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Fuel Load Assessment Methods in Forest and Non-Forest Vegetation in Central Europe: A Comparative Analysis

Introduction

The integration of prescribed burning in the management of different Central European vegetation types to maintain landscape and habitat structures or to reduce forest wildfire hazard has been acknowledged increasingly in the past few years (Goldammer, 2009). This is reflected by the establishment and activities of the Eurasian Fire in Nature Conservation Network (EFNCN).[1] Despite the rising interest and appreciation of fire as a management tool in nature conservation and forestry, including an increasing number of pilot projects and routinely applied prescribed burning, there have been limited empirical studies on fuel conditions. Information on fuels is, however, a prerequisite for any fuel treatment by prescribed fire since the properties and quantity of fuels determine the behaviour and intensity of a fire and thus its impact on the ecosystem.

The objective of this study was to examine which fuel sampling method is most appropriate to obtain information on fuels as required for prescribed burning in pine forest, heathland, and pasture land. This was achieved through comprehensive field surveys conducted in each vegetation type. The focus of the analysis has been on revealing advantages and disadvantages as well as on potential applications of sampling methods.

Fuel sampling in pine forests

In forest stands of *Pinus sylvestris* and *Pinus nigra*, planted 48 years ago in Breisach, the line intersect sampling (Brown, 1974) and the 3P subsampling (Beaufait et al., 1974) were tested. The comparison revealed that the line intersect sampling is to prefer over 3P subsampling since it performed better in terms of practicality, time, data analyses and utility for post-burn sampling.

Figure 1. Line Intersect Sampling (left) in a *Pinus sylvestris* stand (right).

The major advantages of the line intersect sampling are its simplicity to carry out the sampling in the field and its flexibility to adapt the sampling layout to the specific conditions on the surveyed site. This

[1] http://www.fire.uni-freiburg.de/programmes/natcon/natcon.htm

enables to better cope with a dense understorey which was present in both pine stands and was considered as the main constraint by conducting the sampling. The dense grass layer showed clearly that sampling methods developed in other countries can not always be directly transferred but require alterations. The fuel loads measured with the line intersect sampling are demonstrated as examples in Table 1.

Table 1. Fuel loads in *Pinus sylvestris* und *Pinus nigra* stands (kg/m²)

Stand	Size classes (cm)						Total
	0-0.49	0.5-0.99	1-2.99	3-6.99	>7 (rotten)	>7 (sound)	
P. sylvestris	0.034	0.079	0.401	0.434	0.308	0.402	1.658
P. nigra	0.009	0.149	0.837	0.492	1.135	1.512	4.133

Fuel sampling in heathland

The cube method, which was developed in the Mediterranean region to assess fuel load distributions within the canopies of individual shrubs (Cohen et al., 2002), was applied in *Calluna* heathland in Drover Heide Nature Reserve in north-western Germany. In conjunction with the determination of physical properties of the fuel particles, this method provided a thorough description and detailed characterisation of fuels of *Calluna vulgaris* (Table 2).

Table 2. Physical properties of *Calluna vulgaris*.

Fuel family	Surface-to-Volume Ratio (m²/m³)	Mass-to-Volume Ratio (kg/m³)
Leaves	10574	588
0-2 mm	4358	939
2-6 mm	1097	859
6-25 mm	524	862

The prominent benefit of the cube method is the information how the biomass is distributed within the shrub canopies. This enables to develop spatially-explicit vegetation models and further contributes to the prescription of a controlled fire. The fuel bulk density which measures the dry weight per unit volume (kg/m³) is exemplified for the bottom and top of the shrubs in Figure 2.

