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

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## Abstract

**Background:** Forest harvesting is the main factor of habitat degradation and biodiversity loss in forests of the boreal zone. To mitigate potential harmful effects, important small-scale habitats have been protected within production forests. These include woodland key habitats, buffer zones along water bodies as well as habitats 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 conservation.

**Methods:** Research questions are: 1) What is the impact of woodland key habitats on biodiversity conservation in boreal forests? 2) What is the impact of forest buffer zones and buffer strips on biodiversity conservation in boreal forests? 3) What are the impacts of other voluntary conservation areas on biodiversity in boreal forests? Animal, plant and fungal diversities are addressed as well as the amount of deadwood and retention trees within the habitat patches as a proxy indicator for biodiversity. The literature, both academic and grey, will be searched in English, Finnish, Swedish and Russian. The article screening, regarding the inclusion criteria, will be done at title, abstract and full-text scale and the quality of the studies included will be evaluated against appraisal criteria and studies will be categorized based on their quality. 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:** commercial forests, woodland key habitats, buffer zones, voluntary conservation

## Background

Boreal forest is the world's largest terrestrial biome covering large parts of the Northern Hemisphere. Most of the boreal forests, also known as taiga, lie in Russia and Canada. The northern parts of the USA belong to the boreal zone as does Northern Europe.

Most of the Northern European forests are in commercial use and only relatively small proportion of forest land is protected for biodiversity: In Finland 7,2%, Norway 1,2%, Sweden 12,2% and Estonia 6,2% (1). Russian and North American forests differ from Northern Europe not only in the extent of the area, but also forest management is less intense than in Europe and there are large areas of pristine forest. However, as demand for forest products has grown, logging has increased in entire area of the boreal zone in the last decades. Protected forests cover 2,0% of the forests in Russia, 19,8% in USA and 4,9% in Canada (1).

Traditionally, main method for biodiversity conservation has been the establishment of protected areas. However, the network of protected areas is considered inadequate to maintain species assemblages (2–5). Also, setting aside areas is expensive. Even though already existing protected areas are often situated in less productive areas (6), establishing new protected areas is not possible in the magnitude maintaining biodiversity would need (5). Therefore, increased attention has been focused on the land outside of protected areas (7) as well as restoring already degraded habitats (8).

Habitat quality and biodiversity outside protected forest areas gained interest already in 1970's (9) 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 commercial forests included green tree retention, prescribed burning, leaving dead wood in forests and creating habitat corridors and buffer zones (10,11). 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 1990's (12). Without conservation these habitat patches would lose their special characteristics.

But is conserving small habitat patches within production forests effective way to maintain biodiversity? There have been previous systematic reviews on woodland key habitats (12) and retention trees (13) but the evidence base hasn't been reviewed recently with the exception of the creation of deadwood (review forthcoming, Bernes et al. 2016). Here we describe a systematic review protocol for a systematic review on the importance of small conserved habitat patches within production forests for maintaining biodiversity. The review will focus on woodland key habitats, riparian buffer zones along water bodies, and other habitats protected voluntarily. In addition to their direct value as habitats for species, the small patches may contain more deadwood or green retention trees than the surrounding landscape. Both green retention trees and deadwood have been shown to be important for maintaining biodiversity in boreal forests (13,14). Thus, we will include the amount of deadwood and retention trees as outcomes of interest in the review. 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 (15,16) and soon extended to other Nordic countries, the Baltic and Russia (17). 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 (17) and there is no unified approach to the definition of the term (18). There are also differences in the definitions and legal status of the woodland key habitats and their delineation varies between countries. In Finland, woodland key habitats are usually relatively small and protected by the Forest Act (19) whereas in Sweden, Russia and Baltic countries the size of woodland key habitats may vary from single trees to several hundreds of hectares and protection of key habitats is more voluntary based (12,15,17,20–26). Norway has two systems to identify woodland key habitats, one for forestry planning, with the average key habitat size of 0,83 ha (25), the other for municipal land-use planning, with substantially larger size of key habitats, ca. 20 ha (12). In Finland, woodland key habitats are defined by legislation whereas in Sweden, Russia and Baltic countries they are based on observations or probability of endangered species occurrence on given habitat patches or structural properties of the sites.

