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Environmental Evidence

SYSTEMATIC REVIEW PROTOCOL

Open Access

Do small protected habitat patches within boreal production forests provide value for biodiversity conservation? A systematic review protocol

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Abstract

Background: Forest harvesting is the main driver of habitat degradation and biodiversity loss in forests of the boreal zone. To mitigate harmful effects, small-scale habitats with high biodiversity values have been protected within production forests. These include woodland key habitats, and other small-scale habitat patches protected by voluntary conservation action. This article describes a protocol for a systematic review to synthesize the value of small habitat patches left within production landscapes for biodiversity. The topic for this systematic review arose from a discussion with the Finnish forestry sector and was further defined in a stakeholder workshop. Research question: Do small protected habitat patches within production forests provide value for biodiversity conservation in boreal forests? Animal, plant and fungal diversities are addressed as well as the amount of deadwood within the habitat patches as proxy indicators for biodiversity.

Methods: The literature, both peer-reviewed and grey, will be searched from bibliographical databases, organizational websites and internet search engines in English, Finnish, Swedish and Russian. Article screening will be done at two stages (title/abstract and full-text). The validity of the studies included will be evaluated against validity criteria and studies will be categorized based on their risk of bias. To describe the findings a narrative synthesis will be conducted. If there is enough quantitative data retrieved from the studies, a meta-analysis will be conducted.

Keywords: Forest harvesting, Logging, Impact, Woodland key habitats, Voluntary conservation, Species richness, Species diversity, Abundance

Background

Boreal forest is the world's largest terrestrial biome covering large parts of the Northern Hemisphere. Most of the boreal forests in Northern Europe are in commercial use and as demand for forest products has grown, logging has increased in the entire area of the boreal zone in the last decades. Intensive forestry has negative impacts on biodiversity of forest species [1].

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Traditionally, main method for biodiversity conservation has been the establishment of protected areas. However, setting aside areas is expensive and only relatively small proportion of forest land is protected for biodiversity in Northern Europe ranging from 1.2% in Norway to 12.2% in Sweden [2]. Russian and North American forests differ from Northern Europe not only in the extent of the area, but also in the lower intensity of forest management. Large areas of pristine boreal forest still remain especially in Canada and Russian Siberia. Protected forests cover 2.0% of the forests in Russia, 19.8% in USA and 4.9% in Canada [2]. However, the network of protected areas is considered inadequate to maintain species assemblages [3–6]. Protected areas are often situated in less productive areas where biodiversity is not as high as in more productive areas [7], and establishing new protected areas is not possible in the magnitude maintaining biodiversity would need [6]. Therefore, more needs to be done to conserve biodiversity in habitats outside of protected areas [8] alongside restoration of degraded habitats [9].

Habitat quality and biodiversity outside protected forest areas gained interest already in 1970s [10] but it wasn't until after the Rio Declaration in 1992 when biodiversity issues were integrated in production forestry. New practices to maintain and increase biodiversity in production forests included green tree retention, prescribed burning, leaving dead wood in forests and creating habitat corridors and buffer strips [11, 12]. In addition, preservation of small patches of certain habitats (e.g. Woodland Key Habitats) was introduced as a new method in biodiversity conservation in early 1990s [13].

But is conserving small habitat patches within production forests effective way to maintain biodiversity? There have been previous systematic reviews on woodland key habitats [14], retention trees [15], and creation of deadwood in production forests [16]. Woodland key habitats were found to be high in species richness and the number of red-listed species but their ability to maintain diversity in managed landscape could not be addressed [14]. Retention trees were found to be beneficial for biodiversity as they moderated some negative impacts on harvesting, but for forest specialist species retention forestry could not substitute protected forests [15]. As the evidence base hasn't been reviewed recently with the exception of the creation of deadwood in production forests [16, 17], it is time for an update. Here we describe a protocol for a systematic review on the importance of small conserved habitat patches within production forests for maintaining biodiversity. The topic arose from the interest of Finnish forest industry on the effectiveness of conservation actions within production forests to produce beneficial biodiversity outcomes. A stakeholder workshop was held in November 2018 to further discuss the topic. Purposive selection based on known contacts, snowballing and internet search were used to compile a list of stakeholders. An open invitation to participate in the workshop was published on the website of the Evidence-based Forestry in Finland 11 October 2018 and sent by email to 38 stakeholder organizations (Additional file 1) with a notice that it can be further shared with interested individuals and organizations. A reminder email was sent 2 weeks later to those individuals and organizations that had not responded.

