Monitoring of the development of stands in uneven-aged beech and silver fir forest in Slovenia

D. Hladnik

University of Ljubljana, Biotechnical Faculty, Department of Forestry and renewable Forest Resources, Vecna pot 83, 1000 Ljubljana, Slovenia.
e-mail: david.hladnik@bf.uni-lj.si

Abstract

We investigated the stand structure and spatial pattern of major trees in a beech and silver fir forest on the Karst plateau in Slovenia. By comparing the present and past tree structure it was possible to establish the developmental dynamics of the stands on the research plots and compare the results with permanent sample plots of continuous forest inventory. The structure of the forest stands on research plots has changed in the past 50 years similarly as in most beech and silver fir forests in which selection cutting used to be practised. Nowadays these uneven-aged fir and beech forests are frequently endangered by environmental impacts, sleet and snow, natural regeneration is inhibited or even prevented by too numerous herbivores. The methods tested on the research plots could be used in continuous forest inventory to describe the development of the forest stand structure over time and to evaluate the influence of different silvicultural treatments.

Introduction

In many monitoring programmes, the structure and diversity of forest stands has been stated to be of central interest (Fischer and Pommerening 2003, Neumann and Starlinger 2001). The structure of forest has become an important factor in the analysis and management of forest ecosystems. In forest management, structural heterogeneity, complexity and diversity are recurring themes in the explanation of the observed ecosystem processes and functions. Monitoring ecological attributes often requires more measurements and greater site-level precision than are typically needed for regional assessment of timber value. Thus many of the inventory and monitoring needs in the region extend beyond the traditional objectives of regional, aggregate estimates of forest attributes (Gray 2003).

In Slovenia dinaric fir and beech forests occupy a special position. They encompass 1.600 km² (15 % of Slovenian forest area) and they have a wide range of site qualities and stand structures, influenced deeply by former forest management and more recently by forest decline. They have undergone dramatic structural changes in the last 200 years. Their virgin character disappeared in the 18th century. There was a quite long period of nonregulated management, characterized by heavy cuttings, especially those referring to the beech launched intense processes which changed the existing tree-species composition into fir domination. In the second half of the 19th century, large forest estates on the territory of Slovenia started to make forest management plans. In the area of the high Karst original methods were practised in forest regulation and management - a regular selection silvicultural system and the control method in forest management.
The present day silver fir and beech stands are difficult to compare, owing to differences in the preserved structure, to various intensities of selection forest management in the first half of the 20th century and to different possibilities of silver fir regeneration which became the main obstacle for management in the 1950-ies as well as to various decline rates of the fir in the last decades (Hladnik 2004). New models of forest management, with a stress upon natural forest structures have been introduced in the last decades. The cutting system is well known under the term group-graded-management (small area cuttings, used for initiating regeneration cores, regulation of the young-growths tree-species composition, selective cuttings in poles and timber stands) while the renewed method of selection-management was less used. It has been assessed that a small number or absence of large (thick) trees in stands with low growing stocks lowers the resistance of such silver fir and beech stands (Kordiš 1993). In order to provide a continuous supervision of the regional forests and their ecological characteristics, the Slovenian Forest Service launched the continuous forest inventory in 138 forest management units. The sampling plots of 500 m² are systematically located mainly at a density of one plot per 5 to 12.5 hectares.

The objective of this paper was to assess the information content of the continuous forest inventory in uneven-aged beech and silver fir forest, the characteristics of stand structure, differences in diversity on stand level recognisable at the sampling plots and the characteristics of spatial distribution patterns of the major species in beech and silver fir stands.

Methods

This paper outlines two case studies of monitoring of forest stands and some results of developmental dynamics of the stand structure in a beech and silver fir forest. The first case study outlines the concept of monitoring, presented in the forest management unit, which covers 1.300 ha. Photo interpretation of aerial photographs taken in 1957, 1975, 1985 and 2000 was followed by an analysis of the structure and development of control stands. At the lowest hierarchical level of forest monitoring, the data was gathered by continuous forest inventory.

