University of Sopron

Theses of Doctoral (PhD) Dissertation

Natural regeneration of forest gaps under transition silvicultural system in pedunculate oak, sessile oak and turkey oak dominated forest stands in Southwestern Transdanubia

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Table of contents

1. Introduction

One of the interest parts of the recent modern Hungarian silviculture is the treatment of natural and semi-natural forests, its conservation and development. A great amount of knowledge accumulated for this during the decades (and centuries), from which theoretically the adequate natural forest regeneration and transformation methods can be chosen. However the successful forest regeneration methods published in different continents or countries not in each occasion can be transplanted into other sites and forest areas in Hungary.

In Hungarian sites the availability of selection cutting systems of tree species must be confirmed with detailed researches. It is not enough to declare the propriety of silvicultural methods from foreigner examples (typically from variant climatic and site conditions, different tree species) and expect those sematic adaptations in great territories.

My researches provides novelty from the other forest gap monitoring done in several locations in the country, that instead of the relatively well known and examined beech (*Fagus sylvatica*) forests, the transformation system of pedunculate oak (*Quercus robur*), sessile oak (*Quercus petraea*) and turkey oak (*Quercus cerris*) dominated forests are monitored, which have different site demands for light and soil moisture conditions.

2. Objectives

In my research, I am searching answers for the following hypotheses:

1. The regeneration in gaps is indicated by the increased light surplus. Is there advantaged significance of the orientation, size and shape of gaps in the aspect of oak tree species regeneration?
2. In case of gap opening, the soil water content increases. Is it verifiable, that this watering can be affected by the bearing of the gaps? Is the drying effect of the solar radiation can be taken into consideration?
3. Presently, forest management handle the transition silvicultural system forest sub-compartments with gaps sizes in written form. Is it possible to describe the dominant light conditions of a gap by simple gap sizes? What kind of methods could be more appropriate for the description of the light conditions of gaps?
4. One of the main principles of Pro Silva, that regeneration is not the aim of gap opening and harvesting, but its by-product. Is it verifiable, that

opening a gap is enough for regeneration, therefore there are no necessity of already extant seedlings or outstanding acorn producing for the general use of gap regeneration? Is it possible to introduce standard methods and the use of sematic gap openings in transition silvicultural system?

5. Tree species are classified as light demanding and shade tolerant based on their light dimand. In theory, every tree species are suitable for selection cutting (and transition) silvicultural system in a sort of rate. How these monitored oak tree species behave during the research? With suitable gap orientation, can the regeneration of light demanding oak tree species promote?
6. Is it verifiable, that opened forest gaps are being regenerated with minimal or no nursing? In case, it is not verifiable, what interventions are suggestible? Is there any influence of gap orientation on the presence of weed vegetation?
7. Is it verifiable, that in gaps non-native invasive weed species or local cutting site plants are not or with less rate settle?

3. Materials and methods

The researches take place at nine flat area sub-compartments. Six sub-compartments were selected to install long term transition silvicultural system experiments in Western Transdanubia, in the area of Szombathely Forestry Corporation., and other three sub-compartments in Southern Transdanubia in the area of Kaszó Forestry Stock Company. In the Western Transdanubian forest sub-compartments there are turkey oak dominated forests (67 and 71 years old), hornbeam-sessile oak mixed forests (81 and 116 years old) and scotch pine-hornbeam-sessile oak mixed forests (69 and 96 years old). In the Southern Transdanubian forest sub-compartments there are two pedunculated oak dominates forests (66 and 74 years old) and a turkey oak dominated forest (65 years old).

129 gaps were marked for the experiment. The experiments in Western Transdanubian forest sub-compartments are not fenced, while in the experiments in Southern Transdanubia, the research sites were created with fence protection and without fence inside a forest sub-compartment.

In the forest sub-compartments a parcel system of 50 × 50 metres tetragonal grid was marked (0.25 ha/parcel), in which the gaps were placed. In the course of the research, in every forest sub-compartment four different orientation (N-S, E-W, NE-SW and NW-SE) gaps were created with three times repetition if it was possible depend on the area of the forest sub-compartment. By the research plan the experimental gaps were one tree length long and half tree length wide. For comparison, gaps were selected in 30 × 15 metres rectangle area (450 m^2 = 0.045 ha). The possible presence of regeneration was not taken into consideration during the selection; only the grid was the prime objective. The appearances of seedlings were expected from gap opening, in case there was no regeneration at the time of gap marking. From 2013 inside the closed forest stand control points were established, to confront the gaps development with the regeneration found below closed canopy.