In the end, 10 stakeholders participated in the workshop 7 November 2018 to discuss the proposed systematic review (Additional file 1). There was a balanced representation of different stakeholder interest groups from government agencies and academia to non-governmental organizations and private sector. At the workshop, participants were first introduced to systematic reviews to provide them with an understanding of the review process. Then the broader topic of interest, 'biodiversity conservation in production forests' was introduced and key conservation methods described. Afterwards, participants discussed the topic and narrowed it down to the specific study questions included in this review protocol. Based on the research questions, PICO-based search terms were defined, and factors potentially creating heterogeneity discussed.

The proposed systematic review will focus on small scale habitat patches (defined in next sections) protected within production forests. In addition to their direct value as habitats for species, the small patches may contain more deadwood than the surrounding landscape. Both green retention trees and deadwood have been shown to be important for maintaining biodiversity in boreal forests [15, 18]. Thus, we will include the amount of deadwood as an outcome of interest in the review. The amount of green retention trees, however, can be considered as an effect modifier, as it most likely describes the size of the retention area. Below we describe the habitats and green tree retention more in detail.

Woodland key habitats

Woodland key habitats are a common concept in Northern Europe. It was first introduced in Sweden in the early 1990s [19, 20] and soon extended to other Nordic countries, the Baltic and Russia [21]. There are differences in the definitions and legal status of the woodland key habitats and their delineation varies between countries. In Russia the concept of woodland key habitats is applied most widely in the northern regions of the European part of the country and Siberia [21] but there is no unified approach to the definition of the term [22]. In Finland, woodland key habitats are usually relatively small and defined and protected by the Forest Act [23] whereas in Sweden, Russia and Baltic countries the size of woodland key habitats may vary from single trees to several hundreds of hectares. In Finland, woodland key habitats are also defined and protected by the Forest Act [23] while in other countries the definition of woodland key habitats is based on observations or probability of endangered species occurrence on given habitat patches or structural properties of the sites, and protection is more voluntary based [13, 19, 21, 24–30]. Norway has two systems to identify woodland key habitats, one for forestry planning [29], the other for municipal land-use planning, with substantially larger size of key habitats [13].

The mean size of woodland key habitats also varies between countries being 4.6 ha in Sweden [31], between 2 and 3 ha in Estonia, Latvia and Lithuania [13], 0.83 ha in Norway [29] and 0.63 ha in Finland [32]. There has been critique of the small size and scattered distribution of woodland key habitats [1]. It has been suggested that isolated woodland key habitats suffer from extinction debt [33] and that small habitat patches may not be able to maintain species diversity over time [30].

The concept of woodland key habitat is not used in the USA and Canada. Every state in the USA and province and territory in Canada has their own legislation considering forestry and biodiversity conservation. In Canada, national and provincial parks hold most of the protected forests, as majority of the forested land is owned publicly [34]. In the USA public protected areas are defined by the criteria of the International Union for Conservation of Nature whereas protection of private forests is based on voluntary actions and economic incentives [35].

