreement was reached when all workshop participants agreed on a final list of objectives.

After completion of the workshops, we created an aggregated list of objectives. We first coded the objectives based on their workshop of origin. In an attempt to create a consensus list of objectives without outliers (i.e., objectives that only convey the opinion of a small proportion of participants), we eliminated any objectives that were not identified in more than one workshop. We then combined together the objectives that had the same or very similar meaning, making sure to keep, as much as possible, the wording used by the participants. During this process, some objectives were transformed into sub-objectives, defined as "clarification of what is meant by the objective"; sub-objectives are mostly useful for providing more details about what is meant by a more general objective [29].

Following the workshops, we invited participants to complete an online follow-up survey distributed using Fluidsurvey. A total of 52 out of 76 participants responded to the survey (68% response rate). Participants were asked to describe their overall level of agreement with the aggregated list of objectives using a five-point continuous interval scale. A majority of respondents (84%) either "agreed" or "strongly agreed" with the list of objectives identified during the workshops. Because of this level of agreement, no subsequent modification was made to the list of objectives. We also asked participants to weight the relative importance of the objectives by answering the survey question using a nine-point continuous interval scale, from 'not important at all (0)' to 'very important (8)'.

3.2.3. Second Series of Workshops: Evaluation of Mitigation Strategies

The third phase of the engagement process aimed to allow stakeholders and Indigenous Peoples to evaluate six climate change mitigation strategies (see Table 1 for description) against the objectives previously identified. Five of the strategies affect the management of forest ecosystems, whilst the sixth deals with the use of wood and its allocation to short- and long-lived product types. It is important to note that the strategies being examined in this study are not the full suite of mitigation alternatives, and some options, such as those related to preserving existing forest areas (i.e., reduced deforestation) or creating new forest areas (i.e., afforestation), are not included.

Table 1. Climate change mitigation strategies evaluated by stakeholders and Indigenous Peoples during the participatory workshops of phase 3.

Strategy	Description
Bioenergy	A recovery of a portion of harvest residues for local bioenergy production to replace fossil fuels.
	A reduction of on-site burning of harvest residues (pile-burning of slash).
Higher Utilization	Higher utilization of wood from harvest cut blocks so that more wood is extracted per hectare, thereby lowering the area harvested while keeping the harvest volume unchanged.
	Increased proportion of salvage harvesting, referring to the harvesting of trees in forests affected by natural disturbances such as fire and insects, to replace green tree harvesting.
Longer-lived wood products (LLWP)	The production of a commodity mix shifted towards a greater proportion of longer-lived products (sawnwood, other solid wood, and panels), at the expense of pulp and paper products. Both the baseline harvest volume and the proportion exported for each product are assumed to remain unchanged.
Reduced harvest	A reduction in harvest with a corresponding decrease in production of wood products.
Rehabilitation *	The reforestation of underproductive sites where no trees would otherwise be planted.
Old growth conservation	Prevent the harvesting of old growth forests, defined as stands older than 250 years old.

* Not included in modelling [37].

Four one-day participatory workshops (7.5 h each), held during May and June 2017, revisited the same four locations as the first series of workshops (Figure 2). Participation in the first series of workshops was not a prerequisite to be invited. In total, 72 participants from the eight different groups of actors took part in the workshops (Figure 3), out of which 44 (61%) also participated in the previous series of workshops.

The first hour of the workshops was devoted to presenting the six mitigation strategies (Table 1) that would be evaluated and the set of objectives that would be used to evaluate them. The presentation mainly revisited the information found in a consultation document (supplementary material titled "Primer second series of workshops") that had been provided to the participants in preparation for the event and describes in detail the whole process, the objectives, and the strategies [38]. Five of the evaluated strategies originate from a parallel study [37], independent of the engagement process, that was carried out by a team of multidisciplinary experts from the overarching project. At least one member of this team attended each of the workshops as technical experts. The parallel process involved the development of strategies and the modelling of their climate change mitigation potential, financial, and socioeconomic impacts for the years 2017–2050 (more details on the strategies and the modelling exercise can be found in [37]; Table S1 identifies the outputs of the biophysical and socio-economic modelling that were provided to workshop participants). Late in the process, a sixth strategy, rehabilitation, was added because it had subsequently been proposed by the government of BC as a potential mitigation strategy in the Climate Leadership Plan [4] and was included in the BC government's Forest Carbon Initiative announced in February 2017. Time constraints did not allow for modelling of this rehabilitation strategy to be carried out. However, since it may represent an important mitigation strategy for the BC government, we decided to introduce it in the engagement process, acknowledging that the lack of modelling results represents a limitation.

We asked participants to evaluate in small groups (three to six people) each of the six strategies against the objectives. Each group purposefully contained a diversity of actors and was assigned a moderator who took detailed notes of the main issues and trade-offs discussed. The groups in Vancouver and Nanaimo evaluated the strategies for the coastal region, whereas participants in Kamloops and Prince George evaluated the strategies for the interior region. To keep the process straightforward for participants, a simplified value measurement technique inspired by the Simple Multi Attribute Rating Technique (SMART) was used [39–42]. The small mixed groups were asked to evaluate through consensus rating the performance of each strategy against each objective with the use of an 11-point continuous scale (from 'very good' to 'very poor'; modified from [43]).

To conclude the workshops, results of the evaluation exercise were presented back to, and discussed with, the participants in plenary. Participants were also allowed to raise questions and/or comments about the engagement process, the modelling methodology, and results, and to converse about their experience during the workshop (e.g., what they learned/observed, what they liked/disliked). Before leaving, participants filled in a short survey where they were asked to provide their individual levels of support for the strategies using a five-point continuous interval scale.

3.3. Data Analysis

Both descriptive and inferential statistics were performed in R Studio (version 1.0.153, Integrated Development for R. RStudio Inc., Boston, MA, USA, http://rstudio.org/). Because of the ordinal nature of continuous interval scales, we used nonparametric tests (Mann–Whitney *U* test and Kruskal–Wallis one-way analysis) to compare the perceived importance of the objectives by regions (first series of workshops), and individual levels of support for the various mitigation strategies by regions and groups of actors (second series of workshops). This was to permit analysis of differences between the original stakeholder groups represented by participants.

For analysis purposes, the 11-point continuous linguistic scale used for the group evaluation of the mitigation strategies was transformed into numeric scores. A cumulative derived preference for each strategy was calculated by summing, for each objective, the product of the aggregated individual weighted importance of an objective (score out of eight; first series of workshops) and the mean score of the strategy when evaluated against that objective (second series of workshops). The resulting score was the transformed into a percentage by dividing it with the maximum possible score of a strategy.

4. Results and Discussion

4.1. Final Aggregated List of Objectives and Their Relative Importance

Over 30 objectives were identified by participants during the five workshops, and an aggregated list of 11 objectives and their sub-objectives was later generated by the research team based on the results of the workshops (Figure 4). The objectives can be classified into four categories based on their primary focus: biophysical, economic, social, and procedural. For the purpose of this paper, we kept the objectives and their categorization as close as possible to the participants' definitions and classification during the workshops, even though some sub-objectives could better fit into another category (e.g., increasing sustainable economic opportunities and local government revenues would be better classified as economic instead of social sub-objectives).

The objectives identified by our workshop participants are generally comprehensive and similar to general studies on forest values (for examples see [12,44,45]). In particular, the economic, biophysical, and social categories of objectives consistently appear in most studies focused on general forest values, although the terminology used varies (e.g., ecological, environmental, cultural, socio-cultural). Interestingly, procedural objectives are less frequently highlighted by these studies, even though the category appears in many well-known lists of criteria and indicators, often under a category referring to policy, legal, and/or institutional issues [46–48]. Other studies, by analysing public participation in forest management, specifically focus on procedural objectives [49].