The extensive methodology was executed in 129 gaps in 9 forest sub-compartment with frequency depending on the variables. At gap marking, timber volume was calculated. Yearly gap size determination, hemispherical photography at gap centre, recording regeneration of woody plants and plant cover estimation were done. From 2013, at 62 control points, the same monitoring was done yearly.

Along with the large sample gap and control point monitoring, in 2013 intensively monitored gaps were assigned. 2-2 gaps and 1-1 control points of Bejcgyertyános 13/A and Vép 32/D forest sub-compartments were selected for these survey. In the intensively monitored gaps, the still extant studies were expanded with soil moisture measurements. Intensive monitoring was done at two vegetation season at 2013-2014.

4. Results and conclusions

Hemispherical photography showed that light conditions of the gaps are only slightly effects by gap size; light conditions cannot be described with a simple gap size. Light conditions inside a gap are affected greatly by the height of forest stand, openness, side shadow, but there were no significant correlation with the harvested forest stand characteristics. Light conditions measured at gap centre were statistically independent from the bearing of gaps.

Intensive researches showed that there are significant differences in the analysed parameters between the centre of the gaps and the closed canopy forest stand. The maximum intensity of light below the canopy shows a slight

Northward dislocation. Correlation analyses results showed, that the gap's slight Northward irradiation surplus had less effect on soil moisture, regeneration heights and total herb cover than the gap's real shape and size, altogether its openness.

Successful regeneration took place only in two turkey oak sites near Vép village out of the nine sites. The other sites were covered mostly with weeds, or regenerated with not the oak main species. In hornbeam mixed forests, the hornbeam (*Carpinus betulus*) was more vigorously regenerated than the oaks (Quercus sp.) and scotch pine (*Pinus sylvestris*). In the Southern Transdanubian monoculture oak forests the white birch (*Betula pendula*) and the invasive black cherry (*Prunus serotina*) regenerated in great quantity.

The results of extensive monitoring did not confirm that the Northward irradiation surplus has any positive effect on regeneration. The bearing of gaps had no effects on regeneration or plant cover. Correlation analyses showed that the heights of seedlings were primarily determined by the elapsed years and the distance from gap centre. The effect of orientation cannot be confirmed. The correlation of the number of seedlings is also increasing by the elapsed years and the distance from gap centre, so in the gap centre the numbers of seedlings are decreasing, while in the sides of the gaps, numbers are increasing.

At the analyses of plant cover few generally valid relations were found about the behaviour of plants. It is verifiable, that the total plant cover was the greatest in the centre of the gap, but no valuable correlations were found between plant cover and the bearing of gaps or subsection of gaps.

5. Theses

1. Orientation of gaps had no proven effects in the first five years of regeneration in the flat area forest sub-compartments analysed in the research. While the increased light quantity of the gap’s northern area were confirmed, this irradiation surplus could not be detected in the growth of regeneration. The growth of regeneration were mostly limited to the gap centre, in the sides of gaps the growth of seedlings were minimal. To promote the growing of seedlings, the area of gaps must be extended. The lengthened gap shape makes the available area narrow, therefore not suggestible.
2. Soil moisture was higher in gaps than in the closed forest stand. For all samples in the research period, the mean value of Volumetric Water Content (soil moisture) in the vegetation period in the sites was about 6 percentage points higher in the middle of a gap (29%) than in the sides of it (23%). The soil moisture was further 2 percentage points lower under close canopy (21%). Soil moisture of gaps is not reduced by the northward irradiation surplus. The most determinative factors are the gaps shape, the root competition and water intake of the old trees at the gap sides.
3. Describing a gap by a size measurement at ground level does not give adequate answer for what light conditions dominate inside the gap. The gap’s size and canopy closure measured by hemispherical photography are not strictly related. The total light quantity (sum of direct and diffuse) depends on tree height, gap orientation and the spatial location of different canopy closure incompletions beyond the sample plot’s

descriptive data (slope, aspect, altitude, geographical position). The most practical method for the description of light conditions is hemispherical photography. In case it is not achievable, in closed stands greater, in opened stands smaller gap sizes can achieve the aimed light conditions.

4. The gap opening itself was sufficient only for regeneration of turkey oak. In the monitored period there were no countable oak regeneration reinforcements in gaps, only reduction was experienced. Gap opening done with standard system as in the research was not suitable for regeneration in cases, where there were no remarkable quantity oak seedlings in the forest sub-compartment’s full area. Further on there were no chance for oak regeneration from acorn scattering.
5. From the three monitored oak species in the research, only turkey oak has no problems to regenerate with gaps. The specie’s frequent diffuse acorn production, great numbers of seedlings are typical already under closed canopy stand. Turkey oak is less beloved food for the game, therefore no significant game damage were experienced. In hornbeam-sessile oak forests rarer acorn production, significant acorn gathering and seedling consumption by game are not favour for regeneration settle and growing. In addition, because of the shade tolerant admixing species vigorous grooving potential, the light demanding oak seedlings cannot grow, and disappear from gaps. The pioneer silver birch should colonize the gaps after gap opening, while scotch pine was not able for that. Gap orientation cannot give advantage for oak seedlings.