Conservation of other small habitat patches

The above-mentioned conservation actions of woodland key habitats are part of the aim to slow down and eventually stop the degradation of biodiversity. However, forest species are still in decline, especially in countries with intensive forest management, e.g. Finland [36]. To counter the decline, new kind of conservation policies have been developed. In Finland, *Forest Biodiversity Program for Southern Finland* (METSO) [37], is based on forest owners own initiative to protect their forests. Forest owners offer their forest to be protected by the program, and if the forest has enough ecological values, e.g. high volume of dead wood or quantity of large deciduous trees, the owners will get a compensation payment. Thus, conservation does not cause economic losses to them. Same principles and practices are also used in voluntary forest conservation in Norwegian *Frivillig vern* and Swedish *Komet programmet* [38, 39]. In the USA the concept of conservation easements is the main way of voluntary forest conservation. Basically conservation easements mean that landowners give up their right to develop the forest and they get monetary or taxation-based compensation from the government or a conservation group (land trust) [35]. In Canada and Russia almost all forests are publicly owned, and therefore comparable voluntary conservation systems do not exist. In the Baltic countries the private forest ownership has been re-established after regaining their independence in 1991 [40]. Environmental values of forests are emphasized both by national forest programs and private forest owners, but most conservation programs are still determined by state authorities [40, 41].

In addition to voluntary conservation programs, forest management certification systems may include provisions for conserving certain habitats beyond legal requirements. Both Forest Stewardship Council (FSC) and Program for the Endorsement of Forest Certification (PEFC) systems are widely used in the boreal zone [42, 43]. To get certified forest owners must commit themselves to responsible forest management. The national standards vary between countries, but they often include preservation of small habitat patches of high conservation value [44–46].

Objective of the review

The objective of this proposed review is to systematically review and synthesize the biodiversity impacts of conservation of small habitat patches within production forests. Legally designated woodland key habitats as well as any small-scale voluntary conservation areas are included. The review will focus on terrestrial biodiversity of boreal forests. We follow the definition of Boreal zone by Keenan et al. [47], but will include also the Baltic countries. The geographical scope was determined at the stakeholder meeting.

Research question

Do small protected habitat patches within production forests provide value for biodiversity conservation in boreal forests?

We will review if the biodiversity of small protected habitat patches differs from that of unprotected forests. Because Woodland Key Habitats are protected because of their biological values, we will also review if their biodiversity differs from that of larger protected forests that should be closer to natural state than smaller patches. We will further review to what extent will protected small-scale habitats retain their original biodiversity if their immediate surroundings are heavily managed.

Table 1 Components of the review question

Subject	Intervention	Comparator	Outcome
Boreal forests	Small habitat patches set aside for conservation within production forests	Unprotected forests, protected forests, clear-cut surroundings, uncut surroundings	Direct and proxy biodiversity indicators

The study question components are outlined in Table 1.

Methods

This systematic review protocol and the forthcoming review follow the guidelines of Collaboration for Environmental Evidence and complies with the ROSES reporting standards. The ROSES form is included as an Additional file 2.

Searching for articles

Articles will be searched from 1990 onwards because small scale habitat protection within production forests was integrated in production forestry in the 1990s.

Search terms

Various search terms relating to the PICO components were proposed at the stakeholder meeting and discussed by the participants (Table 2).

Based on the discussions at the stakeholder meeting, a search string was formulated using Boolean operators 'OR' and 'AND'. The performance of the search string was tested in the Web of Science and Scopus using a test list of 20 articles collected from previous reviews and from experts (Additional files 3 and 4). The proposed search string (Web of Science format) is:

#1 TS=((Boreal NEAR/5 (forest* OR zone OR tree*)) OR taiga OR spruce* or picea or pine* or pinus or birch* or aspen* or populus)

#2 TS=(Finland or Finnish or Swed* or Norw* or Russia* or Estonia* or Latvia* or Lithuania*, Fennoscan* or Scandin* or Baltic OR "North* Europ*" or Canad* or "North* Ameri*" or Siber* or Alaska or "United States" or USA) and TS=(forest* or tree*)

#3=#1 OR #2

#4 TS=("key habitat*") OR TS=("forest act habitat*") OR TS=(reserve* NEAR/5 (forest* OR OR privat* OR area* OR patch* OR habitat*)) OR TS=("private* protected area*") OR TS=(voluntar* NEAR/5 (conservation* or set-aside*)) OR TS=(METSO NEAR/5 program*) OR TS=(Komet NEAR/5 program*) OR TS=(conservation NEAR/5 easement*) OR TS=(deadwood*) OR TS=("dead wood*") OR TS=(connectiv*)

#5=#3 AND #4

A simplified version of the search string containing only key terms will be used when the search interface does not have the capacity to handle the whole search string. Boolean operators will be used where possible. The used search strings will be published as additional information in the review report. The search will be conducted also in Finnish, Swedish and Russian.

