SR12

A Systematic Review Protocol

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What are the impacts of dead-wood manipulation on the biodiversity of temperate and boreal forests?

A systematic review protocol

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Abstract

Background

Dead wood is a key factor for biodiversity in most forest ecosystems. It is also the most critical resource lost when natural forests are converted into forests managed for timber production. In order to maintain viable populations of species dependent on dead wood, managers of protected forests need to be more aware of how available quantities and qualities of dead wood relate to the habitat requirements of such species.

The current lack of dead wood in forests with a history of timber extraction makes any review of interventions related to dead wood highly relevant. The aim of the proposed systematic review is to clarify how forest biodiversity is affected by manipulation of dead wood, and whether such manipulation is useful as a means of conserving or restoring biodiversity in forest set-asides.

Methods

The review will examine primary field studies of how the abundance and diversity of forest species are affected by manipulation of the quantity or quality of dead wood. Such manipulation includes prescribed burning and creation or addition of dead wood. We will consider studies made in boreal or temperate forests anywhere in the world, and we will incorporate relevant investigations made not only in protected areas but also in stands managed for timber. Non-intervention or alternative kinds or levels of intervention will be used as comparators. Relevant outcomes include the diversity and abundance of any species or species group, other than trees.

Studies will mainly be selected from a recent systematic map of the evidence on biodiversity impacts of active management in forests set aside for conservation or restoration. A search update targeted at more recently published literature will be made using a subset of the search terms and online sources used for the systematic map. Peer-reviewed and grey literature in English and several other languages will also be considered.

Keywords

Dead wood, Saproxylic species, Diversity, Species richness, Species abundance, Forest conservation, Forest restoration, Habitat management, Prescribed burning

Background

Dead wood is a key factor for biodiversity in most forest ecosystems (Harmon et al. 1986; Esseen et al. 1997; Grove 2002; Stokland et al. 2012). Given that traditional forestry aims at effective production and utilisation of timber, it is not surprising that dead wood is also the most critical resource lost when natural forests are converted into production forests. For example, dead-wood volumes throughout Europe's production forests are normally less than 10% of natural levels (Junninen et al. 2006; Jonsson & Siitonen 2012). In protected areas too, current dead-wood volumes are usually lower than natural levels due to past management (e.g. Jonsson et al. in prep.), with long-lasting effects on thousands of dead-wood dependent (saproxylic) species (Bader et al. 1995; Gu et al. 2002; Seibold et al. 2015). Hence, in order to maintain viable populations of saproxylic species (Stokland & Siitonen 2012), managers of protected forests need to be aware of how available quantities and qualities of dead wood can be manipulated to meet the habitat requirements of such species (Müller & Bütler 2010; Seibold et al. 2016).

Identification of review topic

We have recently published a systematic map of how biodiversity is affected by active management of forests set aside for conservation or restoration (Bernes et al. 2015). A systematic map gives an overview of the evidence base by providing a database with descriptions of relevant studies. It does not synthesise reported results, but it can be seen as a first step towards more complete reviews of selected subtopics.

Based on our map of the evidence, we identified four subtopics that were sufficiently covered by existing studies to allow for preparation of a full systematic review, potentially including meta-analysis. The selection of subtopics was also based on their significance for managers of forest reserves and other stakeholders, and on their relevance to Swedish forests.

One of the four suggested subtopics was the effects of various kinds of intervention on dead wood and saproxylic species (including wood-inhabiting species). The current lack of dead wood in forests with a history of timber extraction makes any review of interventions related to dead wood highly relevant. We proposed a systematic review of how dead-wood amounts and species dependent on dead wood are affected by any kind of intervention that may be useful for the conservation or restoration of biodiversity in forest set-asides.

In the process of specifying the scope and focus of the review, as presented in this protocol, we made a set of modifications to the initially broad review question, taking the available evidence base into consideration. Being a general biodiversity indicator, dead wood is often quantified in manipulative forest studies and reported as an outcome along with records of particular species and species groups. However, for many interventions that affect dead-wood amounts, such as prescribed burning that aims to reduce fuel loads, the response of species cannot be clearly linked to dead-wood changes (e.g.

