

# Slutrapport

**Projektrubrik:** Tree cavities as indicators of nature conservation values in forest management

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## Populärvetenskaplig sammanfattning

Tree cavities are small, hidden worlds that shape the lives of countless forest creatures. In the boreal forests of northern Europe, these hollows—whether carved by birds or formed slowly through decay—are essential for forest biodiversity. Yet their presence is far from guaranteed. Modern forestry has transformed the age, structure, and tree species composition of these forests, unintentionally reducing the very features that cavity-dependent species rely on.

Cavities rarely appear by accident. Most begin when a tree is wounded and fungi colonize the exposed wood, softening it from within. This sets the stage for woodpeckers, the true architects of boreal forests. Strong excavators such as the great spotted and black woodpecker can excavate into healthy aspen or pine, while smaller species, like tits or lesser spotted woodpeckers, depend on softer woods such as dying birch and alder. Aspen stands out as the most important species of all. It grows quickly, decays already when young, and provides ideal conditions for both fungi and excavators, making it the backbone of cavity formation.

In unmanaged forests, cavities occur with remarkable abundance. Our study shows that these forests hold up to four times more cavities than managed ones, and they support far richer communities of cavity-nesting birds. The explanation is simple: old trees, dying trees, and broadleaved trees are far more common in forests where trees suitable for cavity formation are common. In contrast, managed forests tend to favor conifers, remove weakened trees during thinning, and are harvested before decay has time to develop. Young, uniform stands have little opportunity to produce all the cavity structures.

Even when cavities do form, their lifespan is finite. Most cavities in dead trees last only a few years, disappearing when the tree breaks or falls. Living trees, particularly large aspens and pines, offer cavities that endure much longer. These long-lived structures are vital for secondary nesters—species that cannot excavate themselves but depend on existing hollows. Without a steady supply of new cavities, these animals soon disappear.

Despite these challenges, forest managers have powerful tools at their disposal. Promoting broadleaved trees, especially aspen, immediately increases cavity potential. Leaving more dying or low-vitality trees in place allows fungi and excavators to do their work. Extending rotation lengths lets trees reach the ages at which cavities become most common. Retention forestry—keeping selected trees standing after harvest—can also safeguard cavity resources, especially when those trees include large aspens or standing dead pines.

Tree cavities may seem like minor features, but they form the foundation of intricate ecological networks. By recognizing their importance and adjusting management to foster their creation, we can ensure that boreal forests remain vibrant habitats, rich with the life that depends on these hidden homes.

## Resultat

The project aimed at revealing the occurrence and ecological values of tree cavities in boreal northern Europe and to provide practical guidelines for managing forests so that cavity availability is enhanced.

The project contained two major activities: (1) To provide an overview of scientific knowledge on cavity occurrence and cavity-associated biodiversity. This is based on an extensive literature review covering about 80 years period of research. (2) To estimate, based on exceptionally long-term empirical data, the influences of forest management on cavity availability, with suggestions on how to enhance cavity availability in managed forests in Fennoscandia.

The main results of the project are presented in two peer-reviewed scientific articles that are published in the top journals in forest ecology and management.

The review demonstrates that tree cavities rarely form without a combination of injury, fungal activity, and bird excavation. Heart rot fungi play a central role by softening the inner wood, allowing excavating bird species to create suitable nesting chambers. Aspen emerges as the most important tree species for cavity formation because it readily develops heart rot and is structurally easier for excavators to work with. This species alone hosts a substantial portion of excavated cavities in boreal forests. Pines, birches, and alders also contribute to cavity availability, but their roles vary depending on the excavator species and local forest conditions. Among the excavators, strong species such as the great spotted and black woodpecker can carve cavities into healthy or slightly decayed trees, while weaker species like tits and lesser spotted woodpeckers rely heavily on soft, fully decayed broadleaves.

The study that compared cavity occurrence in managed and unmanaged forests consistently reveal large differences in both cavity density and cavity nesting bird populations. Unmanaged forests contain between 1.7 and four times more cavities (cavity production rate), and their cavity nester bird populations are roughly twice as dense. This contrast is driven by three core mechanisms embedded in standard silvicultural practice. First, regeneration programs favor conifers over broadleaves, reducing the presence of aspen and birch—the primary substrates for cavity formation. Second, thinning operations, especially thinning from below, selectively remove suppressed or dying trees, which are precisely the individuals most likely to develop cavities. Third, rotation ages are too short for trees to reach the stages when heart rot and structural decline become common. As a result, many managed forests, particularly young stands, contain very few cavities and support diminished assemblages of cavity dependent wildlife.