The mean size of woodland key habitats also varies between countries being 4,6 ha in Sweden (27), between 2 to 3 ha in Estonia, Latvia and Lithuania (12), 0,83 ha measured by the method used in forest industry (25) and 0,63 ha in Finland (28). There has been critique of the small size and scattered distribution of woodland key habitats (29). It has been suggested that isolated woodland key habitats suffer from extinction debt (30) and that small habitat patches may not be able to maintain species diversity over time (26).

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 (31). In the USA public protected areas are defined by the criteria of the International Union for Conservation of Nature (IUCN) whereas protection of private forests is based on voluntary actions and economic incentives (32).

### Buffer zones

Buffer zones were originally established on riparian habitats to prevent erosion and sedimentation and hence, preserve water quality (33,34). They also aimed to prevent non-fluvial disturbances like fire, wind, insects or variable temperature and light conditions that could have impact on water ecosystems (35–38). There is a multitude of studies suggesting the benefits from buffer zones on diversity of vegetation (39), invertebrates (40,41), birds (40,42,43) and mammals (44,45). Buffer zones, as a special case of green tree retention, have also positive impact on biodiversity on larger scale by increasing structural variation and acting as habitat corridors enhancing connectivity in a landscape (46,47).

Buffer zones are widely used especially in riparian forests but also around small lakes and ponds in Northern Europe as well as in USA and Canada. There is variation in the width and legal status of buffer zones. In USA each state and in Canada each jurisdiction has their own recommendations and guidelines for buffer zone width, the variation being from 15.1 to 29 meters. Usually, the northern areas have wider buffer zones. In Finland, buffer zones are not defined by legislation, except for those surrounding of springs and brooks that are also woodland key habitats in the Forest Act (19). Also, the recommendations for good forest management (48) propose that buffer zones will be left on lakeshores and along rivers. In Sweden, the forestry law does not define the width of a buffer zone, but requires a buffer zone to be left along water bodies (49). Also, forest companies have set recommendations for riparian and lakeside buffer zones (50, 51). In Russia, buffer zones are specified in the Water Code of the Russian Federation, in Latvia by the Protection Zone Act, in Lithuania by the Act of Protected Area and in the resolution of the Government and Ministry of the Environment (52). In all these three countries the width of the buffer is determined by the length of the water body. In Russia also the slope of the shore affects the width of the buffer, and it can vary from 30 meters to 200 meters. Estonian legislation determines a fixed width of a buffer zone. Furthermore, restrictions to forest management in buffer zones are determined by the Nature Conservation Act and the Water Act, and depend on the type of water body and the size of watershed (52).

In addition to national requirements and recommendations for buffer zones, certification systems may require establishment of buffer zones (53, 54).These may be either areas where no harvesting is allowed (53) or areas where harvesting is allowed when special care is taken to avoid adverse effects on soil properties, water quantity and quality as well as biodiversity (55).

### Conservation of other small habitat patches

All the above-mentioned conservation actions are aiming to slow down and eventually stop the degradation of biodiversity. However, forest species are still in decline, especially in countries with intensive forest management (56). To counter the decline, new kind of conservation policies have been developed. In Finland, *Forest Biodiversity Program for Southern Finland* (METSO) (57), 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, 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* (58,59). In the USA the concept of conservation easements is the main way of voluntary forest conservation. This means that landowners give up their right to develop the forest and get monetary or taxation-based compensation from the government or a conservation group (land trust) (32). In Canada and Russia almost all forests are publicly owned, and therefore comparable voluntary conservation systems do not exist.

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 (53, 60). 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 biodiversity value, e.g. forests with large amount of dead wood and herb-rich forest patches.

### Green tree retention

Leaving certain amount of trees permanently in regeneration stands, or green tree retention, was developed in USA and Canada a few decades ago (61). Green tree retention aims at saving structural variation and biodiversity values in the long term (62). The method aims at helping species to survive through regeneration, since it increases structural variation within forest stand and enhances connectivity in a landscape (11, 61). The method has been studied widely and it has been shown to benefit most species groups (63). Retention tree method (aggregated or dispersed retention) and retention tree species can have impact on the ecological effects (11, 63), but two relatively recent meta-analyses (13, 64) acknowledge the importance of green tree retention in biodiversity conservation.