BIOPHYSICAL

INCREASE CLIMATE CHANGE ADAPTATION AND FOREST RESILIENCE.
Increase the natural capacity of BC's forests to:
· adapt to climate change
· respond to climate change perturbations by resisting damage and recovering quickly

MAINTAIN ECOSYSTEM SERVICES.
· maintain water quality and quantity
· maintain air quality
· maintain soil quality
· maintain recreational, cultural and spiritual opportunities

MAINTAIN EXISTING BIODIVERSITY.
· ensure biodiversity conservation
· ensure the protection of natural old growth forests

MAXIMIZE THE CLIMATE CHANGE MITIGATION POTENTIAL.
· maximize carbon sequestration from BC forests and forest sector
· minimize greenhouse gases emissions from BC forests and forest sector

PROCEDURAL

ENSURE EVIDENCE-BASED DECISION MAKING
Ensure that future forest carbon mitigation strategies make use of:
· the best available science
· First Nations traditional knowledge.

RECOGNIZE INDIGENOUS PEOPLES RIGHTS AND CLAIMS TO FOREST LANDS.
· recognize Indigenous Peoples existing titles and claims
· respect Indigenous Peoples rights
· ensure inclusion of Indigenous Peoples in decision-making

SOCIAL

ENSURE SOCIAL LICENSE AND POLITICAL FEASIBILITY.
Ensure that future forest carbon mitigation strategies make use of:
· ensuring participation and public sense of ownership
· promoting public awareness
· maximizing administrative flexibility, adaptability and feasibility

INCREASE RESILIENCE OF LOCAL COMMUNITIES.
· increase sustainable economic opportunities
· increase local government revenues
· increase local participation in decision-making

ECONOMIC

INCREASE ECONOMIC OPPORTUNITIES FOR INDIGENOUS PEOPLES.
· increase generated revenues
· increase employment
· increase professional development

INCREASE PROVINCIAL NET ECONOMIC BENEFITS
· increase industry competitiveness
· maximize efficiency of resource use
· increase the production of value-added products (e.g., long-lived wood products)

INCREASE PROVINCIAL SOCIOECONOMIC BENEFITS.
· maximize direct employment from the forests and forest sector
· maximize indirect employment from the forests and forest sector

Figure 4. List of the 11 key objectives and sub-objectives for evaluating BC's forests carbon mitigation strategies by categories. The sub-objectives reflect what was discussed in the workshops and may only partially describe the scope of the objectives, meaning that specific issue (e.g., aesthetic values) may not be represented in the list.

The perceived importance of the 11 objectives based on a nine-point continuous interval scale aggregated across all participants is illustrated in Figure 5. All of these objectives are rated on the higher end of the importance scale, though the biophysical objective tended to be the highest rated and the economic objective the lowest rated. These results are in line with previous studies evaluating public priorities for forest management in BC, which generally find a preference for environmental values over social and economic values [12,45]. Our study also highlights the high importance of procedural objectives, indicating that stakeholders and Indigenous Peoples are as concerned about the fairness, effectiveness, and inclusiveness of the decision-making process as they are about its outcomes [49,50].

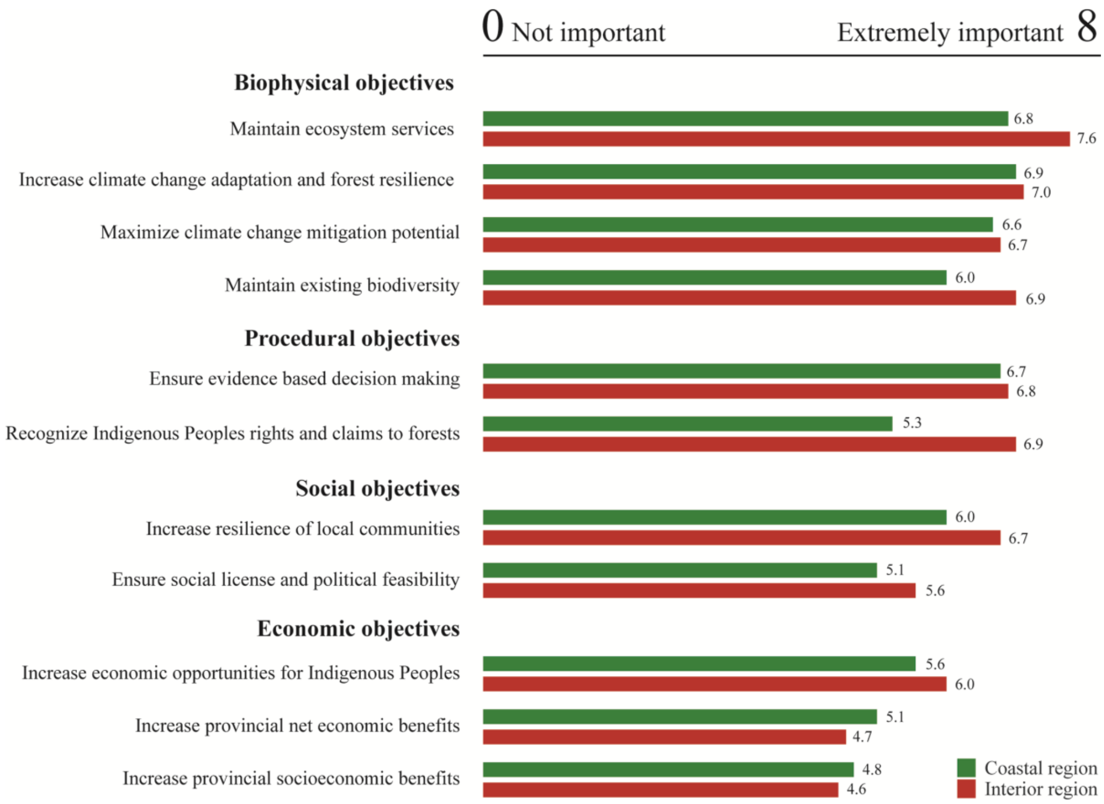

Figure 5. Weight of the objectives for the coast and the interior regions, where 0 = not at all important and 8 = very important.

Perhaps the most important result lies in the finding that mitigating climate change, while perceived as important, is not considered as the highest priority, but as just one of many objectives that should be considered when developing forest carbon management strategies. Three other objectives rank higher in terms of relative importance in the Coastal region, and five other objectives in the Interior. This result is consistent with discussions worldwide about the important of considering co-benefits (e.g., poverty reduction, biodiversity conservation, and increase in soil and water quality) when using forests to mitigate climate change [51,52].

In general, there is little divergence in the weighting of the objectives between the two regions, with the only statistically significant difference found for "recognize Indigenous Peoples rights and claims to forest land" (Mann–Whitney $U = 201.5$, $p = 0.02$), where the average score in the interior (7.92) was significantly higher than on the coast (6.33). This result can be partly explained by the fact that Indigenous People's attendance was strongly weighted toward the interior (all indigenous participants but one). One could also expect that an overall greater representation of indigenous participants, which was relatively low at 12%, would have increased the perceived importance of the two objectives associated with indigenous peoples.

4.2. Evaluation of the Six Mitigation Strategies

4.2.1. Group Evaluation: Performance of the Strategies against the Objectives

This section presents results from the evaluation of the strategies against the objectives carried out during the second series of participatory workshops. As noted above, at each workshop, groups of participants with a diversity of actors were asked to develop consensus evaluations. In this section, the group evaluations are discussed, along with views of participants more generally. Importantly, participants in all workshops agreed that the procedural objectives should be excluded from the evaluation because they are mainly on the process and are not relevant to the assessment of the strategies. Figure 6 highlights the performance of the strategies against each of the nine other objectives (Table 1) for the coastal and interior regions, whereas Figure 7 shows the cumulative derived preference for each strategy. The next sections describe in detail the performances of the strategies against the objectives, the regional differences, if any, and the main points of discussion during group deliberation.