To screen articles that are published before the data synthesis is started, a search alert will be set in bibliographic databases. The number of articles attained through the search alerts will be reported in the review report.

Languages

This systematic review will include studies published in English, Finnish, Swedish and Russian. The language selection is based on the geographical scope of the systematic review and is limited by the language skills of the review team. Organizational websites will be searched in English, except of Finnish, Swedish and Russian websites that will be searched in the primary language the website is published. In addition, if the publications section includes studies published in other of the review languages (e.g. main website language is Swedish but there are also unique publications in English), the search will be conducted in those languages as well.

Table 2 The eligibility criteria for article screening for the study question

Question elements	Eligibility criteria
Populations	*Included*: Studies conducted in boreal forests including Baltic countries
Intervention	*Included*: Woodland key habitats, small scale protected forest patches
Comparators	*Included:* Managed forests, production forests, natural forests, uncut forest *Excluded*: Non-forest lands, urban parks, wooded fields, e.g. Christmas tree plantations
Outcomes	*Included*: Species diversity, richness, assemblage, individual abundance, the amount of deadwood
Study design	*Included:* Control-intervention studies
Language	*Included:* English, Finnish, Swedish and Russian

Bibliographic searches

- CATQuest—University of Vermont Catalogue (http://primo.uvm.edu/primo-explore/search?vid=UVM&sortby=rank&lang=en_US).
- Directory of Open Access Repositories (https://doaj.org/); 'Search all' field will be used with not further limitations.
- Doria (https://www.doria.fi/).
- EMU DSpace—The digital archive of Estonian University of Life Sciences Library (https://dspace.emu.ee/).
- Helda—University of Helsinki Catalogue (https://helda.helsinki.fi/); All fields will be searched with no further limitations.
- Jultika—University of Oulu repository; All fields will be searched with no further limitations. (http://jultika.oulu.fi/).
- JYX—Publication archive of the University of Jyväskylä (https://jyx.jyu.fi/).
- Lakehead University Library Catalogue (https://inukshuk.lakeheadu.ca/vwebv/searchBasic?sk=en_CA).
- NEOS Catalogue for the University of Alberta Library (https://catalogue.neoslibraries.ca/?lib=universityofalberta).
- Oria—Library Catalogue of Norwegian University of Life Sciences (https://bibsys-almaprimo.hosted.exlibrisgroup.com/primo-explore/search?vid=NMBU&sortby=rank&lang=no_NO).
- Primo—Catalogue of Latvia University of Life Sciences and Technologies (https://primolatvija.hosted.exlibrisgroup.com/primo-explore/search?sortby=rank&vid=371KISCLLU_VU1&lang=en_US).
- Russian Science Citation Index on the Web of Science (https://clarivate.com/); Topic search, access from 2005 onwards.
- Scopus (https://www.scopus.com/home.uri); Title, abstract, and keyword search.
- Swedish University Dissertations (http://www.avhandlingar.se/).
- Swepub—Academic publications at Swedish universities (http://swepub.kb.se/).
- University of British Columbia Library Catalogue (http://search.library.ubc.ca/).
- University of Manitoba Library Catalogue (http://umanitoba.ca/libraries/).
- University of New Brunswick Library Catalogue (https://lib.unb.ca/).
- University of Toronto Library Catalogue (articles) (https://query.library.utoronto.ca/).
- URSUS—University of Maine Catalogue (https://ursus.maine.edu/).
- Vancouver Island University Library Catalogue (https://marlin.viu.ca/malabin/door.pl/0/0/0/60/792/X).
- Vytautas Magnus University Library Catalogue https://biblioteka.vdu.lt/en/.
- Web of Science Core collection (https://clarivate.com/); Topic search covering all years within Science Citation Index Expanded (1945-present), Social Sciences Citation Index (1956-present), Arts & Humanities Citation Index (1975-present), Conference Proceedings Citation Index- Science (1990-present), Conference Proceedings Citation Index- Social Science & Humanities (1990-present), Emerging Sources Citation Index (2015-present).