Cavity persistence adds complexity that has rarely been addressed as the studies on cavities tend to cover too short time scales to address this aspect. Cavities in dead or heavily decayed trees generally last only a few years before the tree collapses or the cavity structure fails. Cavities in living trees persist much longer, sometimes for decades, though their formation in those trees is less common.

Standing dead pines are a notable exception, as they remain intact far longer than other dead broadleaves and provide stable cavity structures for extended periods. Secondary cavity nesters prefer recently excavated cavities and tend to avoid older ones that have degraded or accumulated parasites, meaning that a continuous supply of new cavities is vital for maintaining viable populations.

If managed forests are to sustain healthy cavity dependent communities, several adjustments are essential. Increasing the presence of broadleaved species, especially aspen, plays a foundational role. Natural regeneration strategies that allow broadleaves to establish and persist can reverse the trend toward conifer dominance. Reducing thinning intensity and allowing a greater proportion of low vitality and standing dead trees to remain in the stand will enhance opportunities for cavity formation and provide substrates for both excavators and fungi. Extending rotation lengths allows trees to develop the large diameters and senescent features associated with higher cavity frequency. Retention forestry, when practiced with an emphasis on preserving cavity prone species and structures, can substantially increase cavity availability across managed landscapes. Continuous cover forestry may also support cavity nesting species, particularly through improved food resources, though success depends on deliberate retention of suitable trees rather than reliance on harvesting systems alone. Artificial nest boxes can supplement natural cavities for some species, but they are not a viable long term substitute for natural cavity dynamics.

## Målbeskrivning

The project was successful in reaching its major scientific aims. To me, the most important achievement was the compilation and analyses of an exceptionally long-term and detailed data set of the cavity occurrence (or cavity production rate CPR) in spruce-dominated forests that had experienced different levels of forest management intensities. Without the support of this project, this long-term data would probably have been completely lost as there were no other resources to complete the task. Additionally, we also reached the goal of providing a scientific review and summary of the cavity occurrence in boreal Europe, with special emphasis on the effects that forest management may have on cavities and associated biota and biodiversity. These main results and outputs are presented in scientific articles that are published in the leading forest ecology and forest management journals. This study provided a very novel and impactful evidence that forest management is closely related to the cavity occurrence. Additionally, the study provided several key insight into how cavity occurrence could be facilitated along with the forest management and probably with only marginal costs (though we did not study economic effects directly). The other goal to provide a thorough review and synthesis of cavities in boreal Europe was also reached.

Unfortunately, the project experienced also drawbacks and even failures. Most importantly, the principal scientist in the project experienced major health problems towards the end of the funding period. He had to leave the project prematurely several months before the 2-yr project was completed. Sadly, this coincided with the major reporting period. Despite his absence, and due to Finnish employment regulations, we still had to pay majority of his salary from the project grant. As the empirical data was collected by him and many parts of it were accessible only to him, I faced serious challenges and quite overwhelming situation to get the project completed. Fortunately, the main article was possible to complete as the empirical data for this part was available for reporting. However, all this took much more of my time compared with the plan. I suppose, however, that the

major empirical findings to be expected from the project were completed sufficiently well. For the review article, I managed to get participation from a competent young scientist (Dr. Aleksi Nirhamo).

One thing we failed due to these aforementioned problems was the knowledge transfer and dissemination that was initially planned. Initially, we included some communication forums and events to present the project results but these were not possible to organize due to lack of necessary staffing in the project.

All the problems and drawbacks experienced have been communicated with Skogssällskapet continuously during the project, and the consequent changes in the project plan have been discussed and approved

### **Kommunikation och nyttiggörande av resultat**

The results of the project are communicated in the two scientific articles (attached). Additionally, we have prepared a popular science article to one of the a nature conservation journal, but they have not yet consider it fully. We hope that this can be published later and also translated to Swedish. The Finnish text, together with an automatic and unchecked Swedish translation is attached.

Compared to our initial plan, communication part has not been quite successful or reached its aims so far. The reasons for the drawbacks in the communication plan are described above

### **Bilaga till slutrapport**

Bilaga 1

Bilaga 2

Bilaga 3

Bilaga 4