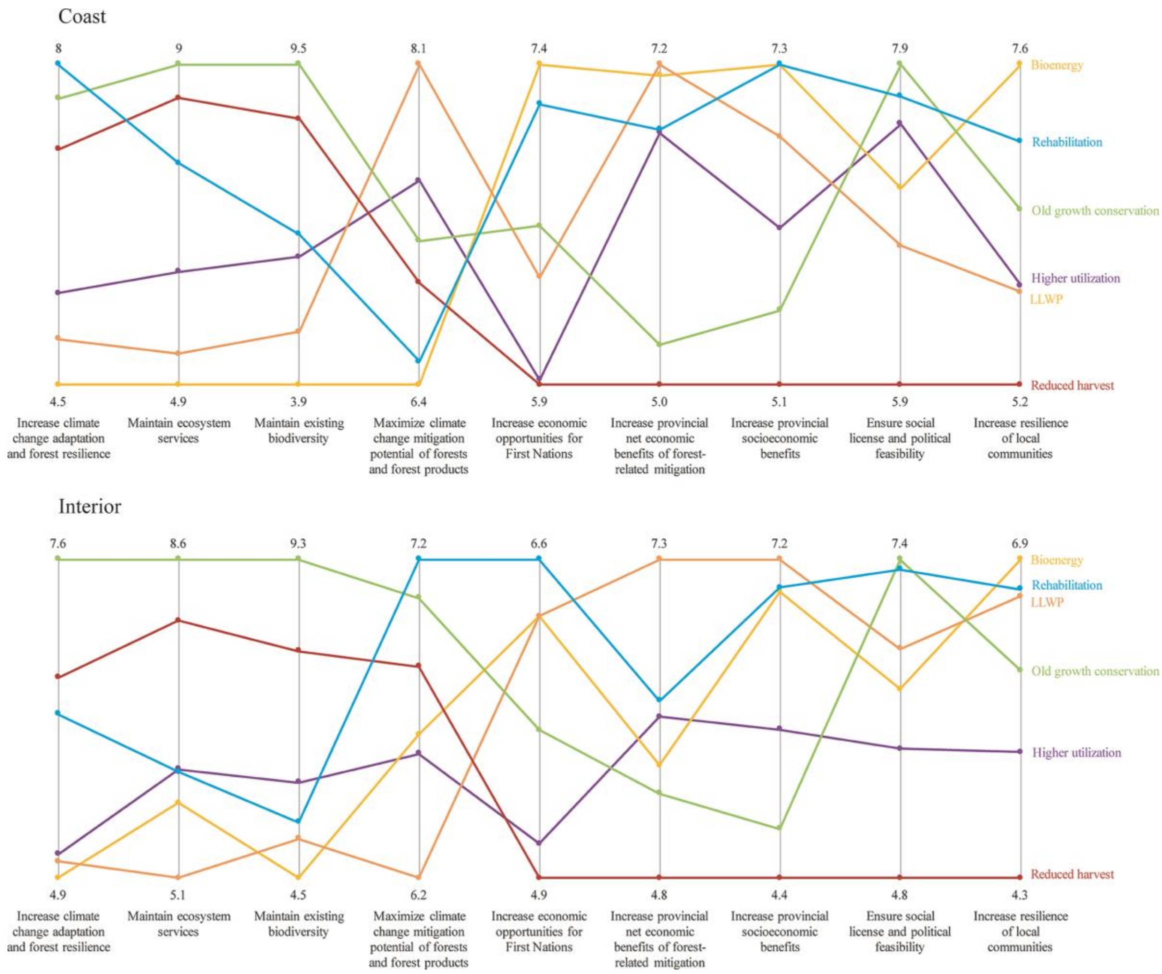

Figure 6. Average score of the six strategies on performance against each of the nine objectives for the coast (Nanaimo and Vancouver) and the interior (Kamloops and Prince George). The values are normalized (from 0 to 1) from the average score (from 0 = very poor to 10 = very good), with each vertical axis representing the scores of the strategies against one objective. The minimum and maximum average scores (out of 10) across scenarios are also shown in numbers at the top and bottom of the graph.

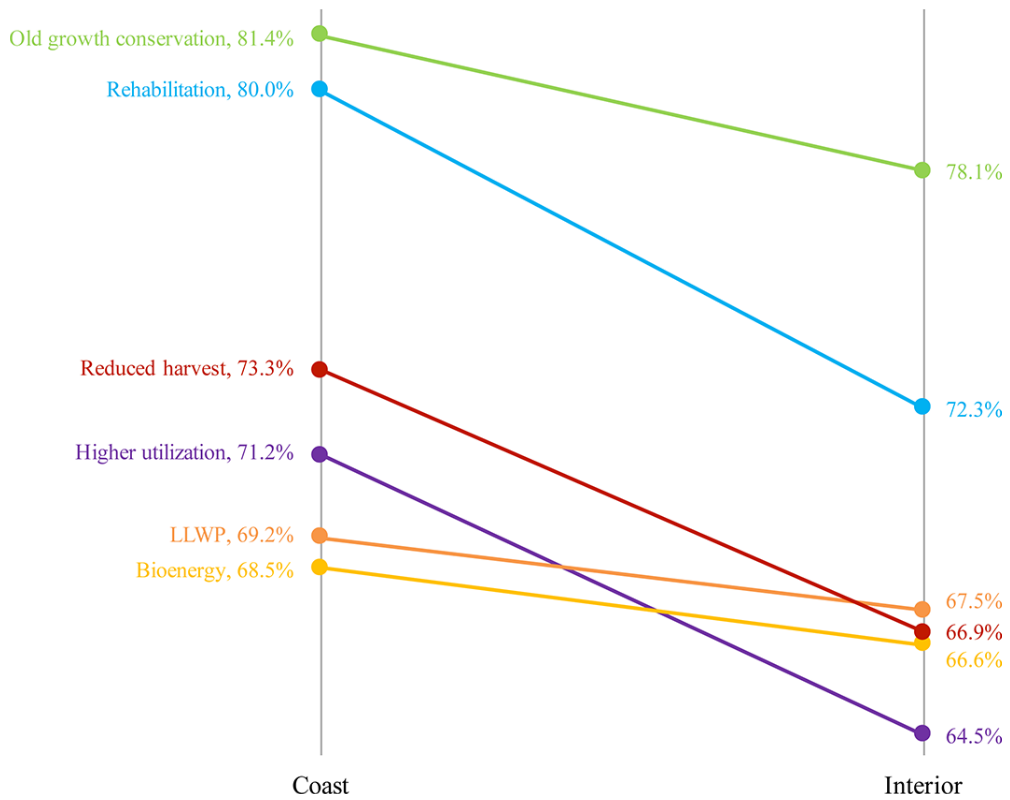

Figure 7. Average cumulative derived preference for the six strategies on the coast and the interior. The derived preference of each strategy was calculated by summing, for each objective, the product of the average performance of a strategy against an objective (Figures 6 and 7) with the weight of this objective (Figure 5). The resulting score was transformed into a percentage by dividing it with the maximum possible score of a strategy.

Bioenergy

The evaluation of the bioenergy strategy was mainly consistent in both regions. The strategy scored relatively low against the biophysical objectives, mainly because of concerns that removing an excessive amount of coarse woody debris, which holds a key role in providing nutrients and habitats to plants, animals, and insects, could lead to soil disturbance and negatively affect ecosystem services and ecological habitats (for instance, see [32]). Consequently, many participants agreed that sustainable harvesting of residues should be ensured by identifying the ecologically valuable proportion of the biomass that should be left on the forest floor (discussed in [53]). Participants did not appear to associate bioenergy use from forest thinning for fire risk reduction as a climate change adaptation strategy, or a potential win-win strategy (see [54]).