Amacher et al. 2008; Chiono et al. 2012) but rather to changes in light and shading, microclimate or soil conditions (Seibold et al. 2016). Studies of such interventions will not provide managers with relevant information on biodiversity effects of changes in dead-wood volumes or qualities.

Therefore, we decided to focus on deliberate manipulations of dead wood and other interventions where dead-wood changes constitute dominant primary effects and where confounding factors have been sufficiently controlled. Such interventions are likely to affect saproxylic species in particular, but we decided to include studies of other species groups as well (except trees, since we judged that it is rarely relevant for managers of forest set-asides to manipulate dead wood in order to promote the richness or abundance of living trees).

A recent study reviewed experimental studies of biodiversity associated with dead wood (Seibold et al. 2015). However, this study did not provide a full systematic review of the outcomes, but rather focused on current knowledge gaps with the aim of guiding further experimental work. Another recent study (Mason & Zapponi 2015) reviewed literature on forest management for saproxylic conservation but included no quantitative synthesis of the evidence. Hence, we believe that our review will provide an important complement by exploring biodiversity outcomes of dead-wood manipulation at a more detailed level.

Objectives

The primary aim of the proposed systematic review is to clarify how the abundance and diversity of species (other than trees) are affected by manipulation of the quantity or quality of dead wood in temperate and boreal forest stands. Three kinds of intervention that can change dead-wood amounts and properties will be studied: creation of dead wood (e.g. through felling or girdling of trees) , addition of dead wood from elsewhere, and prescribed burning (but only in cases where effects on species are likely to be related to dead-wood changes).

The ultimate purpose of the review is to investigate whether manipulation of dead wood is useful as a means of conserving or restoring biodiversity in forest set-asides. Nonetheless, we will also include any relevant studies of dead-wood manipulation in forests under commercial management. In particular, prescribed burning is sometimes included not only in the management of reserves but also in forestry that combines commercial and conservation purposes.

The review will follow the guidelines for systematic reviews in environmental management issued by the Collaboration for Environmental Evidence (CEE 2013).

Primary question: *What are the impacts of dead-wood manipulation on the biodiversity of temperate and boreal forests?*

Components of the primary question:

Population:	Temperate and boreal forests
Intervention:	Manipulation of dead wood (through prescribed burning or creation/addition of dead wood)
Comparator:	Non-intervention or alternative kinds or levels of intervention
Outcomes:	Diversity and abundance of species (other than trees)

Methods

Selection of studies identified in the systematic map

Most of the evidence on which this systematic review will be based is included in the recently completed systematic map of how biodiversity is affected by active management of forest set-asides (Bernes et al. 2015). Of the 812 studies in the map, about 240 reported on how species (other than trees) were affected by prescribed burning or creation/addition of dead wood. Of the studies of prescribed burning, however, we will only include those that also reported quantitative estimates of how the intervention changed dead-wood amounts.

The systematic map was based on searches using 13 publication databases, 2 search engines, 24 specialist websites and 10 literature reviews. The majority of searches were performed in May-August 2014. In March 2015, a search update was made using Web of Science and Google Scholar.

Search update and screening of additional literature

In order to identify more recently published literature on dead-wood manipulation that may be relevant to this review, we will perform an additional search update, using the following subset of search terms applied for the systematic map:

Subject:	forest*, woodland*, "wood* pasture*", "wood* meadow*"

Forest type: boreal, boreonemoral, hemiboreal, nemoral, temperate, conifer*, deciduous, broadlea*, "mixed forest", spruce, "Scots pine", birch, aspen, beech, "*Quercus robur*", Swed*

Intervention: conserv*, restor*, rehabilitat*, "active management", (prescribed OR control* OR experiment*) AND (burn* OR fire*), girdl*

Outcomes: *diversity, species AND (richness OR focal OR target OR keystone OR umbrella OR red-list* OR threatened OR endangered OR rare), "species density", "number of species", indicator*, abundance, "dead wood", "woody debris", "woody material", habitat*

The terms within each category ('subject', 'forest type', 'intervention' and 'outcomes') will be combined using the Boolean operator 'OR'. The four categories will then be combined using the Boolean operator 'AND'. An asterisk (*) is a 'wildcard' that represents any group of characters, including no character.