Search engines

- Google Scholar (https://scholar.google.com/).
- Google (https://www.google.com/).
  The searches with internet search engines will be conducted in 'private' mode to prevent the influence of previous browsing history and location on search results. A simplified search string using key terms with Boolean operators will be used. The results will be organized by relevance. After the first 50 hits, results will be checked until relevant articles are no longer retrieved as advised in Livoreil et al. [48]. To safeguard against finishing the search too early, a hundred irrelevant hits will be allowed. If no relevant hits appear after a hundred irrelevant hits, the search will be terminated. The date and number of hits received and searched will be recorded and included in the review report.

Organizational websites

Besides known sources of potential literature, internet was searched extensively to find additional sources. We chose the organizational websites dealing with related issues and conducted scoping during the search of those websites for possibly relevant material. The final list of organizational websites to be included in the review:

- Alberta Biodiversity Monitoring Institute (http://www.abmi.ca/home.html).
- Community Research and Development Information Service (https://cordis.europa.eu/home_en.html).
- Department of Natural Resources Canada: Canadian Forest service (http://cfs.nrcan.gc.ca/publications).
- Estonian Environment Agency (https://www.keskkonnaagentuur.ee/et).
- European Forest Insititute (https://www.efi.int/).
- Finnish Environment Insititute (http://www.syke.fi/).

- Finnish Society of Forest Science (http://www.metsatieteellinenseura.fi/): Publication Dissertationes Forestales (https://dissertationesforestales.fi).
- Forestry Research Institute of Sweden (https://www.skogforsk.se/).
- International Boreal Forest Research Association (http://ibfra.org/).
- International Union for Conservation of Nature (https://www.iucn.org/).
- Latvian State Forestry Research Institute (http://www.silava.lv/mainen/aboutus.aspx).
- Lithuanian Research Centre for Agriculture and Forestry (https://www.lammc.lt/lt).
- Natural Resources Institute Finland (https://www.luke.fi/).
- Northern Research Institute of Forestry (http://www.sevniilh-arh.ru).
- Norwegian Forest Research Institute (http://www.skogforsk.no/).
- Russian Academy of Sciences: Centre for Forest Ecology and Productivity (http://cepl.rssi.ru/).
- Russian Academy of Sciences: Forest Research Institute of Karelian Research Centre (http://forestry.krc.karelia.ru/).
- Russian Academy of Sciences: Siberian Branch, Institute of Natural Resources, Ecology and Cryology (http://inrec.sbras.ru/).
- Russian Academy of Sciences: Siberian Branch, V.N. Sukachev Institute of Forest (http://forest.akadem.ru/).
- Saint-Petersburg Forestry Research Institute (http://spb-niilh.ru/).
- SNS Nordic Forest Research (http://nordicforestresearch.org/).
- Sustainable Forest Management Network (Canada) (https://sfmn.ualberta.ca/).
- Swedish Forest Society (https://www.skogssallskapet.se/).
- Swedish Research Council Formas (http://www.formas.se/).
- United States Department of Agriculture: Forest Service, Library's Digital collection (https://www.fs.fed.us/library/forestryReports.shtml).
- United States Department of Agriculture: Forest Service, Research Publications Online (https://www.fs.usda.gov/treesearch/).

Supplementary searches

To supplement the search, citation chasing in review articles will be undertaken. A call for unpublished data will also be published on the website of the Evidence-Based Forestry in Finland project (http://npmetsa.fi/en/frontpage/) and in ResearchGate and sent directly to stakeholder organizations that may have unpublished data on the topic.