Participants generally recognized the mitigation potential of limiting wood waste at harvest and using a portion of harvest residues for energy to replace local fossil fuel use, especially since the carbon would otherwise be emitted to the atmosphere, either progressively through decay or immediately through slash-and-burn, as discussed by Miner, et al. [55] and Smyth, et al. [56]. Participants insisted that bioenergy should only be used to replace emission-intensive fossil fuels such as coal and diesel, but not clean energy (for example, see [57]). Many groups also discussed the fact that the strategy would be most effective in the context of off-the-grid remote communities that are using emission-intensive energy sources like diesel (discussed in [58]). Although it was not analysed or presented to participants, many wished to stress that standing live trees should not be harvested to produce bioenergy. Standing live trees are typically not harvested for bioenergy in BC since they typically provide greater mitigation potential when used in long-lived wood products rather than to produce energy, which offers no or very little emission reductions (discussed in [5,59]). Some participants believed that the GHG emissions generated by the transportation of harvest residues to the processing plant should be considered to ensure the climate effectiveness of the activity.

The strategy scored relatively high against economic and social objectives. Many groups anticipated that this strategy could lead to the creation of a new industry, involving the construction of a "bioenergy grid" and numerous processing plants with the potential to stimulate economic and local development and generate employment in many regions. Some participants also highlighted technical issues associated with transportation (i.e., extensive distance between residues and processing plants) and the high upfront cost of building new processing plants, and questioned the cost-effectiveness of the strategy compared to other options. Finally, while many participants believed that the strategy would receive public and political support, some feared that bioenergy is still perceived as a "dirty industry" because of air pollution.

Higher Utilization

Most groups were supportive of the strategy, mentioning that there is a great need to improve harvesting practice to reduce waste that could otherwise be utilized. However, the strategy's low cumulative derived preference (Figure 7) can be partly attributed to the fact that many participants expressed doubts regarding its technical feasibility. While they agreed that gains at harvest can be made in some areas (i.e., it is possible to extract and make greater use of harvested material), reservations were expressed regarding the assumption that the same quality of wood products could be produced with the extra wood extracted. This feeling was stronger in the interior, where many participants judged that forest companies already maximize the amount of wood they can cost-effectively extract from harvested areas.

Similar to the bioenergy strategy, some participants explained that removing an excessive amount of wood debris could negatively affect climate change adaptation and forest resilience, ecosystem services, and biodiversity. Nonetheless, some participants advocated the strategy for its potential to lower the area harvested each year (because more wood is extracted per hectares, a given harvest volume can be achieved from less area). Higher utilization scored relatively high in terms of its climate change mitigation potential, with many participants highlighting the benefits of reducing both the amount of harvesting waste left to decay or to be burned on site and the area harvested while maintaining carbon transfer into wood products (discussed in [5,56]).

Many groups claimed that "reducing waste" in the forest sector would receive significant social licence due to the negative perception associated with big slash piles. The strategy's relatively low performance against the economic and social objectives is partly due to the technical reservations previously discussed and the high perceived cost associated with implementing the strategy.

Longer-Lived Wood Products (LLWP)

Participants from both regions highlighted the fact that producing a higher proportion of longer-lived wood products to the detriment of pulp and paper products did not really affect forest management on the ground and therefore had no real impact on the first three biophysical objectives (most groups gave a neutral score).

Participants from both regions agreed that there should be a positive climate change mitigation potential. While the strategy scored higher than all other strategies in relation to mitigation potential on the coast, it was perceived as a relatively less effective strategy on average in the interior. This discrepancy can be explained by the concerns brought up by various participants in regards to what percent of the carbon removed through harvesting was considered to remain stored and the extent to which there would be substitution in wood products. In effect, without contesting the benefits associated with the production of wood products, some participants highlighted the uncertainties associated with factors used to calculate carbon storage and displacement effects (for instance, see [53,56,60]), expressing a concern that the current numbers may overestimate the benefit of using harvested wood products. Others also discussed the issues associated with leakage (i.e., emissions avoided in one location simply occur in another location, see [61]), pointing out that the paper products that are not produced in BC could simply be produced somewhere else if consumption does not diminish.

In general, the strategy performed well against economic and social objectives. Various participants hoped that such a strategy could stimulate innovation and the development of new technologies maximizing the use of lower quality biomass (e.g., harvest residues). However, other participants, mostly on the coast, mentioned that such a strategy would be challenging to implement due to the current lack of technical capacity to allow for the transformation of low quality timber into longer-lived wood products. Others also feared that transitional issues in terms of political feasibility and economic impacts would arise in the short term because of a reduction in the production of pulp and paper, which could lead, for instance, to mill closure and the loss of employment in certain regions.

Reduced Harvest

Reduced harvest, which scored similarly in both regions, was deemed effective at increasing climate change adaptation and forest resilience and maintaining ecosystem services and existing biodiversity because it allowed for the conservation of more forest areas. However, it was pointed out that this strategy could also be detrimental in the long term since it would reduce the possibility of implementing reforestation strategies to adapt to climate change in BC's forests, including the use of genomic-assisted seed selection (i.e., selecting seeds from trees that are genetically adapted to anticipated future climatic conditions; see [62]) and assisted migration (i.e., planting species in areas that are anticipated to be climatically suitable in the future; see [63]).

While reducing harvest scored relatively high in terms of climate change mitigation, mainly because of an expected increase in carbon density at the landscape level, some groups argued that the strategy could significantly reduce the carbon storage and substitution benefits associated with wood products, and that leakage could simply shift harvest to another location. Certain groups also discussed the risk of reversal, that is when the mitigation benefits of a strategy are compromised by natural disturbances such as wildfire or insect outbreaks (see [64]). Such natural disturbances are expected to increase both in intensity and frequency in BC and in Canada [17,65,66], indicating the risk that conserved forests may become carbon sources in future years. This issue was particularly emphasized in the interior region where frequent natural disturbances make it difficult to establish forest carbon reserves through conservation strategies. As Stinson and Freedman [33] (p. 12) explain, the obstacles associated with frequent natural disturbances are common to most of Canada's forests, where "it may not be feasible to establish protected forest-carbon reserves for the purposes of sequestering and maintaining carbon on the landscape".

The strategy scored lowest against all of the economic and social objectives in both regions. In general, reducing harvest was expected to have negative economic and employment impacts at the provincial and local levels. Nonetheless, a few groups, mainly on the coast, believed that reducing harvest could stimulate non-traditional forestry activities (e.g., tourism, use of non-timber forest products) and, in the long term, induce innovation in the forest sector.

Old Growth Conservation

Conserving old growth forests obtained the highest aggregated score in both regions (Figure 7). However, some participants questioned the definition of old growth forests used in the modelling of the strategy (i.e., forests of over 250 years old), pointing out that age class of old growth forests varies greatly between the coast and the interior.

In general, the strategy was considered the most effective at increasing forest resilience and maintaining ecosystem services and biodiversity. It was also considered extremely effective at mitigating climate change, even though issues were raised. First, as with the reduced harvest strategy, various groups discussed the risks associated with reversal. That being said, while natural disturbances are frequent in the interior and could prevent conservation initiatives, various participants highlighted the conservation opportunities found in BC's coastal temperate rainforests that are characterized by very infrequent disturbance natural patterns and a high carbon density [32,33,67].

Second, many groups spent a considerable amount of time discussing the rate of carbon uptake in old growth forests. Disagreement arose over whether or not carbon uptake by old growth forests (and therefore their potential role at mitigating climate change) was undervalued by conventional forest carbon science, which treats older forests as offering a lower carbon uptake than younger maturing forests [19,68]. Under such conditions, "a conservation strategy with no or limited harvest is expected to yield landscapes with high carbon density (but lower uptake rates), whereas a strategy that involved intensive management will yield a forest landscape with a lower carbon density but a higher carbon uptake rate" [19] (p. 306). Notwithstanding the conclusions of these discussions, most groups agreed that conserving old growth forests, particularly the temperate rainforests found on BC's coastal region, should be done in spite of uncertainties associated with its climate effectiveness. That being said, some participants, particularly from the forest industry, indicated that large scale old growth conservation could be detrimental to BC's forest sector (e.g., reduction of annual allowable cut, loss of employment) and should thus be implemented with caution.