In boreal zone, green tree retention is nowadays commonly used in Canada, USA and Fennoscandia (11, 65). According to Vanha-Majamaa & Jalonen (11), leaving trees in regeneration fellings is against regulations in Russia, but some trees are commonly left in cutting areas. In Canada, the guidelines on the amount of retention trees vary between provinces, but both dead and living trees are supposed to be left in cutting areas (11). In the USA, green trees are guided to be left on at least 15 % of the cutting area (11, 66). In Sweden and Finland green tree retention is recommended but not required by the Forest Act and there are no exquisite instructions of the number of retention trees per ha (11).

Green tree retention is used in regular production forests, whereas woodland key habitats, voluntary conservation areas and patches protected by certification schemes are usually habitats of endangered species or otherwise of special concern (57,58). Retention of both dead and living trees enables continuum of dead wood in production forests from present to the future (62). Therefore, green tree retention can be considered as a method that compliments biodiversity conservation in production forests.

## Objective of the review

The objective of this paper is to systematically review and synthesize the biodiversity impacts of conservation of small habitat patches. Riparian and lakeside buffer zones, protection of woodland key habitats and small-scale voluntary conservation areas are included.

Primary research question:
Do small habitat patches within production forests provide value for biodiversity conservation in boreal forests?

The primary research question is divided into three sub-questions:

1) What is the impact of woodland key habitats on biodiversity?

2) What is the impact of buffer zones along water bodies on biodiversity?

3) What are the biodiversity impacts of conserving other small habitat patches?

The study questions can be broken into the following structure:

| Subject | Intervention | Comparator | Outcome |
|---|---|---|---|
| Boreal forests | Small habitat patches set aside for conservation within production forests | No intervention | Changes in direct and proxy biodiversity indicators |

## Methods

### Stakeholder engagement

The topic for this systematic review arose from the discussions of evidence needs related to sustainability issues with the Finnish forestry sector. Finnish Forest Industries, Metsä Group, Metsähallitus, Stora Enso Oyj and UPM-Kymmene participated the discussions

A stakeholder workshop was held 7 November 2018 to discuss the proposed systematic review. 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 (Annex 1) with a notice that it can be further shared with interested individuals and organizations. A reminder email was sent two weeks later to those individuals and organizations that had not responded.

In the end, 10 stakeholders participated in the workshop. 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 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 three 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.

### Searching for articles

#### *Search terms*

A list of search terms relating to the PICO components was proposed at the stakeholder meeting and validated by the participants (Table 1).

*Table 1. Search terms proposed at the stakeholder meeting*

| Forest type | Population | Intervention | Comparator | Outcomes |
|---|---|---|---|---|
| Boreal, taiga | Vegetation, plant, fungi, mammal, polypore, bird, red-listed species, endangered species<br><br>Small water bodies | Woodland Key Habitat, key habitat, forest buffer, buffer zone, riparian buffer zone, voluntary conservation, certification | Clear-cut, regeneration cut, natural forest, uncut forest, woodland key habitat, uncertified | Biodiversity, biological diversity, diversity, species, richness, abundance, assemblage |

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 will be tested in the Web of Science and Scopus using a test list of 20 articles collected from previous reviews. The proposed search string in English is as follows:

*(Boreal forest OR boreal zone OR taiga OR spruce OR pine OR birch OR aspen)*
*AND (woodland key habitat* OR key habitat* OR forest act habitat* OR buffer strip* OR buffer forest OR buffer zone* OR riparian buffer* OR voluntary conservation OR voluntary set-aside OR private* protected area* OR private reserve* OR METSO program OR Komet program OR conservation easement*)*
*AND (species richness OR abundance OR assemblage OR diversity OR biodiversity OR deadwood OR retention)*

The search string will be translated to Finnish, Swedish and Russian. Also, it will be simplified by reducing the number of search terms to search organizational websites and to conduct internet searches. The used search strings will be published as additional information in the review report.

To screen articles that are published before the data synthesis is started, a search alert will be set in publication 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, and in Finnish, Swedish and Russian websites in the primary language the website is published.