Searches for literature published in 2014 or later will be made in Web of Science and Google Scholar. In the latter case, the first 200 hits (based on relevance) will be examined for appropriate data. No language or document type restrictions will be applied.

Articles will be evaluated for inclusion at three successive levels. First, they will be assessed by title. Next, each article found to be potentially relevant on the basis of title will be judged for inclusion on the basis of abstract. Finally, each article found to be potentially relevant on the basis of abstract will be judged for inclusion based on the full text. At all stages of this screening process, the reviewer will tend towards inclusion in cases of uncertainty. Final decisions on whether to include doubtful cases will be taken by the review team as a whole.

A list of studies rejected on the basis of full-text assessment will be provided in an appendix together with the reasons for exclusion.

Study inclusion criteria

In order to be included, each study must pass each of the following criteria (a subset of those used for the systematic map):

- *Relevant subjects:* Forests in the boreal or temperate vegetation zones.

Any habitat with a tree layer is regarded as forest, which means that studies of e.g. wooded meadows and urban woodlands may be included.

As an approximation of the boreal and temperate vegetation zones we will use the cold Köppen-Geiger climate zones (the D zones) and some of the temperate ones (Cfb, Cfc and Csb), as defined by Peel et al. (2007). The other temperate Köppen-Geiger climate zones are often referred to as subtropical and are therefore considered to fall outside the scope of this review.

Nevertheless, forest stands dominated by ponderosa pine (*Pinus ponderosa*) will be considered as relevant even if located outside the climate zones mentioned above. These forests constitute a well-studied North American habitat type that shares several characteristics with the pine forests in boreal and temperate regions.

- *Relevant types of intervention:* Prescribed burning, creation of dead wood (e.g. through felling or girdling of trees), and addition of dead wood (from somewhere else).

Studies of prescribed burning will be included only if they provide quantitative estimates of how the amounts of dead wood changed as a result of the intervention.

- *Relevant type of comparator:* Non-intervention or alternative kinds or levels of intervention.

Both temporal and spatial comparisons of how dead-wood manipulations affect the richness or abundance of forest species are considered to be relevant. This means that we will include both 'BA' (Before/After) studies, i.e. comparisons of the same site prior to and following an intervention, and 'CI' (Control/Impact) studies, i.e. comparisons of treated and untreated sites (or sites that had been subject to different kinds of treatment). Studies combining these types of comparison, i.e. those with a 'BACI' (Before/After/Control/Impact) design, will also be included.

Most CI and BACI studies that are relevant to the subject of this systematic review compare different forest stands or different parts of a single stand. However, some studies of how creation or addition of dead wood affects biodiversity are based on comparisons of individual trees (logs or snags) that have been subject to different treatments (e.g. girdling *vs*. other ways of killing trees), and we will include such comparisons as well. Hence, the review will cover both tree-level and stand-level interventions.

Moreover, we have found a number of seemingly useful dead-wood studies that do not compare effects of different kinds of intervention but are based on other types of comparison instead, and we have therefore decided to extend the comparator criterion by also including studies in the three following categories:

A) Studies comparing effects of dead-wood creation/addition in different kinds of forest stands (e.g. stands of different age or stands subject to different kinds of management).

B) Studies comparing effects of creation/addition of different kinds of dead wood (e.g. wood of different species or sizes).

C) Studies of created/added *vs.* naturally occurring dead wood.