Conserving old growth forests also scored the highest in terms of social license, with many participants discussing the historical willingness found in BC's population for old growth forest conservation [69,70]. However, trade-offs between social license and political feasibility were also highlighted, suggesting that possible resistance from the forest industry and forest-dependent communities could complicate the implementation of the strategy. The strategy scored somewhat lower against the economic and social objectives for many of the same reasons as the reduced harvest strategy (e.g., negative impact on economy and employment). Nevertheless, in contrast to the reduced harvest strategy that focuses solely on reducing harvesting, various groups believed that targeting the conservation of old growth forests could provide further economic benefits associated with tourism.

Rehabilitation

Rehabilitation received the second highest cumulative score in both regions (Figure 7). Nonetheless, many participants argued that this strategy was mostly applicable and beneficial in the interior, where various opportunities exist to plant trees in areas that have been damaged by recent wildfires or insect infestation [17] and are not successfully regrowing. In contrast, participants on the coast agreed that a rehabilitation strategy should focus mostly on ecosystem and habitat restoration activities. While various groups from the coast evaluated the strategy with such activities in mind, two groups in the coast workshops (one in Vancouver, one in Nanaimo) decided to skip the evaluation of the strategy because they judged it to be inapplicable.

Participants from both regions agreed that the strategy has the potential to increase climate change adaptation and forest resilience, provided that it includes activities focused on adaptation (e.g., use of improved seeds, assisted migration), as discussed above in the context of the reduced harvest strategy. Similarly, participants mentioned that rehabilitating forests could benefit ecosystem services and biodiversity only if it focuses on re-establishing and/or improving ecological and structural characteristics, species diversity and composition, and ecological processes. However, many groups gave a lower score to the strategy because they feared that the reforestation/rehabilitation actions would focus on monocultures of only a few commercial species.

Participants on the coast considered that the strategy had positive, although limited, potential to generate climate change mitigation. In contrast, participants from the interior assessed it as the most effective strategy for mitigation because of the climate benefits associated with increased carbon sequestration due to accelerated regrowth.

Participants all agreed that rehabilitation would receive strong public support, thereby supporting BC government's Forest Carbon Initiative, which will focus on "the reduction of carbon emissions in the forest sector and the capture of carbon through the restoration of forests damaged by disease and wildfire" [9]. The rehabilitation strategy was also positively appraised in term of its economic and social impact, mainly because participants judged that it has the inherent capacity to stimulate the economy by generating employment and helping to more quickly re-establish the province's timber supply that has been reduced by the recent mountain pine beetle epidemics [71]. However, participants also discussed the high cost associated with the strategy, pointing out the large areas of forests that were affected in recent years and would need to be rehabilitated.

4.2.2. Individual Support for Strategies: Regional and Sectoral Variations

Figure 8 shows the results from the post-workshop survey where participants identified their individual level of support for or opposition to the different mitigation strategies in their respective region (i.e., coast or interior). On average, participants supported each of the six strategies, with significant difference in the levels of support between strategies on the coast (Kruskall wallis: $H(5) = 17.5$, $p = 0.004$), but not in the interior (Kruskall wallis: $H(5) = 2.8$, $p = 0.73$). The coastal participants tended to be more supportive than the interior participants.

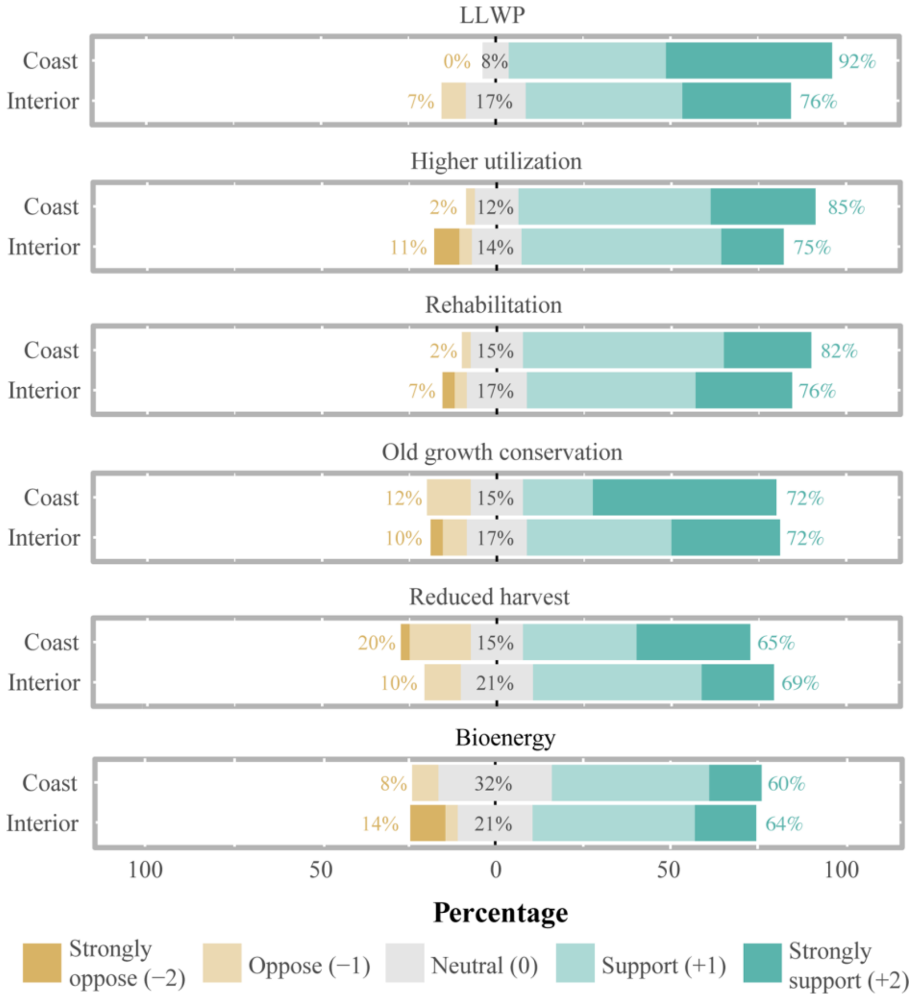

Figure 8. Degree of support for, or opposition to the strategies, as indicated in the individual post-workshop survey.

Long-lived wood products (LLWP), higher utilization, and rehabilitation are the strategies that received the greatest support in both regions, which somewhat differs from the results of the group evaluation where old growth conservation ranked the highest. Two reasons may explain this finding. First, participants may support a strategy even though they do not perceive it as the best performing, especially since participants could support more than one strategy. This is particularly important in the context of forest carbon management in BC, since only an approach that combines various strategies that are adapted to geographical and economic particularities will be able to maximize climate benefit [5,56,68]. Second, as previously explained, the LLWP strategy was judged as having no impact on most biophysical objectives, meaning that its cumulative derived preference averaged lower than other strategies.

Our results suggest that, in general, there is little divergence in the levels of support for each of the strategies between regions and between groups of actors, which is not dissimilar to what was previously found in BC [12]. In effect, no significant difference was found between regions, and only one significant difference between groups arose, for old growth conservation (Kruskall wallis $H(7) = 15.4$, $p = 0.03$), where the mean response of NGOs (1.65) was significantly higher than the forest industry (-0.143, $p = 0.01$). This divergence in support for the old growth strategy also highlights the enduring division between the environmental movement and the forest industry regarding the role and importance of conserving old growth forests in BC [69,70,72]. The fact that NGOs were the best represented group in the evaluation exercise (25% of participants), combined with their advocacy for increasing old growth conservation, might partly explain why the old growth conservation strategy performed so well in the evaluation exercise. A greater participation from the forest industry, which was more likely to oppose the strategy, might have shifted the overall results.

The results in Figure 8 also demonstrate relatively few cases of strong opposition and extreme polarity in response to alternative scenarios. Only with the higher utilization and bioenergy scenarios in the Interior was there a substantive minority (>10% of participants) strongly opposed, and every scenario had substantially more participants who were strongly supportive then strongly opposed. This suggests that the level of controversy or polarity in public preference may not be high with any of these options.