*Testing for the performance of the search*

To evaluate the performance of the search, a test list of 20 articles was collected from previous reviews (Annex 2). The performance of the search string will be tested in the Web of Science and search string modified if necessary.

*Publication databases*

- Aleksandras Stulginskis University Library Catalogue (https://aleph.library.lt/F?func=find-b-0&local_base=lzu01)
- Brage NMBU - Open Research Archive of Norwegian University of Life Sciences (https://brage.bibsys.no/xmlui/handle/11250/92927)
- CAB Abstracts (https://www.cabi.org/); Keyword search from 1973 onwards.
- 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.
- Digital Dissertations Library of Russian State Library (http://diss.rsl.ru/)
- Doria (https://www.doria.fi/)
- EMU DSpace - The digital archive of Estonian University of Life Sciences Library (https://dspace.emu.ee/)
- Helka - University of Helsinki Catalogue (https://helka.finna.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.
- Russian Scientific Electronic Library (https://elibrary.ru/)
- 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 Massachusetts Amherst Library Catalogue (https://www.library.umass.edu/)
- University of New Brunswick Library Catalogue (https://lib.unb.ca/)
- University of New Hampshire Library Catalogue (https://librarycatalog.unh.edu/)
- University of Toronto Library Catalogue (https://search.library.utoronto.ca/index)

- URSUS - University of Maine Catalogue (https://ursus.maine.edu/)
- UTUPub - University of Turku repository (https://www.utupub.fi/)
- Vancouver Island University Library Catalogue (https://marlin.viu.ca/malabin/door.pl/0/0/0/60/792/X)
- 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).

#### *Internet searches*

- Google Scholar (https://scholar.google.com/); Title search will be conducted with the function ‘at least one of the words’.
- Google (https://www.google.com/)

#### *Organizational websites*

The list of organizational websites is given in Annex 3 due to the large number of organizational websites included.

#### *Supplementary searches*

To supplement the search, citation chasing 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 sent directly to stakeholder organizations that may have unpublished data on the topic. In addition, data will be asked from individuals suggested at the stakeholder workshop.

### Search record database

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

## Article screening and study inclusion criteria

### Screening process

Articles will be screened as a three-step process by three people: first the title, second the abstract and third full text level. At the title stage the first 50 articles (or, if the total number is less than 50, all the articles) in the EndNote file will be screened by all three persons. If their decisions on the screening are the same, rest of the articles will be divided among the screeners. If the decisions differ, an additional 50 articles will be screened jointly. The process will be repeated until the screeners achieve a fully aligned agreement. If discrepancies in inclusion decisions occur, they will be discussed to facilitate the consistency in the screening process. In the abstract stage the same process will be repeated. If a screener is not sure about the inclusion of an article, it will be moved to next stage. At the full text stage the articles will be screened by all three persons, except the articles in Russian that will be screened by only one person.

A separate EndNote file of the excluded articles will be created at each step of the screening process. At the full text stage reasons for exclusion will be recorded and included in the review report as additional information as well as a list of excluded articles.

In the review, articles published by the authors of the review may be included. Their inclusion during screening and critical appraisal stage will be determined by other authors in accordance with the eligibility and appraisal criteria.

### Eligibility criteria

The eligibility criteria are based on PICO components, study design and geographic location of the studies. Only studies conducted in the boreal vegetation zone will be included.

If there are multiple studies from one study site, they will be appraised as a group to avoid inclusion of duplicate data.

*Table 2. The eligibility criteria for article screening in relation to question elements*

| Question elements | Eligibility criteria |
|---|---|
| Populations | *Included*: Animals, plants, fungi, deadwood, retention trees |
| Interventions | *Included*: Woodland key habitats, buffer zones, small-scale areas of voluntary forest conservation |
| Comparators | *Included:* Managed forests, commercial forests, natural forests, uncut forest<br><br>*Excluded*: non-forest lands, urban parks, wooded fields e.g. Christmas tree plantations |
| Outcomes | *Included*: Species diversity, richness, assemblage, abundance, composition, the amount of deadwood, the number of retention trees |
| Study design | *Included*: control / intervention studies, comparisons between intervention areas of different sizes, comparisons along gradient (e.g. diversity measurements within same buffer zone at different widths), before / after studies |