Search record database

All search records will be exported into the reference management software EndNote. When all the searches are conducted, the files will be merged and duplicates will be removed. If the exportation into reference management software is not possible, a record will be created into a separate file manually. After that the articles will be screened.

Article screening and study eligibility criteria

Screening process

We will use Colandr software to conduct the screening process. Articles will be screened in two stages by three people: first based on title and abstract and then at full text level. At the first stage a random set of 100 articles will be screened by all three persons. If their inclusion decisions do not vary more than 5%, the rest of the articles will be divided among the screeners. All discrepancies in screening decisions will be discussed to facilitate the consistency in the screening process. If the screening decisions differ more than 5%, a second set of 100 articles will be screened jointly. Although Kappa-test is used to quantify screener agreement and support subsequent screening by a single person, CEE guidelines [49] state that "*the use of the kappa statistic to demonstrate high reviewer agreement in support of employing only one screener to assess the majority of articles is not advised*". Thus, we have opted to pursue 95% agreement between the reviewers to justify the subsequent division of articles between the reviewers without it influencing the inclusion/exclusion of articles. Articles in Russian will be screened by only one person. To check that inclusion criteria is used consistently, the Russian speaker will talk the other screeners through the decision process on a random set of 20 articles.

The review may include articles published by the authors of the review. Their inclusion in the review at the screening and critical appraisal stage will be jointly determined by the other authors in accordance with the eligibility and appraisal criteria.

Eligibility criteria

The eligibility criteria (Table 3) are based on PICO components, study design, language and geographic location of the studies. Only studies conducted in the boreal vegetation zone as described in [47] and the Baltic countries will be included.

At each stage of the screening a separate file will be created of the excluded articles. At the full text stage, a reason for exclusion will be recorded, and a list of the excluded articles with the reason for rejection will be included as additional information in the review report.

Table 3 Critical appraisal criteria to assess studies in the full text stage

Factor	Low	Medium	High
Study design	Experimental studies (includes also quasi-experimental studies)	Observational studies	Case studies (descriptive studies)
Sampling	Large sample size Sampling method suitable for the population of interest[a] Properly conducted randomisation. Control and intervention areas matched	Small to medium sample size Sampling method suitable for the population of interest[a] Control and intervention areas comparable based on their ecological characteristics	Sampling method not suitable for collecting data on the population of interest[a]
Accounting for heterogeneity and potential effect modifiers	Effect modifiers identified, and data collected on them	Effect modifiers identified and considered in relation to the results	Effect modifiers not identified or considered
Data analysis methods	Methods appropriate[b]	Methods appropriate[b]	Methods not appropriate[b]

[a] Suitable sampling method refers to the use of methods that are known to work for the population in question based on published studies, e.g. flying insects are sampled by trapping or fogging, not by cutting branches

[b] Appropriate methods refer to the use of statistical methods that consider data characteristics such as sample size and distribution. For example, non-parametric statistical tests are used for data that does not follow normal distribution

If there are multiple articles from one study site (i.e. linked articles), they will be appraised as a group to avoid inclusion of duplicate data following Frampton et al. [50]. True duplicate studies will be removed, and the rest will be screened as a single unit to consider all available data pertinent to the study when making eligibility decisions.

Study validity assessment

All studies included in the full text stage will be critically appraised and categorized as having 'low', 'medium', or 'high' risk of bias. The assessment is based on following factors (more detailed in Table 3):

- Study design.
- Sampling (method, location, time and length of data collection).
- Accounting for potential effect modifiers and sources of heterogeneity.
- Data analysis methods.

Study will be categorised as 'low risk' when it fulfils all the criteria in the category low. If any of the criteria is in the medium or high risk category then the study will be categorised accordingly (but see data synthesis and presentation section for testing robustness of results with sensitivity analysis). In addition, studies with insufficient methodological description will be excluded unless sufficient clarifying details are received by contacting the authors of the study. All studies will be assessed by two persons and any inconsistencies or uncertainties discussed with other research group members.