5. Conclusions

This study examined what objectives are prioritized by stakeholders and Indigenous Peoples when discussing forest carbon mitigation in BC's forests, as well as the perceived effectiveness of, and levels of support for, six forest-based carbon mitigation strategies through their participation in an analytical-deliberative engagement process. Our study effectively demonstrates the potential and efficacy of this non-traditional method in informing a variety of stakeholders in different regions, and generating consistent results with a surprising degree of consensus on both key objectives and preference for mitigation alternatives.

Participants identified a total of 11 objectives that can be classified into four categories: biophysical, economic, social, and procedural. On average, participants ascribed a higher level of importance to biophysical and procedural objectives than to economic and social objectives. Conservation-focused strategies (i.e., old growth conservation and reduced harvest) generally performed better against biophysical objectives and were often judged as more adapted for the coastal region (although old growth conservation opportunities also exist and were pointed out in the interior), whereas strategies focused on improving forest management (i.e., higher utilization, bioenergy, rehabilitation, LLWP) scored higher against economic and social objectives and were generally perceived as most relevant in the interior. The greater weights granted to biophysical objectives therefore partly explain why old growth conservation, and reduced harvest to a lesser extent, performed relatively well in terms of their cumulative derived preferences.

On average, all strategies received positive cumulative derived preferences (i.e., all higher than 60%) and individual levels of support, indicating that stakeholders and Indigenous Peoples are inclined to consider alternative practices in managing forests and wood products in the context of climate change mitigation. However, participants also raised various issues that require consideration. Most notably, questions were raised regarding assumptions used in the modelling (e.g., the rate of carbon intake in old forests, displacement factors), the costs associated with implementing certain strategies (e.g., rehabilitation, higher utilization and bioenergy), and technical limitations that might impede some strategies (e.g., engineering capacity to transform low grade harvested material into longer-lived wood products). Additionally, questions were raised about the potential negative impacts of certain strategies on ecosystems and forest health (e.g., bioenergy, higher utilization), issues that were not addressed in the modelling.

In addition, many participants argued that some strategies, including old growth conservation, and to a lesser extent reduced harvest, should be implemented for reasons other than their climate effectiveness (e.g., biodiversity conservation). However, it was also noted that the expected increase in natural disturbances due to climate change could limit the capacity to effectively implement these strategies, particularly in the interior region. This constraint is particularly important in a context where massive fire and insect outbreaks are typically hard to contain [65], and fire suppression can sometimes lead to unwanted consequences, leading to the view that it should be implemented with caution [32]. For instance, one cause of the massive mountain pine beetle outbreak of the 2000s is that the proportion of mature pine, which is more vulnerable to the beetles, tripled between 1910 and 2000 because of historic fire repression [73]. Consequently, participants agreed that forest management strategies should aim as much as possible to rebuild the natural resilience of forests to disturbance and increase their adaptability to climate change.

Very little variation in levels of support for the strategies was found across regions and groups of actors, with the only significant difference found between NGOs and the forest industry in terms of their support for the old growth conservation strategy. That being said, the unbalanced representation of different groups of actors in the workshops, with a marked dominance of NGOs and forestry professionals (accounting together for nearly 50% of participants), might still have influenced and somewhat biased the group evaluation of the strategies.

To conclude, the diversity of mitigation options, combined with their associated uncertainties and complexity, points to a crucial question: how are we to take advantage of alignments and make trade-offs to identify the best portfolio of mitigation strategies? According to recent studies, forest carbon mitigation in Canada [37,56,68], as well as other parts of the world (e.g., Sweden [74]; USA [75]), cannot be maximized by implementing a single strategy, but rather with combinations of options adapted to geographical particularities. Only a systems perspective taking into account all the carbon pools and fluxes will allow identification of the best mitigation scenario(s) and an understanding of the trade-offs between increasing carbon storage in forest ecosystems or increasing it in wood products [2,18,20]. Forest carbon mitigation will also need to be conceived and implemented together with climate change adaptation strategies and with other biophysical, procedural, economic, and social objectives in mind. This paper provides a first overview of these alignments and trade-offs. A sustained consideration of the perceptions of all interested and affected parties during the design and implementation of a provincial forest carbon management strategy, as carried out with this approach to analytic deliberative participation, could help legitimize the process and ensure/sustain its public acceptance and perceived effectiveness. Investment in carbon-focused management actions in public forests will also require increased monitoring and reporting of management outcomes. This will increase the accountability of the managers, particularly in countries where forests are predominantly publicly owned. Transparency and accountability will be a key prerequisite to sustain public support and investments in carbon-focused forest management.

Supplementary Materials: The following are available online at http://www.mdpi.com/1999-4907/9/4/225/s1, Two primers used as consultation documents for the first and second series of workshops respectively; Table S1: Results of the biophysical and socio-economic modelling that were provided to participants during the second series of workshops.

Acknowledgments: This research was financially supported by the Forest Carbon Management Project of the Pacific Institute for Climate Solutions (PICS), while the work of G.P.S.-L. was supported by the Social Sciences and Humanities Research Council of Canada and PICS. Special thanks are due to Michelle Connolly, Caren Dymond, Robin Gregory, Shannon Hagerman, Robert Kozak, Tony C. Lemprière, Sara Muir-Owen, Dennis Paradine, Carolyn Smyth, Werner A. Kurz, and Zach Xu for their support in preparing workshop material, for their different roles during the workshops and for reviewing previous versions of the manuscript. We are grateful to all the workshop participants for the strong interest that they showed in our project.

Author Contributions: G.P.S.-L., G.H., and S.S. conceived and designed the experiments; G.P.S.-L., G.H., and S.S. performed the experiments; G.P.S.-L. analysed the data; G.P.S.-L. wrote the original draft; G.H. and S.S. contributed to reviewing and editing.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. IPCC. *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2014.
2. Food and Agriculture Organization of the United Nations (FAO). *Forestry for a Low-Carbon Future: Integrating Forests and Wood Products in Climate Change Strategies*; Fao Forestry Paper 117; FAO: Rome, Italy, 2016.
3. BC MFLNRO (Ministry of Forests, Lands and Natural Resource Operation). *Our Natural Advantage: Forest Sector Strategy for British Columbia*; Government of British Columbia: Victoria, BC, Canada, 2012.
4. Government of British Columbia. *British Columbia's Climate Leadership Plan*; Government of British Columbia: Victoria, BC, Canada, 2016.
5. BC MFLNRO. *Climate Mitigation Potential of British Columbian Forests: Growing Carbon Sinks*; Government of British Columbia: Victoria, BC, Canada, 2013.
6. Hoberg, G.; Peterson St-Laurent, G.; Schittecatte, G.; Dymond, C.C. Forest carbon mitigation policy: A policy gap analysis for British Columbia. *For. Policy Econ.* **2016**, *69*, 73–82. [CrossRef]
7. Peterson St-Laurent, G.; Hagerman, S.; Hoberg, G. Emergence and influence of a new policy regime: The case of forest carbon offsets in British Columbia. *Land Use Policy* **2017**, *60*, 169–180. [CrossRef]
8. Peterson St-Laurent, G.; Hagerman, S.; Hoberg, G. Barriers to the development of forest carbon offsetting: Lessons from British Columbia, Canada. *J. Environ. Manag.* **2017**, *203*, 208–217. [CrossRef] [PubMed]
9. Forest Enhancement Society of BC. $150-Million Reforestation Investment Will Help Fight Climate Change, Create More Rural Jobs. Available online: http://www.fesbc.ca/reforestation-investment.html (accessed on 23 January 2018).
10. Howlett, M.; Rayner, J.; Tollefson, C. *From Old to New Dynamics in Canadian Forest Policy: Dynamics whithout Change?* 3rd ed.; Boardman, R., VanNijnatten, D.L., Eds.; Oxford University Press: Don Mills, ON, Canada, 2009; pp. 183–196.
11. Diaz-Balteiro, L.; Romero, C. Making forestry decisions with multiple criteria: A review and an assessment. *For. Ecol. Manag.* **2008**, *255*, 3222–3241. [CrossRef]
12. Sheppard, S.R.J.; Meitner, M. Using multi-criteria analysis and visualisation for sustainable forest management planning with stakeholder groups. *For. Ecol. Manag.* **2005**, *207*, 171–187. [CrossRef]
13. Natural Resource Council (NRC). *Understanding Risk: Informing Decisions in a Democratic Society*; National Academy Press: Washington, DC, USA, 1996.
14. Cullen, D.; McGee, G.J.A.; Gunton, T.I.; Day, J.C. Collaborative planning in complex stakeholder environments: An evaluation of a two-tiered collaborative planning model. *Soc. Nat. Resour.* **2010**, *23*, 332–350. [CrossRef]
15. Tindall, D.B.; Trosper, R.; Perreault, P. *Aboriginal Peoples and Forest Lands in Canada*; UBC Press: Vancouver, BC, Canada, 2013.
16. BC MOE. British Columbia Greenhouse Gas Inventory. Available online: http://www2.gov.bc.ca/gov/content/environment/climate-change/reports-data/provincial-ghg-inventory (accessed on 31 August 2017).
17. Kurz, W.A.; Dymond, C.C.; Stinson, G.; Rampley, G.J.; Neilson, E.T.; Carroll, A.L.; Ebata, T.; Safranyik, L. Mountain pine beetle and forest carbon feedback to climate change. *Nature* **2008**, *452*, 987–990. [CrossRef] [PubMed]