### 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 study. 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. Below we present a non-comprehensive list of potential effect modifiers and sources of heterogeneity:

- Geographic location
- Climatic conditions
- Forest type
- Soil type
- Differences in forest management
- Tree species composition
- Size of trees
- The size, amount and quality of dead wood
- The size and disposition of retention trees
- The category and size of the woodland key habitat
- The type of buffer zone (for example, riparian or lakeside)
- Differences in management (for example, width of the buffer zone, the amount of retention trees)
- Certification system
- The owner of the study site(s)

### Study quality assessment

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

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

All the 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 extraction strategy

Data from included studies will be extracted and saved in an Excel spreadsheet. In the data, meta-data, outcomes, effect modifiers and potential sources of heterogeneity will be included. 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, coding will be first conducted together to insure consistency.

## Data synthesis and presentation

A narrative synthesis of data from all the studies included will be produced. There will be a description of the base of the evidence with figures and tables in the synthesis and description of interventions and comparators, locations, designs and lengths of the studies and studied taxa will be included. There will also be descriptions of the intervention effects on biodiversity outcomes.

If there is enough quantitative data to be extracted from the included studies to calculate effect sizes, a meta-analysis will be conducted to assess the effects of woodland key habitats, forested buffer zones as well as voluntary conservation policies on biodiversity separately. If meta-analysis can be conducted, publication bias will be quantitatively explored by conducting tests for publication bias and by producing funnel plots.

## Declarations

### Authors' contributions

MH, SS, AJ wrote the first draft. MH lead the writing. The first draft was discussed with MM and PP. All authors read and approved the final manuscript.

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### Ethics approval and consent to participate

Not applicable.

## Consent for publication

Not applicable.

## Availability of data and material

Not applicable.

## Competing interests

The authors declare that they have no competing interests.

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## Appendices

Annex 1. List of organizations invited to the stakeholder workshop

Arctic Flavours Association
Arvometsä Oy
Bioenergy Association of Finland
BirdLife Finland
Central Union of Agricultural Producers and Forest Owners
Commelina
Etämetsänomistajien liitto
Finnwatch
Finnish Association for Nature Conservation
Finnish Environment Institute
Finnish Environmental Journalists Association
Finnish Forest Association
Finnish Forest Centre
Finnish Forest Industries
Finnish Nature League
Finnish Society for Nature and Environment
Finnish Society of Forest Science
Finnish Wildlife Agency
Forest Stewardship Council Finland Office
Friends of Ancient Forest
Friends of the Earth Finland
Greenpeace Finland
Helsingin Kaupunkimetsäliike
Industrial Union (Finland)
Koneyrittäjät
LUVA – Natural Resources
Metsä Group
Metsähallitus
Ministry of Agriculture and Forestry
Ministry of the Environment
Natural Resources Institute Finland
PEFC Finland
Stora Enso
Tapio
Tornator
University of Helsinki

UPM-Kymmene
WWF Finland

Annex 2. A list of articles to test the performance of the search string


1. Berglund H & Jonsson BG (2005) Verifying an Extinction Debt among Lichens and Fungi in Northern Swedish Boreal Forests. Conservation Biology 19: 338-348.

2. Cockle KL & Richardson JS (2003) Do riparian buffer strips mitigate the impact of clearcutting on small mammals? Biological Conservation 113: 133–140.

3. Crawford JA & Semlitsch RD (2007) Estimation of core terrestrial habitat for stream-breeding salamanders and delineation of riparian buffers for protection of biodiversity. Conservation Biology 21: 152–158.

4. Darveau M, Beauchesne P, Bélanger L , Huot J & Larue P (1995) Riparian forest strips as habitat for breeding birds in boreal forest. Journal of Wildlife Management 59: 67–78.

5. Elbakidze M, Angelstam P, Andersson K, Nordberg M & Pautov Y (2011) How does forest certification contribute to boreal biodiversity conservation? Standards and outcomes in Sweden and NW Russia. Forest Ecology and Management 262: 1983-1995.

6. Gustafsson L, De Jong J & Norén M (1999) Evaluation of Swedish woodland key habitats using red-listed bryophytes and lichens. Biodivers. Conserv. 8: 1101-1114.

