University of West Hungary

Doctoral theses

A comparison of shelterwood and gap cutting in an oak-hornbeam forest

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INTRODUCTION

Nowadays, studying the natural forest dynamics and mimicking the natural processes are basic principles in silviculture. The main goal is to execute close-to-nature forestry. However, there are hardly any practical experiences or scientific results in connection with close-to-nature forestry in Hungary, as indicated by the contradictory theories published in forestry literature.

OBJECTIVES

In this study, uniform shelterwood and gap cutting carried out in a Hungarian sessile oak-hornbeam forest in Pilis Mountains (North Hungary) are compared. The following aspects were considered: increment of the parent stand; change of tree crowns in size and shape; establishment, mortality and height growth of tree seedlings; spatial pattern of seedling growth; compositional changes and proliferation of the shrub and herb layers. Three additional topics were examined in an explorative way: spatial pattern of the herb layer; in the case of gap cutting, effects of herbivory on regeneration of tree species as well as on composition and dominance structure of the herb layer; economics.

METHODS

Forest regeneration operations

One part of the study stand was opened evenly on two harvesting occasions. The fist harvesting was carried out in the winter of 2002-2003 while the second one was carried out four years later (in the winter of 2006-2007). One third of the standing volume was removed on each occasion. In the other part of the forest, five circular gaps of 25 – 30 m in diameter were cut in the winter of 2002 – 2003. Three sampling plots were established in the evenly opened part and five sampling plots (corresponding to the gap number) were established in the gap cutting part of the stand. All plots were fenced before starting the regeneration except for two gap cutting plots.

Blackberry (*Rubus fruticosus agg.*) was removed from two of the gaps in the autumn of 2004. Since then, all plots have been annually weeded. Beating up was carried out with two-year-old seedlings in 1 m x 1 m spacing in two gaps in the autumn of 2004. Furthermore, a second beating up was carried out by the same method in three gaps and in one evenly opened plot in the autumn of 2005. Weeding time per plot was measured in the summer of 2007 to estimate weeding costs. All plots were weeded by the same team.

Sampling

All living trees were sampled in each plot in the autumn of 2002 and in the winter of 2007-2008. Those trees, which were cut during the second harvesting of shelterwood cutting, were sampled in the winter of 2006-2007 (just before the felling). Tree seedlings and saplings were annually sampled in systematically distributed

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permanent circles of 2 m in radius from 2002 to 2007. Percentage cover of shrub and herb layer species was visually assessed in a grid of 9 x 11 in each plot (i.e. size of grid cells was 5 m x 5m) during the spring and the summer aspect in 2001 and annually from 2003 to 2005. In 2007, the botanical sampling was carried out in two perpendicular 5-m-wide transects (which were one row and one column of the original grid) in every plot during the spring and the summer aspect.

Data analysis

It was examined thoroughly which significance test could be applied on the data of the tree, shrub and herb layers as well as on those of seedlings and saplings in such a way that would be meaningful either from mathematical or from silvicultural point of view. It was found that no parametric tests can be used since the assumptions of them could not be met.

From the non-parametric methods, Kruskal-Wallis test was chosen to study the increment of the remaining sessile oak trees, Kendall rank correlation was used to analyze the relation between the distance from the gap centre and the increment of sessile oak trees as well as principal components analysis and Mantel test of matrix correlation were applied to examine the spatial and temporal pattern of the herb layer. However, no significance tests were carried out on height and density distributions of tree seedlings and saplings because the data were inappropriate for such tests.

Data of only seven plots (two evenly opened plots, three fenced and two unfenced plots of gap cutting) were evaluated in the thesis due to methodological reasons.

MAIN RESULTS (THESES)

Changes in volume and quality of the parent stand

I. Sessile oak trees of the evenly opened plots grew significantly faster than those at the edge of gaps during the first five years of the regeneration. However, total increment of sessile oak relative to the initial standing volume of sessile oak was approximately identical between the two methods on plot level.

II. The increment of sessile oak significantly decreased with the distance from gap centre mainly northwards but also eastwards and westwards.

III. Sessile oak trees at the edge of gaps (particularly north to the gaps) produced more and larger sucker shoots than those of the evenly opened plots (qualitative investigation!). Sessile oak trees of the shelterwood cutting plots developed sucker shoots mainly only after the second cut.

Crown expansion

IV. Tree crowns expanded mainly southwards and westwards both in the cases of shelterwood and gap cutting.

V. Crown of sessile oak was surprisingly plastic. Some crowns of sessile oak grew even by 5.5 m southwards. However, crown expansion of trees at gap edges was highest not towards the gap.

Seedling establishment, survival and height growth

VI. After the first cut of the two regeneration methods, considerable amount (1-2 N/m^2) of sessile oak seedlings disappeared from every plot presumably due to the severe draught of 2003. Later on, many sessile oak seedlings

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established naturally in the shelterwood plots. By contrast, hardly any seedlings emerged naturally in the gaps.

VII. Concurrence of the associate tree species was much higher in the gaps than in the evenly opened plots. In the fenced gaps, average height of these species was approximately as high one year after a weeding occasion as before.

VIII. Survival and growth of sessile oak seedlings were controlled mainly by biotic factors (by the competition from common ash, blackberry and bushgrass /*Calamagrostis epigeios/*). Light and soil moisture conditions inside the circular gaps of one tree-height in diameter were suitable for survival and continuous growth of sessile oak seedlings. By the fifth year of the regeneration period, some sessile oak seedlings had grown over 1 m in some gaps.

IX. Seedlings of sessile oak and those of the associate tree species grew most quickly at the same topographical position inside the gaps: in the gap centre and in the north part of the gap. Effects of gap cutting were minor on growth of tree seedlings occurred under the closed canopy nearby the gaps.

Processes in the shrub and herb layers

X. Qualitative changes in the herb layers of gap and shelterwood cutting plots correlated significantly if considering the first three years of the regeneration period. However, the extent of the changes was different. Weed proliferation was much higher in the gaps than in the evenly opened plots. Hardly any changes occurred in

the herb layers under the closed canopy surrounding the gaps in the first five years of the regeneration.

XI. Gap cutting made blackberry competitively superior over all other species in the horizontal competition. Proliferation level of blackberry was much lower in the shelterwood cutting plots.

Additional results

XII. Consistent regular pattern of the herb layer could be observed neither in the gaps nor under the closed canopy surrounding the gaps. Thus, herb layers of the gap cutting plots did not indicate any site gradients.

XIII. Herbivory of ungulates facilitated the regeneration of sessile oak inside the gaps since it reduced vegetation (including associate tree species) competition. Browsing of blackberry allowed several herb species to increase their cover by over 10 %. However, in spite of the herbivory, blackberry had proliferated to a great extent in the unfenced gaps by the fifth year of the regeneration.

XIV. Value increment of the parent stand calculated for the first five years of the regeneration period were not considerably different between the two regeneration methods.

XV. In the first five years of the regeneration period, costs of weeding and beating up were much higher if applying gap cutting than if applying shelterwood cutting.

CONCLUSIONS

Based on the results it can be concluded, that from silvicultural point of view, shelterwood cutting was superior over cutting gaps of one tree-height in diameter under the studied site conditions. Presumably, regeneration of sessile oak could be made safer and cheaper if starting the regeneration with cutting smaller or elliptical gaps and enlarging them gradually.

PUBLICATIONS

Book chapters in Hungarian

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