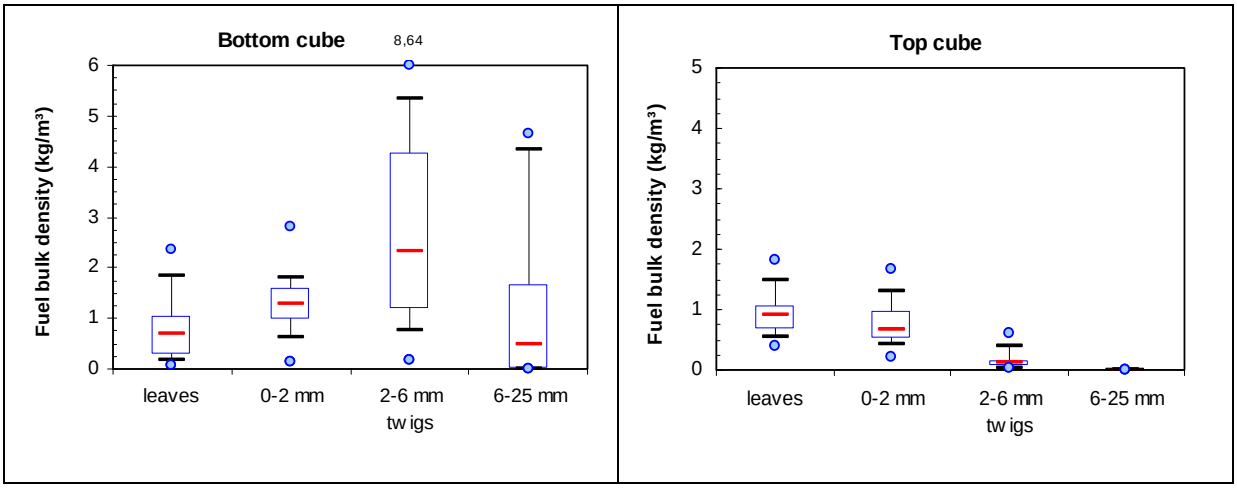

Figure 2. Fuel bulk density of leaves and twigs of the bottom (left) and top (right) of shrubs of *Calluna vulgaris*. Boxplots showing minimum and maximum values (circles, first and ninth deciles (bars), first and third quartiles (box) and median (red line).

However, the sampling procedure is very time-consuming and causes the cube method to be inappropriate for fuel assessment prior to prescribed burning. The ocular estimate technique was found to be better suitable in situations where time is a crucial factor. This technique was developed by the Fire Ecology Group in Freiburg in the frame of the Fire Paradox project[2] and consists of an estimate by eye of the percentage cover of the leaves and twigs and of the litter for different height categories on a circular plot. Based on the proportion occupied by the species in the circle the average fuel load per hectare is determined.

Figure 3. Cube measuring device (left) used in *Calluna* heathland in the Drover Heide (right).

Fuel sampling on pasture land

To estimate fuel loads in pasture land, the disc pasture meter, a widely used device originally developed for African Savannas (Bransby and Tainton, 1977; Trollope and Potgieter, 1986), was examined on three different sites in high altitudes of the Rohrhardsberg region in the Black Forest. A calibration of the instrument including all study sites could not be determined but a separate analysis of the data from each site revealed a reliable regression relationship that can be used for making

Figure 4. Disc Pasture Meter (left) applied in pastures in the Rohrhardsberg region of the Black Forest (right).

management decisions. Due to its rapidity and non-destructive nature, the disc pasture meter can be applied for a wide range of purposes in the management of grazing grounds. It provides a sound

[2] www.fireparadox.org

foundation to evaluate the use of prescribed burning on grass swards and to optimize the application of other measures to maintain pasture land.
The information on fuels obtained through the sampling in the field is an indispensable prerequisite to assess any fuel problem. The ability to quantitatively describe fuels plays a crucial role when planning prescribed burning and or addressing other fire issues particularly in the following cases:

- Planning of prescribed burning at local level, to evaluate its impacts and effectiveness, and to enhance the benefit of the use of different measures in the management of ecosystems;
- Obtaining of information about the distribution of fuel loads over the forest area on the national level, e.g. for the utilization of phytomass as renewable source of energy or for pyrogenic emissions estimates; and
- Exchange of experiences and promotion of international fire research in terms of defining fuel types and thereupon developing fuel models.

The findings of this study show that the investigated methods were appropriate to assess and characterise fuels in the different vegetation types of Central Europe and the derived information provide a fundamental basis for the application of prescribed burning.

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