- *Relevant types of outcome:* Measures of diversity or abundance of species (other than trees).

- *Relevant type of study:* Primary field studies.

Based on this criterion, we will exclude e.g. simulation studies, review papers and policy discussions.

- *Language:* Full text written in English, French, German, Danish, Norwegian, Swedish, Finnish, Estonian or Russian.

Potential effect modifiers and reasons for heterogeneity

To the extent that data are available, the following potential effect modifiers will be considered and recorded for all studies included in this review:

Geographical coordinates
Altitude
Climate
Mean age of forest stand
Dominant tree species
Forest density (e.g. basal area or overstorey canopy cover)
Type of intervention (prescribed burning or various forms of creation or addition of dead wood)
Dead-wood species and sizes
Areal extent and seasonality of intervention
Size of plots from which data were collected
Time elapsed from intervention to final data sampling
Intervention strength (change of dead-wood amounts)
Change of other dead-wood properties
Other interventions at study sites (harvesting, thinning, understorey removal, grazing etc.)
Landscape aspects (such as degree of isolation)
History of land use and protection

A final list of effect modifiers will be established as the review proceeds.

Study quality assessment

Studies that have passed the relevance criteria described above will be subject to critical appraisal: Based on assessments of their validity, they will be categorised as having high, medium or low susceptibility to bias.

Studies will be excluded from the review due to high susceptibility to bias (low quality) if any of the following factors apply:

- No true replication
- Methodological description insufficient
- Intervention and comparator sites not well-matched
- Severely confounding factors present
- Intervention data difficult to interpret
- Outcomes difficult to interpret (due to poor study design and/or poor presentation or analysis of the data)
- Outcomes not clearly an effect of dead-wood changes

Studies that are not excluded due to low quality will be considered to have medium susceptibility to bias (medium quality) if any of the following factors apply:

- Location of study plots potentially biased
- BA study (not CI or BACI)
- No useful data on variance or sample sizes
- No useful data on intervention strength (change of dead-wood amounts)

If none of the above factors apply, the study will be considered to have low susceptibility to bias (high quality).

Additional or more specific quality criteria may be developed as the review proceeds.

Detailed reasoning for the critical appraisal of each study will be recorded in a transparent manner. In general, the quality of a study will be assessed by one reviewer, but final decisions in doubtful cases will be taken by the review team as a whole. A list of studies rejected on the basis of quality assessment will be provided in an appendix together with the reasons for exclusion.

Data extraction strategy

Outcome means, measures of variation (standard deviation, standard error, confidence intervals) and sample sizes will be extracted from tables and graphs, using image analysis software when necessary. Data on interventions and other potential effect modifiers will also be extracted from the included articles.

It may in some cases be useful to ask authors of relevant articles to supply data in digital format. This will primarily be done where useful data have been published in graphs from which they are difficult to accurately extract, or when it is known or assumed that considerable amounts of relevant but unpublished data may be available in addition to the published results. If raw data are provided, summary statistics will be calculated by us.

Data synthesis and presentation

A narrative synthesis of data from all studies included in the review will describe study findings and study quality. Tables will be produced to summarise results. Where studies report similar outcomes, meta-analysis may be possible. In these cases effect sizes will be standardised and weighted appropriately. Details of the quantitative analysis will only be known when full texts have been assessed for their contents and quality.

If meta-analysis of effect sizes is possible, it will take the form of random-effects models. Meta-regressions or subgroup analysis of categories of studies will also be performed where sufficient studies report common sources of heterogeneity. Publication-bias and sensitivity analysis will be

carried out where possible. Overall management effects will be presented visually in plots of mean effect sizes and variance.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

The manuscript was drafted by CB, BGJ, KJ, JM and JS. All authors read and approved the final manuscript.

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EviEM conducts systematic reviews of environmental issues identified as important by public agencies and other stakeholders. These provide an overall assessment of the state of scientific knowledge and help to improve the basis for environmental decision-making in Sweden.

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