7. Hottola J, Siitonen J (2008) Significance of woodland key habitats for polypore diversity and red-listed species in boreal forests. Biodivers. Conserv. 17: 2559-2577.

8. Hylander K, Nilsson C & Göthner T (2004) Effects of Buffer- Strip Retention and Clearcutting on Land Snails in Boreal Riparian Forests. Conservation Biology 18: 1052-1062.

9. Junninen K & Kouki J (2006) Are woodland key habitats in Finland hotspots for polypores (Basidiomycota)? Scandinavian Journal of Forest Research Volume 21: 32-40.

10. Kinley TA & Newhouse NJ (1997) Relationship of Riparian Reserve Zone Width to Bird Density and Diversity in Southeastern British Columbia. Northwest Science 71: 75-86.

11. Laita A, Mönkkönen M & Kotiaho JS (2010) Woodland key habitats evaluated as part of a functional reserve network. Biol. Conserv. 143: 1212-1227.

12. Mäntymaa E, Juutinen A, Mönkkönen M & Sventoa R (2009) Participation and compensation claims in voluntary forest conservation: A case of privately owned forests in Finland. Forest Policy and Economics 11: 498-507.

13. Pearson SF, Giovanini J, Jones JE & Kroll AJ (2015) Breeding Bird Community Continues to Colonize Riparian Buffers Ten Years after Harvest. PLoS One 10(12):e0143241.

14. Perhans K, Gustafsson L, Jonsson F, Nordin U & Weibull H (2007) Bryophytes and lichens in different types of forest set-asides in boreal Sweden. For. Ecol. Manage. 242: 374-390.

15. Pykälä J (2007) Implementation of Forest Act habitats in Finland: Does it protect the right habitats for threatened species? Forest Ecology and Management 242: 281 – 287.

16. Selonen VAO & Kotiaho JS (2013) Buffer strips can pre-empt extinction debt in boreal streamside habitats. BMC Ecology 13: 24.

17. Sverdrup-Thygeson A , Borg P & Bergsaker E (2008) A comparison of biodiversity values in boreal forest regeneration areas before and after forest certification. Scandinavian Journal of Forest Research 23: 236:243.

18. Timonen J, Gustafsson L, Kotiaho JS & Mönkkönen M (2011) Hotspots in cold climate: conservation value of woodland key habitats in boreal forests. Biol. Conserv. 144: 2061-2067.

19. Whitaker DM, Carroll AL & Montevecchi WA (2000) Elevated numbers of flying insects and insectivorous birds in riparian buffer strips. Canadian Journal of Zoology 78: 740-747.

20. Ylisirniö A-L, Mönkkönen M, Hallikainen V, Ranta-Maunus T & Kouki J (2016) Woodland key habitats in preserving polypore diversity in boreal forests: Effects of patch size, stand structure and microclimate. Forest Ecology and Management 373: 138-148.