18. Kurz, W.A.; Smyth, C.E.; Lemprière, T.C. Climate change mitigation through forest sector activities: Principles, potential and priorities. *Unasylva* **2016**, *246*, 61–67.
19. Lemprière, T.C.; Kurz, W.A.; Hogg, E.H.; Schmoll, C.; Rampley, G.J.; Yemshanov, D.; McKenney, D.W.; Gilsenan, R.; Beatch, A.; Blain, D.; et al. Canadian boreal forests and climate change mitigation. *Environ. Rev.* **2013**, *21*, 293–321. [CrossRef]
20. Nabuurs, G.J.; Masera, O.; Andrasko, K.; Benitez-Ponce, P.; Boer, R.; Dutschke, M.; Elsiddig, E.; Ford-Robertson, J.; Frumhoff, P.; Karjalainen, T.; et al. Forestry. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the IPCC*; Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., Meyer, L.A., Eds.; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2007; pp. 541–584.
21. Smyth, C.; Rampley, G.; Lemprière, T.C.; Schwab, O.; Kurz, W.A. Estimating product and energy substitution benefits in national-scale mitigation analyses for Canada. *GCB Bioenergy* **2016**, *9*, 1071–1084. [CrossRef]
22. Jasanoff, S. Technologies of humility: Citizen participation in governing science. *Minerva* **2003**, *41*, 223–244. [CrossRef]
23. Petts, J.; Brooks, C. Expert conceptualisations of the role of lay knowledge in environmental decisionmaking: Challenges for deliberative democracy. *Environ. Plan. A* **2006**, *38*, 1045–1059. [CrossRef]
24. Garmendia, E.; Gamboa, G. Weighting social preferences in participatory multi-criteria evaluations: A case study on sustainable natural resource management. *Ecol. Econ.* **2012**, *84*, 110–120. [CrossRef]
25. Renn, O. A model for an analytic-deliberative process in risk management. *Environ. Sci. Technol.* **1999**, *33*, 3049–3055. [CrossRef]
26. Burgess, J.; Stirling, A.; Clark, J.; Davies, G.; Eames, M.; Staley, K.; Williamson, S. Deliberative mapping: A novel analytic-deliberative methodology to support contested science-policy decisions. *Public Underst. Sci.* **2007**, *16*, 299–322. [CrossRef]
27. Mendoza, G.A.; Martins, H. Multi-criteria decision analysis in natural resource management: A critical review of methods and new modelling paradigms. *For. Ecol. Manag.* **2006**, *230*, 1–22. [CrossRef]
28. Sheppard, S.R. Participatory decision support for sustainable forest management: A framework for planning with local communities at the landscape level in Canada. *Can. J. For. Res.* **2005**, *35*, 1515–1526. [CrossRef]
29. Gregory, R.; Failing, L.; Harstone, M.; Long, G.; McDaniels, T.; Ohlson, D. *Structured Decision Making*; John Wiley & Sons, Ltd.: Chichester, UK, 2012.
30. Failing, L.; Gregory, R.; Higgins, P. Science, uncertainty, and values in ecological restoration: A case study in structured decision-making and adaptive management. *Restor. Ecol.* **2013**, *21*, 422–430. [CrossRef]
31. Ohlson, D.W.; McKinnon, G.A.; Hirsch, K.G. A structured decision-making approach to climate change adaptation in the forest sector. *For. Chron.* **2005**, *81*, 97–103. [CrossRef]
32. Carlson, M.; Chen, J.; Elgie, S.; Henschel, C. Maintaining the role of Canada's forests and peatlands in climate regulation. *For. Chron.* **2010**, *86*, 434–443. [CrossRef]
33. Stinson, G.; Freedman, B. Potential for carbon sequestration in canadian forests and agroecosystems. *Mitig. Adapt. Strateg. Glob. Chang.* **2001**, *6*, 1–23. [CrossRef]
34. Grimble, R.; Wellard, K. Stakeholder methodologies in natural resource management: A review of principles, contexts, experiences and opportunities. *Agric. Syst.* **1997**, *55*, 173–193. [CrossRef]
35. Harrison, S.R.; Qureshi, M.E. Choice of stakeholder groups and members in multicriteria decision models. *Nat. Resour. Forum* **2000**, *24*, 11–19. [CrossRef]
36. Herath, G. Incorporating community objectives in improved wetland management: The use of the analytic hierarchy process. *J. Environ. Manag.* **2004**, *70*, 263–273. [CrossRef] [PubMed]
37. Xu, Z.; Smyth, C.E.; Lemprière, T.C.; Rampley, G.J.; Kurz, W.A. Climate change mitigation strategies in the forest sector: Biophysical impacts and economic implications in British Columbia, Canada. *Mitig. Adapt. Strateg. Glob. Chang.* **2018**, *23*, 257–290. [CrossRef]
38. Peterson St-Laurent, G.; Hoberg, G.; Kurz, W.A.; Lemprière, T.C.; Smyth, C.E.; Xu, Z. *Evaluating Options for Managing British Columbia's Forest Sector to Mitigate Climate Change*; Pacific Institute for Climate Solutions: Victoria, BC, Canada, 2017.
39. Barfod, M.B.; Leleur, S. *Multi-Criteria Decision Analysis for Use in Transport Decision Making*; Technical University of Denmark: Kgs Lyngby, Denmark, 2014.
40. Kajanus, M.; Kangas, J.; Kurttila, M. The use of value focused thinking and the A'WOT hybrid method in tourism management. *Tour. Manag.* **2004**, *25*, 499–506. [CrossRef]