6. In gaps without nursing the oak species is dominated the faster growing weeds and shade tolerant admixing tree species. The fewest nursing in good growing turkey oak regeneration should be possible. In that case, after the strengthening of turkey oak regeneration (4-5 years) it is sufficient to thin the suckers, not needed mix species and greater blackberry patches. In hornbeam-sessile oak forests or forests sub-compartments endangered with invasive tree species –such as black cherry – nursing cannot be abandoned, for determining the frequency of nursing, further researches are needed, but because of the decreased light conditions, oaks should grow slower, long time nursing might be needed, which query the naturality and economically efficiency. Weed cover is unaffected by gap orientation, the greatest cover is always in the gap centre.
7. One reason of the unsuccessful regeneration during this study was the notable advance of weeds after gap opening, which overwhelmed the already in placed seedlings or did not allowed the further acorn spreading to germinate. The decreased light quantity did not stopped blackberry to settle at great scale. Also significantly appeared the invasive weeds, such as giant goldenrod, pokeweed or the woody black cherry. Bush grass, which is characteristic at cutting sites, only appeared individually in the monitored gaps.

6. Publications

6.1. Scientific publications

6.1.1. Kollár, T., 2017. Light conditions, soil moisture and vegetation cover in artificial forest gaps in western Hungary. Acta Silvatica et Lignaria Hungarica, pp. 25-40.

6.1.2. Kollár, T., 2013. Lékek fényviszonyainak vizsgálata hemiszférikus fényképek segítségével [Determining gap size with the aid of hemispherical photography]. Erdészettudományi Közlemények, 3 (1). kötet, pp. 71-78.

6.1.2.1. Hivatkozás: Bali, L. és mtsai., 2016. Mesterségesen kialakított lékek talajközelben élő pókfaunájának (Araneae) vizsgálata [Survey of the ground-dwelling sider fauna (Araneae) of artificial forest gaps]. Növényvédelem, 77 (52): 6. kötet, pp. 287-296.

6.1.2.2. Hivatkozás: Barton, Z., 2015. A tölgyek és a fény [The oaks and the light]. Erdészeti Lapok, CL. (10). kötet, pp. 294-296.

6.1.2.3. Hivatkozás: Erdős, L. és mtsai., 2014. Vegetation pattern along a topographical gradient in a beech forest reserve in the Mecsek Mts (Hungary). Austrian Journal of Forest Science, 131 (2). kötet, pp. 58-106.

6.2. Conference publications

6.2.1. Kollár, T., 2014. Temporal and spatial changes of soil moisture in artificial forest gaps in western Hungary. Bratislava, Catchment processes in regional hydrology: Confronting experiments and modelling in Carpathian drainage basins International conference articles, pp. 1-8.

6.2.2. Kollár, T., 2014. Lékek fényviszonyainak vizsgálata hemiszférikus fényképek segítségével [Analyses of light conditions of gaps with the aid of hemispherical photography]. Sopron, IV. Kari Tudományos Konferencia, konferencia kiadvány, pp. 198-202.

6.2.3. Kollár, T., 2014. Hemiszférikus fényképek használata lékek fényviszonyainak elemzéséhez [Use of hemispherical photography for analyses of gap’s light conditions]. Keszthely, A magyar agrár felsőoktatás PhD-s szemmel konferencia kötet, pp. 92-98.

6.2.4. Kalicz, P. et al., 2014. Effects of continuous cover forestry on soil moisture pattern – Beginning step of a Hungarian study. Wien, Geophysical Research Abstracts, Vol. 16, EGU2014-10653.

6.2.5. Kollár, T., 2013. Lékek talajnedvesség változásainak vizsgálata Field Scout TDR 300 talajnedvesség mérő szonda alkalmazásával [Analyses of soil moisture changes in gaps with Field Scout TDR 300 soil moisture meter]. Sopron, Kari Tudományos Konferencia, a konferencia előadásainak és posztereinek kivonata, p. 72.

6.2.6. Kollár, T., 2013. Lékek fényviszonyainak vizsgálata hemiszférikus fényképek segítségével [Analyses of light conditions of gaps with the aid of hemispherical photography]. Sopron, Kari

Tudományos Konferencia, a konferencia előadásainak és posztereinek kivonata, p. 60.