Annex 3. Organizational websites

- Alberta Biodiversity Monitoring Institute (http://www.abmi.ca/home.html)
- All-Russian Research Institute of Silviculture and Mechanization of Forestry (http://www.vniilm.ru)
- Bellona Foundation (http://bellona.ru/)
- BiodivERsA - the network programming and funding research on biodiversity and ecosystem services across European countries and territories (https://www.biodiversa.org/)
- Biodiversity Conservation (Russia) (http://www.biodiversity.ru/)
- Canadian Council of Forest Ministers (https://www.ccfm.org/english/index.asp)
    - Sustainable forest management in Canada (https://www.sfmcanada.org/en/)
- Canadian Parks and Wilderness Society (http://cpaws.org/)
- Centre for Economic Development, Transport and the Environment (Finland) (https://www.ely-keskus.fi/)
- Community Research and Development Information Service (https://cordis.europa.eu/home_en.html)
- Confederation of European Forest Owners (http://www.cepf-eu.org/)
- Convention on Biological Diversity (https://www.cbd.int/)
- Department of Natural Resources Canada (https://www.nrcan.gc.ca/home)
    - Canadian Forest service
        - Atlantic Forestry Centre (https://www.nrcan.gc.ca/forests/research-centres/afc/13447)
        - Great Lakes Forestry Centre (https://www.nrcan.gc.ca/forests/research-centres/glfc/13459)
        - Laurentian Forestry Centre (https://www.nrcan.gc.ca/forests/research-centres/lfc/13473)
        - Northern Forestry Centre (https://www.nrcan.gc.ca/forests/research-centres/nofc/13485)
        - Pacific Forestry Centre (https://www.nrcan.gc.ca/forests/research-centres/pfc/13489)
- Ecological Society of America https://www.esa.org/esa/
- Estonian Environment Agency (https://www.keskkonnaagentuur.ee/et)
- Estonian Foundation Private Forest Centre (https://www.eramets.ee/)
- Estonian Fund for Nature (https://elfond.ee/et)
- European Forest Insititute (https://www.efi.int/)
- Far East Forestry Research Institute (http://dalniilh.ru/)
- Federal Forestry Agency (Russia) (http://rosleshoz.gov.ru/)
- Federal State Budget Education Institution of Higher Education Voronezh State University of Forestry and Technologies named after G.F. Morozov (http://vgltu.ru/)
- Finnish Association for Nature Conservation (https://www.sll.fi/)
- Finnish Environment Institute (http://www.syke.fi/)
- Finnish Forest Association (https://smy.fi/)
- Finnish Forest Centre (https://www.metsakeskus.fi/)
- Finnish Forest Foundation (http://www.metsasaatio.fi/)
- Finnish Nature League - Luonto-Liitto (http://www.luontoliitto.fi/)
- Finnish Society of Forest Science (http://www.metsatieteellinenseura.fi/)

- Food and Agriculture Organization of the United Nations (http://www.fao.org/home/en/)
- Forestry Research Institute of Sweden (https://www.skogforsk.se/)
- Foundation for Strategic Environmental Research (Sweden) (https://www.mistra.org/)
- Greenpeace Canada (https://www.greenpeace.org/canada/en/)
- Greenpeace Norway (http://www.greenpeace.org/norway/no/)
- Greenpeace Finland (http://www.greenpeace.org/finland/fi/)
- Greenpeace Russia (https://www.greenpeace.org/russia/ru/)
- Greenpeace Sweden (http://www.greenpeace.org/sweden/se/)
- Greenpeace USA (https://www.greenpeace.org/usa/)
- International Boreal Forest Research Association (http://ibfra.org/)
- International Union for Conservation of Nature (https://www.iucn.org/)
- International Union of Forest Research Organizations (https://www.iufro.org/)
- IVL Swedish Environmental Research Institute (https://www.ivl.se/)
- Latvian State Forests (https://www.lvm.lv/)
- Latvian State Forestry Research Institute (http://www.silava.lv/sakums.aspx)
- Lithuanian Research Centre for Agriculture and Forestry (https://www.lammc.lt/lt)
- Metsähallitus ( http://www.metsa.fi/)
- Metsäteho (http://www.metsateho.fi/)
- Ministry of Agriculture (Latvia) (https://www.zm.gov.lv/)
- Ministry of Agriculture and Food (Norway) (https://www.regjeringen.no/no/dep/lmd/id627/)
- Ministry of Agriculture and Forestry (Finland) (https://mmm.fi)
- Ministry of the Environment (Estonia) (https://www.envir.ee/et)
- Ministry of the Environment (Finland) (http://www.ym.fi)
- Ministry of the Environment (Lithuania) (http://am.lrv.lt/)
- Ministry of the Environment and energy (Sweden) (https://www.regeringen.se/sveriges-regering/miljo--och-energidepartementet/)
- Ministry of Environmental Protection and Regional Development (Latvia) (http://www.varam.gov.lv/)
- Ministry of Natural Resources and Environment of the Russian Federation (http://www.mnr.gov.ru/)
- National Science Foundation, Long-term Ecological Research Network (USA) https://lternet.edu/
- Natural Resources Institute Finland (https://www.luke.fi/)
- Nature Canada (http://naturecanada.ca/)
- Nature Conservancy (https://www.nature.org/en-us/)
- Nature Conservancy of Canada (http://www.natureconservancy.ca/en/)
- NOLTFOX Northern European Database for Long-Term Forest Experiments (http://noltfox.metla.fi/)
- Northern Research Institute of Forestry (http://www.sevniilh-arh.ru)
- Norwegian Forest Research Institute (http://www.skogforsk.no/)
- Norwegian Institute of Bioeconomy Research (NIBIO) (https://www.nibio.no/)
- Norwegian Institute for Nature Research (https://www.nina.no/)
- Norwegian Society for the Conservation of Nature, Friends of the Earth Norway (https://naturvernforbundet.no/)
- Norwegian State Forest and Land Corporation (https://www.statskog.no/)