41. Reynolds, K.M. Prioritizing salmon habitat restoration with the ahp, smart, and uncertain data. In *The Analytic Hierarchy Process in Natural Resource and Environmental Decision Making*; Springer: Dordrecht, The Netherlands, 2001; Volume 3, pp. 199–217.
42. Kangas, J.; Kangas, A. Multiple criteria decision support in forest management—The approach, methods applied, and experiences gained. *For. Ecol. Manag.* **2005**, *207*, 133–143. [CrossRef]
43. Stagl, S. Multicriteria evaluation and public participation: The case of uk energy policy. *Land Use Policy* **2006**, *23*, 53–62. [CrossRef]
44. Waeber, P.O.; Nitschke, C.R.; Le Ferrec, A.; Harshaw, H.W.; Innes, J.L. Evaluating alternative forest management strategies for the champagne and aishihik traditional territory, southwest yukon. *J. Environ. Manag.* **2013**, *120*, 148–156. [CrossRef] [PubMed]
45. Kozak, R.A.; Spetic, W.C.; Harshaw, H.W.; Maness, T.C.; Sheppard, S.R.J. Public priorities for sustainable forest management in six forest dependent communities of British Columbia. *Can. J. For. Res.* **2008**, *38*, 3071–3084. [CrossRef]
46. The Montréal Process. The Montréal Process: Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests. Available online: https://www.montrealprocess.org/Resources/Criteria_and_Indicators/index.shtml (accessed on 28 June 2017).
47. Prabhu, R.; Colfer, C.J.P.; Dudley, R.G. *Guidelines for Developing, Testing and Selecting Criteria and Indicators for Sustainable Forest Management: A C&I Developer's Reference*; CIFOR: Jakarta, Indonesia, 1999; Volume 1.
48. Forest Stewardship Council. FSC Principles and Criteria: International Guidelines Developed through Consensus. Available online: https://ca.fsc.org/en-ca/fsc-certification/forest-management-certification/principles-criteria (accessed on 28 June 2017).
49. Tindall, D.B.; Harshaw, H.W.; Sheppard, S.R.J. Understanding the social bases of satisfaction with public participation in forest management decision-making in British Columbia. *For. Chron.* **2010**, *86*, 709–722. [CrossRef]
50. Harshaw, H.W.; Sheppard, S.R.J.; Jeakins, P. Public attitudes toward sustainable forest management: Opinions from forest-dependent communities in British Columbia. *BC J. Ecosyst. Manag.* **2009**, *10*, 81–103.
51. Freedman, B.; Stinson, G.; Lacoul, P. Carbon credits and the conservation of natural areas. *Environ. Rev.* **2009**, *17*, 1–19. [CrossRef]
52. Simonet, G.; Delacote, P.; Robert, N. On managing co-benefits in REDD+ projects. *Int. J. Agric. Resour. Gov. Ecol.* **2016**, *12*, 170. [CrossRef]
53. Lippke, B.; Oneil, E.; Harrison, R.; Skog, K.; Gustavsson, L.; Sathre, R. Life cycle impacts of forest management and wood utilization on carbon mitigation: Knowns and unknowns. *Carbon Manag.* **2011**, *2*, 303–333. [CrossRef]
54. Blanco, J.A.; Flanders, D.; Littlejohn, D.; Robinson, P.; Dubois, D. *Fire in the Woods or RE in the Boiler? A New Tool to Help Rural Communities Determine If Forest Biomass from Wild RE Abatement Can Sustainably Fuel a District Heating System*; Pacific Institute for Climate Solutions: Victoria, BC, Canada, 2013.
55. Miner, R.A.; Abt, R.C.; Bowyer, J.L.; Buford, M.A.; Malmsheimer, R.W.; O'Laughlin, J.; Oneil, E.E.; Sedjo, R.A.; Skog, K.E. Forest carbon accounting considerations in us bioenergy policy. *J. For.* **2014**, *112*, 591–606.
56. Smyth, C.E.; Stinson, G.; Neilson, E. Quantifying the biophysical climate change mitigation potential of Canada's forest sector. *Biogeosciences* **2014**, *11*, 3515–3529. [CrossRef]
57. McKechnie, J.; Colombo, S.; Chen, J.; Mabee, W.; MacLean, H.L. Forest bioenergy or forest carbon? *Assessing trade-offs in greenhouse gas mitigation with wood-based fuels. Environ. Sci. Technol.* **2011**, *45*, 789–795. [PubMed]
58. Smyth, C.; Kurz, W.A.; Rampley, G.; Lemprière, T.C.; Schwab, O. Climate change mitigation potential of local use of harvest residues for bioenergy in Canada. *GCB Bioenergy* **2016**, *9*, 817–832. [CrossRef]
59. Greig, M.; Bull, G. *Carbon Management in British Columbia's Forests: Opportunities and Challenges*; Forrex Series 24; Forum for Research and Extension in Natural Resources Society (FOREX): Kamloops, BC, Canada, 2008.
60. Lippke, B.; Wilson, J.; Meil, J.; Taylor, A. Characterizing the importance of carbon stored in wood products. *Wood Fiber Sci.* **2010**, *42*, 5–14.
61. Gan, J.; McCarl, B.A. Measuring transnational leakage of forest conservation. *Ecol. Econ.* **2007**, *64*, 423–432. [CrossRef]
62. ONeill, G.; Wang, T.; Ukrainetz, N.; Charleson, L.; McAuley, L.; Yanchuk, A.; Zedel, S. *A Proposed Climate-Based Seed Transfer System for British Columbia*; B.C. Tech. Rep. 099; Government of British Columbia: Victoria, BC, Canada, 2017.

63. Park, A.; Talbot, C. Assisted migration: Uncertainty, risk and opportunity. *For. Chron.* **2012**, *88*, 412–419. [CrossRef]
64. Parker, C.; Merger, E.; Streck, C.; Conway, D.; Tennigkeit, T.; Wilkes, A. *The Land-Use Sector within the Post-2020 Climate Regime*; Norden: Copenhagen, Denmark, 2014.
65. Kurz, W.A.; Stinson, G.; Rampley, G.J.; Dymond, C.C.; Neilson, E.T. Risk of natural disturbances makes future contribution of Canada's forests to the global carbon cycle highly uncertain. *Proc. Natl. Acad. Sci. USA* **2008**, *105*, 1551–1555. [CrossRef] [PubMed]
66. Swift, K.; Ran, S. Successional responses to natural disturbance, forest management, and climate change in British Columbia's forests. *BC J. Ecosyst. Manag.* **2012**, *13*, 1–23.
67. Parfitt, B. *Managing BC's Forests for a Cooler Planet: Carbon Storage, Sustainable Jobs and Conservation*; Canadian Centre for Policy Alternatives: Vancouver, BC, Canada, 2010.
68. Kurz, W.A.; Shaw, C.H.; Boisvenue, C.; Stinson, G.; Metsaranta, J.; Leckie, D.; Dyk, A.; Smyth, C.; Neilson, E.T. Carbon in Canada's boreal forest—A synthesis. *Environ. Rev.* **2013**, *21*, 260–292. [CrossRef]
69. Pralle, S. *Branching out, Digging in: Environmental Advocacy and Agenda-Setting*; Georgetown University Press: Washington, DC, USA, 2006.
70. Cashore, B.; Hoberg, G.; Howlett, M.; Rayner, J.; Wilson, J. *In Search of Sustainability: British Columbia Forest Policy in the 1990s*; UBC Press: Vancouver, BC, Canada, 2001; p. 340.
71. BC MFLNRO. *Discussion Paper: Area-Based Forest Tenures*; Government of British Columbia: Victoria, BC, Canada, 2014.
72. Price, K.; Roburn, A.; MacKinnon, A. Ecosystem-based management in the great bear rainforest. *For. Ecol. Manag.* **2009**, *258*, 495–503. [CrossRef]
73. Taylor, S.W.; Carrol, A.L.; Alfaro, R.I.; Safranyik, L. *Forest, Climate and Moutain Pine Beetle Outbreak Dynamics in Western Canada*; Safranyik, L., Wilson, B., Eds.; Natural Resource Canada: Victoria, BC, Canada, 2006; pp. 67–94.
74. Lundmark, T.; Bergh, J.; Hofer, P.; Lundström, A.; Nordin, A.; Poudel, B.; Sathre, R.; Taverna, R.; Werner, F. Potential roles of swedish forestry in the context of climate change mitigation. *Forests* **2014**, *5*, 557–578. [CrossRef]
75. Malmsheimer, R.W.; Bowyer, J.L.; Fried, J.S.; Gee, E.; Izlar, R.L.; Miner, R.A.; Munn, I.A.; Oneil, E.; Stewart, W.C. Managing forests because carbon matters: Integrating energy, products, and land management policy. *J. For.* **2011**, *109*, S7–S51.