The second case study deals with three experimental plots in the silver fir and beech stands on the Karst plateau. In 1950 research plots were set up in a beech and silver fir forest to study the optimal values of growing stock levels and the structure of selection forests on those plots. In 2003 we repeated the measurement of trees on 3 research plots, which comprise 2 ha each. All woody stems ≥ 10 cm dbh were measured and the location of all stems was mapped. We described the stand structure using stem density, basal area, and dbh distribution. The plots were divided into contiguous quadrats by dividing the plot (2 ha) in half again and again, to up to 12.5 x 12.5 m quadrats. The spatial distribution of stems was analysed using Morisita’s index of dispersion (Miyadokoro et al. 2003), Cox index of clumping, the variance in relation to mean distances between trees and the standard deviation in relation to mean distances (Hladnik 2004).

Results

The structure of the forest stands varied in stand density and in the spatial distribution of stems, analysed using different methods for the characterisation of spatial distribution of trees. The present stands are rather scanty remains of former silver fir-beech forests. Not only has their density decreased but also the structure of stands has changed. Considerable losses in stand productivity (30 %) are due to silver fir decline.
Fig. 1. Estimates of mean stand growing stock and annual increment in two control stands in silver fir and beech forest: (a) stand with severely damaged and (b) less damaged silver fir trees.

The results of a chronological comparative analyses of the same trees, which was performed by photo-interpretation of CIR photographs and a field survey in control stands, indicate that there were no considerable changes in the degree of their damage in the last decades. The differences in the condition of stands indicate that the current damage results partly also from the development of stands in the past and the degree of intensity of their management.

Fig. 2. Frequency distribution of silver fir and spruce by needle loss classes in control stands in silver fir and beech forest on a Karst plateau.

In the past 50 years, the structure of the forest stands on the three research plots has changed similarly as in most silver fir and beech forests in which selection cutting was practised. The predominant diameter class in the growing stock structure is the class above 50 cm, whose share has already exceeded 60 % of the total growing stock. On the basis of
the data from the repeated measurements of trees we have attempted to determine the stand structure from which the trees which at present constitute the thick trees on the research plots originate. In all diameter classes above 30 cm which have been studied in the past 50 years a smaller recruitment rate has been noticed.

Based on theoretical models of spatial distribution, a tendency of clustering or clumping of trees was evident in the stands on three research plots. The spatial distribution of silver fir, spruce and beech varied significantly (P<0.01) from a random distribution. Stems of spruce were aggregated in small patches (up to 300 m²), beech and silver fir were aggregated in small and medium patches (up to 2500 m²).

**Fig. 3.** Coefficients of variation and variances of the estimated distances between dominant trees on the research plot in the beech and silver forest on Karst Plateau in 2003 (CV T - theoretical, CV R – computed).

We have estimated that the trees which are thickest today made up the population of the most vigorous or at least predominant and dominant silver fir trees of 50 years ago. Dominant trees were regularly distributed in the stands, indicating that after the period of silver fir decline the structure of stands did not deteriorate.

**Discussion and conclusions**

The methods described and tested on the research plots could be used to describe the development of the forest stand structure over time and to evaluate the influence of different silvicultural treatments. In forest inventory several structural variables have been taken to represent forest structure, including stem density, basal area, canopy cover, the mean and variation in diameter of trees. These stand descriptors do not incorporate directly the vertical and horizontal spatial arrangement of the plants, and largely ignore the spatial character of forest structure (Zenner and Hibbs 1999). Depending on the size of the sampling plots, continuous forest inventory is suitable to describe stand structure and diversity, however it would be impractical to measure small trees, which tend to occur at relatively high densities, with large plots. Many differences in stand structure are recognisable at the sampling plots of continuous forest inventory and my complement data from aerial photography. The assessment methods based on aerial photographs are likely to become more widely used due to technical progress in automating structure assessment (Bebi et al. 2001).

Nowadays, the orientation to yield maximal increment is more and more supplemented or substituted by the wish to establish and maintain stands with highest stability or protective effects. This is valid especially for mountain forests (Neuman and Starlinger 2001, Bebi et al. 2001) and the forest of the Karst. In addition to natural variation, the silvicultural operations
have the greatest impact on the structure and species composition of a stand. To understand the processes involved in the stand structure of uneven-aged stands it is vital to acquire information on the historical background and past management practices.

Koehl et al. (1995) presented the limitations and recommendations for linking both growth and yield research plots and sample plots for regional forest surveys. Similarly to their results and conclusions, we will try to develop models from both survey data and research plots to overcome the information gaps in forest monitoring.

Reference