If enough quantitative data will be available to conduct meta-analysis during data synthesis, the studies will be weighted in the analysis according to their category.

Data coding and extraction strategy

Data from included studies will be extracted and saved in an Excel spreadsheet and will be made available as supplementary information of the systematic review. In the data, study characteristics (meta-data), outcomes such as sample size, mean, standard deviation (SD) and standard error (SE) will be included. In the case SD or SE are not available, the data on test statistics that can be converted into effect sizes will be collected. Furthermore, data on effect modifiers and potential sources of heterogeneity will be extracted to enable statistical analysis of the relationships between outcomes and sources of heterogeneity. If there are independent results from several studies in one article, these will be treated as separate studies in the extraction of the data. To retrieve missing information or data, authors of the studies will be contacted.

Data will be extracted by more than one person. Thus, to ensure consistency, a set of five studies will be first coded together. If later any uncertainties with the extraction occur, they will be discussed among group members. The data from Russian studies will be extracted by one person only, but any uncertain decisions will be discussed with the research team.

Potential effects modifiers and sources of heterogeneity

To understand possible variation in the effects of the studies better, possible effect modifiers will be extracted from the studies. As the studies in this systematic review may have been completed in a relatively large area, large part of the Holarctic region, there are several factors that may result in heterogeneity among studies, including geographical location and climatic conditions of the study site. In addition, temporal variation is expected even though this review concentrates on studies in relatively short period of time compared to the natural life cycle of boreal forests lasting more than 100 years. As forest management has changed over the years, the year a study was conducted may influence the results. Also, time passed since intervention was started may cause variation depending on the timing and nature of harvests as well as natural succession of vegetation after harvests. Below we present a non-comprehensive list of potential effect modifiers and sources of heterogeneity: The list was compiled on the basis of the authors' experience and consultation at the stakeholder meeting.

- Geographic location.
- Climatic conditions.
- Forest type.
- Soil type.
- Differences in forest management.
- Tree species composition.
- Size of trees.
- The size and disposition of retention trees.
- The category and size of the woodland key habitat.
- Differences in management (for example, the amount of retention trees).
- Certification (certified or not, certification system).
- The owner of the study site(s).

Data synthesis and presentation

A narrative synthesis of data from all the studies included will be produced. There will be a description of the evidence base with figures and tables in the synthesis as well as description of the intervention effects on biodiversity outcomes.

Quantitative data on the stated biodiversity outcomes will be extracted to conduct meta-analysis. If there is enough data to conduct further quantitative analysis, heterogeneity in the results will be explored using meta-regression. To avoid the risk of false-positive results, the treatment of several outcomes of the same experimental study will be considered prior to the statistical analysis. Only data from comparable study settings will be included in the same analysis. If there is not enough data to be extracted for meta-analysis, other analytical methods will be considered along with narrative synthesis.

When conducting the systematic review, steps are taken to minimise bias in the results. To test the effect of the validity assessment (i.e. exclusion of articles) and the robustness of the studied outcomes, a sensitivity analysis will be conducted. This will be done by conducting analyses including and excluding studies with high or medium risk of bias. In addition, the presence of publication bias will be evaluated visually by producing funnel plots. If publication bias is detected visually, and if there is enough data available, 'trim and fill' method will be used to adjust the results for publication bias.

Additional files

Additional file 1. Stakeholder organizations. A list of stakeholder organizations invited to the stakeholder workshop. The ones with bold participated in the workshop.

Additional file 2. ROSES form.

Additional file 3. Test list. A list of articles to test the performance of the search string.

Additional file 4. The performance of the search string. Document of testing search string in search engines.

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Authors' contributions
MH, SS, AJ wrote the first draft. MH led the writing. AU and TS built and tested the search string. The first draft was discussed with MM and PP. All authors read and approved the final manuscript.

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