6.2.7. Kamandiné Végh, Á., Kámpel, J. & Kollár, T., 2011. Természetközeli erdőfelújítási eljárások alkalmazásának lehetősége Alföldi kocsányos tölgy állományokban [Possibility of close to nature forest regeneration methods in Lowland pedunculate oak stands]. Sopron, Alföldi erdőkért egyesület kutatói nap, tudományos eredmények a gyakorlatban, pp. 57-60.

6.3. Posters

6.3.1. Kollár, T., 2017. Lékekben kialakuló biotikus és abiotikus tényezők összefüggéseinek vizsgálata cseres és gyertyános-tölgyes erdőkben [Correlation analyses of biotic and abiotic factors inside gaps in turkey oak and hornbeam-sessile oak forests]. Sopron, Élő erdő konferencia, 2017.03.21.

6.3.2. Kalicz, P. et al., 2014. Effects of continuous cover forestry on soil moisture pattern – Beginning step of a Hungarian study. Wien, Geophysical Research Abstracts, Vol. 16, EGU2014-10653.

6.3.3. Kollár, T., 2013. Lékek talajnedvesség változásainak vizsgálata Field Scout TDR 300 talajnedvesség mérő szonda alkalmazásával [Analyses of soil moisture changes in gaps with Field Scout TDR 300 soil moisture meter]. Sopron, Kari Tudományos Konferencia, a konferencia előadásainak és posztereinek kivonata, p. 72.

6.3.4. Kámpel, J. & Kollár, T., 2011. Folyamatos erdőborítást biztosító eljárások alkalmazásának lehetőségei [Possibility of uses continuous cover forestry methods]. Budapest, Magyar Tudomány Ünnepe rendezvénysorozat: Az erdők helye a vidékstratégiában − 2011. Az erdők nemzetközi éve konferencia, 2011.11.21.

6.3.5. Kamandiné Végh, Á., Kámpel, J. & Kollár, T., 2011. Természetközeli erdőfelújítási eljárások alkalmazásának lehetősége Alföldi kocsányos tölgy állományokban [Possibility of close to nature forest regeneration methods in Lowland pedunculate oak stands]. Sopron, Alföldi erdőkért egyesület kutatói nap, tudományos eredmények a gyakorlatban, pp. 57-60.

6.4. Presentations

6.4.1. Kollár, T., 2015. Az abiotikus tényezők változásának nyomon követése, és a felújulás vizsgálata lékekben [Tracking the changing of abiotic factors and the analyses of regeneration in gaps]. Szombathely, OEE Szombathelyi Helyi Csoport évnyitó rendezvénye, 2015.03.19.

6.4.2. Kollár, T., 2014. Temporal and spatial changes of soil moisture in artificial forest gaps in western Hungary. Bratislava, Catchment processes in regional hydrology: Confronting experiments and modelling in Carpathian drainage basins Abstracts of the Conference, p. 19.

6.4.3. Kollár, T., 2014. Hemiszférikus fényképek használata lékek fényviszonyainak elemzéséhez [Use of hemispherical photography for analyses of gap’s light conditions]. Keszthely, A magyar agrár felsőoktatás PhD-s szemmel konferencia Absztraktkötet, p. 11.

6.4.4. Kollár, T., 2013. Lékek fényviszonyainak vizsgálata hemiszférikus fényképek segítségével [Analyses of light conditions of gaps with the aid of hemispherical photography]. Sopron, Kari Tudományos Konferencia, a konferencia előadásainak és posztereinek kivonata, p. 60.

6.4.5. Kollár, T., 2013. Átalakító üzemmódú kísérletek Kaszóban [Transition silvicultural system experiments in Kaszó]. Kaszópuszta, Kaszó Life, Life12 NAT/HU/000593 konferencia, 2013.12.05.

6.4.6. Kollár, T., 2013. A folyamatos erdőborítás hidrológiai vonatkozásainak vizsgálata az ERTI-nél [Study of hydrological references of continuous cover forestry at ERTI]. Sárvár, OEE Erdészeti Vízgazdálkodási Szakosztály rendezvénye, 2013.10.30.

6.4.7. Kollár, T., 2013. Hidrológia és fényviszonyok vizsgálata [Hydrology and light condition analyses]. Sopron, TÁMOP Workshop, 2013.07.01.

6.4.8. Kollár, T., 2012. Felújítási folyamatok vizsgálata átalakító üzemmódú erdőkben [Analyses of regeneration progression in transition silvicultural system]. Szombathely, OEE Szombathelyi Helyi Csoport évadnyitó rendezvénye, 2012.03.23.