Review of indicators and field methods for monitoring biodiversity within national forest inventories. Core variable: Deadwood

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Abstract Deadwood is one of the four elements taken into account in this review of indicators and field methods and is often considered as a key indicator of forest biodiversity. We have analysed the main types of surveys and have realised how greatly the needs and constraints used to monitor deadwood can vary among them. For instance, classical National Forest Inventories usually tend to avoid time-consuming collecting methods. In the wide variety of existing definitions of deadwood, such inventories require simple and clear definitions, especially in terms of quantified thresholds. Thus, deadwood is properly described by characterising several components, such as snags, logs, stumps, branches and fine woody debris. Deadwood sampling methods alter depending on the different components and dimensions considered (standing dead trees, lying dead trees and branches, etc. assessed quantitatively). Attributes such as tree species and stage of decay are used mainly to qualify the deadwood components. The deadwood volume estimations are usually based on classical approaches already applied to living or felled trees: volume equations and/or formulas giving the volumes of common geometric solids. The purpose of this paper is to focus on different deadwood assessment techniques and to provide the information necessary to identify the most relevant methods for collecting deadwood data. The latter is used to build indicators that characterise the evolution of forest biodiversity at the scale of large forest territories.

Keywords Deadwood · Deadwood attributes · Deadwood components · Forest biodiversity · National forest inventory · Sampling methods · Volume calculations

Introduction

As agreed by many authors, deadwood is an element of biodiversity and, to some extent, an indicator of forest management sustainability that deserves to be taken into account in inventories, especially at the national level. It is an important attribute because it was not measured in the majority of National Forest Inventories (NFIs) before the 1990s. It was during the 1990s that the first deadwood surveys were initiated within the NFIs of Finland, Sweden, Norway and Switzerland (Stokland et al. 2004; Böhl and Brändli 2007).

In this paper, deadwood is characterised in terms of identified attributes, used sampling methods, volume calculations and operational use.
of monitoring and assessment. The importance of deadwood and its role in the forest ecosystem is at stake, and a state of the art of deadwood assessment in European NFIs is done. It appears that deadwood is now assessed in many European countries and in the USA, especially in NFIs and that the methodology often differs. It is therefore important to investigate options for harmonising collected data, field measurements and the types of expected results for international reporting. Questionnaires sent to 26 European countries by the COST Action E43\(^1\) (a project initiated by the European National Forest Inventory Network (ENFIN) network and financed by the European Union) have been used to identify the types of data collected as well as the methods and designs in current or past use. Some of the data and results from this questionnaire are briefly presented here.

This paper can be considered as a synthesis of numerous studies that take into account different objectives and different methodologies developed to provide estimations of standing and lying deadwood.

**Importance of deadwood and its role in the forest ecosystem**

Deadwood is considered as an important component of forest ecosystems and is of interest to ecologists, mycologists, foresters and fuel specialists. Information collected on debris is very useful and often constitutes an indicator of biodiversity (Humphrey et al. 2002). It is also a key factor in the nutrient cycle (Harmon et al. 1986) and provides habitat for numerous plants, animals and fungi (Ferris et al. 2000). Deadwood is known to be important or even critical for insects (e.g. many scolytids and buprestids, beetle species, etc.; Köhler 2000), fungi (Heilmann-Clausen and Christensen 2003; Möller 1994), epiphytic lichens and bryophytes (Humphrey et al. 2002; Kruys and Jonsson 1999), arthropods (Alexander 2003; Komonen 2003), mammals (e.g. bats and dormice; Taake 1991; Erickson and West 2003) and also birds (Bunzel et al. 2002; Bursell 2002; Utschik 1991).

Consequently, many forest-occurring species characterised by high habitat diversity depend on the presence of decaying wood. Deadwood can also help to describe the quality and status of wildlife habitat, the structural diversity within a forest and the storage and cycling of nutrients and water. It is also an interesting indicator or a reference for sustainable forest management. Dead coarse woody debris serves as an important substrate for the regeneration of some tree species (Zielonka 2006). The new approaches taken into account by NFIs make it possible to describe the diversity of this core variable at a large scale.

It is important to recall here that the needs for deadwood quantification are not the same for a NFI, for nature reserve management (Bruciamacchie 2005) or for a forest management unit that wishes to analyse the amount and the quality of deadwood in relation to the influence of silvicultural practices. For example, deadwood below ground as well as belonging to living trees (often branches) is conventionally excluded from NFIs because such data are generally too difficult to collect and to quantify.

**Definitions and attributes**

**Definitions**

Within the activities of COST Action E27\(^2\) “Protected forest areas in Europe—analysis and harmonisation”, experts have gathered several definitions for deadwood:

- Material over a certain size (limit >10 cm diameter) that is no longer living and that is left in the forest
- Woody material from forest trees and shrubs no longer living in the stand
- All woody detritus in forests comprising stems, twigs and roots but excluding deadwood parts of living trees

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\(^1\)“Harmonisation of National Forest Inventories in Europe: Techniques for Common Reporting” (http://www.metla.fi/eu/cost/e43).

\(^2\)COST E27 homepage: http://bfw.ac.at/020/profor/.