- Ontario Catalogue of natural resource scientific and technical publications (https://www.ontario.ca/page/catalogue-natural-resource-scientific-and-technical-publications)
- Regional Public Nature Conservation Organization of Karelia (Russia) (http://spok-karelia.ru/)
- Reshetnev Siberian State University of Science and Technology (https://www.sibsau.ru/, http://hbz.sibsau.ru/ru)
- Research institute of Sweden (https://www.ri.se/)
- Royal Swedish Academy of Agriculture and Forestry (http://www.ksla.se/)
- Russian Academy of Sciences (http://www.ras.ru/)
    - Centre for Forest Ecology and Productivity (http://cepl.rssi.ru/)
    - Far Eastern Branch, Institute of Biological Problems of the North (http://www.ibpn.ru/)
    - Forest Research Institute of Karelian Research Centre (http://forestry.krc.karelia.ru/)
    - Siberian Branch, Institute of Natural Resources, Ecology and Cryology (http://inrec.sbras.ru/)
    - Siberian Branch, Institute for Water and Environmental Problems (http://www.iwep.ru/ru/)
    - Siberian Branch, V.N. Sukachev Institute of Forest (http://forest.akadem.ru/)
    - Ural Branch, Institute of Biology of Komi Scientific Centre, Department of Forest Science (https://ib.komisc.ru/rus/)
- Russian Center for the Protection of Forests (http://rcfh.ru/)
- Russian Institute of Continuous Education in Forestry (http://vipklh.ru/)
- Saint-Petersburg Forestry Research Institute (http://spb-niilh.ru/)
- Saint-Petersburg State Forest Technical University (http://spbftu.ru/)
- SNS Nordic Forest Research (http://nordicforestresearch.org/)
- Skydda Skogen (http://skyddaskogen.se/sv/)
- Society for Conservation Biology (https://conbio.org/)
- State forest management centre (Estonia) (https://www.rmk.ee/et)
- Stockholm Environment Institute (https://www.sei.org/)
- Sustainable Forest Management Network (Canada) (https://sfmn.ualberta.ca/)
- Swedish environmental protection agency (http://www.naturvardsverket.se/)
- Swedish Forest Agency (https://www.skogsstyrelsen.se/)
- Swedish Forest Society (https://www.skogssallskapet.se/)
- Swedish Forestry Association (https://www.skogen.se/)
- Swedish Research Council Formas (http://www.formas.se/)
- Swedish Society for Nature Conservation (https://www.naturskyddsforeningen.se/)
- Tapio (http://tapio.fi/)
- United Nations Forum on Forests (http://www.un.org/esa/forests/)
- United States Department of Agriculture (https://www.usda.gov/)
    - Forest Service (https://www.fs.fed.us/)
        - Research and Development (https://www.fs.fed.us/research/)
        - Pacific Northwest Research Station (https://www.fs.usda.gov/pnw-beta/)
        - Rocky Mountain Research Station (https://www.fs.fed.us/rmrs/)
        - Northern Research Station (https://www.nrs.fs.fed.us/)
        - Research Publications Online https://www.fs.usda.gov/treesearch/

        - Natural Resources Conservation Service https://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home /
- United States Department of the Interior, Bureau of Land Management https://www.blm.gov/
- United States Environmental Protection Agency https://www.epa.gov/
- United States Geological Survey https://www.usgs.gov/
- Wildlife Habitat Canada (https://whc.org/)
- WWF Canada (http://www.wwf.ca/)
- WWF Finland (https://wwf.fi/)
- WWF Latvia (http://lv-pdf.panda.org/)
- WWF Norway (https://www.wwf.no/)
- WWF Russia (https://wwf.ru/)
- WWF Sweden (http://www.wwf.se/)
- WWF USA (https://www.worldwildlife.org/)