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THE EFFECT OF GAP SIZE AND SHAPE ON THE SUCCESS OF NATURAL REGENERATION IN ORIENTAL BEECH (*FAGUS ORIENTALIS* LIPSKY) FOREST STANDS IN THE BARTIN-HASANKADI DISTRICT IN TURKEY

Halil Barış Özel

Department of Silviculture, Faculty of Forestry, University of Bartın, 74100 Bartın, Turkey.
E-mail: halilbarisozel@yahoo.com

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Abstract

In this study, which has been carried out in natural beech gap regeneration field in division 56c in oriental beech (*Fagus orientalis* Lipsky) forest in Bartın-Hasankadı Forest Range District Directorate, the relationship between the number of young beeches and gap shape, gap direction, and gap size has been investigated. According to the findings obtained, it was determined that there is a significant relationship between gap shape and the number of natural beech juvenilities (P<0.01). According to the result of Duncan test performed within this scope, in P<0.05 confidence level, during 4 years of investigation was determined that the beech juvenilities densely occur in oval-shaped gaps, followed by round-shaped and rectangle-shaped gaps, respectively. On the other hand, according to the bilateral regression analysis, it was determined that there is a 98% (R^2=0.98) linear relationship between the gap shape and the number of beech juvenilities. The relationships between gap direction and the number of beech juvenilities were examined in this research. According to the performed variance analysis (P<0.01), it was found that there is a statistically significant difference between gap directions. That is why, as a result of Duncan test performed at the confidence level of P<0.05, it was determined that the number of beech juvenilities is more dense in northern parts of the gaps, and consequently the north takes first place in terms of the number of juvenility, and that north is followed by west and east beech directions, respectively. When considering the result of bilateral regression analysis performed in this direction, it was determined that there is a 96% linear relationship (R^2=0.96) between the number of juvenility and the direction of gap. Accordingly, as the direction of the gap changes from shadowy to sunny exposures, significant decrease occurs in the number of oriental beech juvenilities. In this study carried out in division 56c in Hasankadı region, the relationship between the number of beech juvenilities located in various sized gaps and the size of gap was investigated, and it has been tried to determine the optimal gap size. Within this scope, 10 different gap sizes were examined in this research. As a result of performed variance analysis (P<0.001 confidence level), it was found that there are statistically significant differences among gaps in terms of the number of juvenilities in gaps. After determining this difference, Duncan test was implemented in order to categorize the various-sized gaps according to the number of juvenility. As a result of this test, it was determined that 400 m^2, 500 m^2 and 600 m^2-sized gaps are in 1st category in terms of the number of juvenility, while ones having sizes of 100 m^2, 200 m^2 and 300 m^2 are in 2nd category, and the ones having sizes of 700 m^2, 800 m^2, 900 m^2 and 1000 m^2 are in 3rd category.

Key words: gap direction, gap size, gap shape, oriental beech, natural regeneration.

Indtroduction

It has been determined by many researchers that gap dynamics are very effective on the success of natural gap regeneration efforts performed within the scope of nature-friendly forestry approach in recent years (Mataji et al. 2006). Thus, the different juvenility dynamisms arising depending on sizes, shapes and directions of the gaps occur as a result of this situation (Karlsson et al. 2006). Different gap sizes, shapes and directions directly affect the success of natural regeneration effort especially on species growing slowly in juvenility period (Madsen et al. 2006). In beech forests, which grow slowly in juvenility period, requirement of upper and side protector shelter effect, and rehabilitating the forest soil, the natural regeneration efforts in recent years are carried out in gaps in accordance with nature-compliant silviculture (Özel 2007). In natural and artificial gap regeneration studiesperformed in both common beech and oriental beech forests, important problems are experienced in determining the size, location and shape of the gap (Diaci 2002). Similar problems have been observed in natural and artificial gap regeneration efforts performed within the Turkish-German Forestry Project in oriental beech forests in Turkey, and many unsuccessful efforts have been made (Özel 2007). In this study carried out in division 56c in Bartın-Hasankadi region, natural regeneration gaps have been opened in various sizes and shapes in order to profit from good-seed year occurred in beech of region in 2010, and the number of beech juvenilities in gaps have been counted for 4 years, and their locations have been determined.

Material and Method

Material

The Hasankadi Forest Range Directorate located within the territorial borders of Kozcağız district of Bartın is administratively affiliated with Bartın Forest Directorate. Planning unit is located in sheets numbered F29-a1, F29-a2 and F29-a4 in 1/25,000 scaled topographic Zonguldak map. Accordingly, Hasankadi region is located between 32°27’55” – 32°40’43”E and 41°29’18” – 41°22’18”N. The horizontal distance of the unit from sea is 50 km. According to the forest society classification performed by Mayer and Aksoy (1998), the forests of Hasankadi planning unit is in *northwestern euxin* forest sub-division of *euxin* forest division.

Being under the influence of the western Black Sea Climate (IIc), Hasankadi region has no meteorology station. That is why, the precipitation and temperature values required in order to draw the climate Walter diagram have been calculated from long-term average data of the nearest Bartın Meteorology Station (32 m a.s.l.). For this purpose, the data obtained from meteorological station have been interpolated for Hasankadi region having average altitude of 789 m. Accordingly, the mean annual and monthly precipitation values of Hasankadi Region are presented in Table 1.

The mean annual and monthly temperature values of Hasankadi region are presented in Table 2.

When the values in Table 2 are evaluated, it is seen that the mean annual temperature of Hasankadi region is 10.6 C, while the lowest mean temperature belongs to Janu-

Table 1. Mean monthly and annual precipitation values of Hasankadi Forest Range District.

Location	Altitude, m	Mean precipitation, mm												Annual
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Bartın	32	115.4	86.5	72.7	57.8	53.9	69.8	66.5	85.3	85.7	100.7	117.6	128.2	1040.1
Hasankadi	789	149.4	120.5	106.7	91.8	88.0	103.9	100.6	119.4	119.8	134.8	151.7	162.3	1448.9

Table 2. Mean monthly and annual temperature values of Hasankadi Forest Range District.

Location	Altitude, m	Mean Temperature, °C												Annual
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Bartın	32	4.1	4.8	7.2	11.4	18.4	19.7	21.6	21.3	17.6	13.4	9.3	7.4	12.9
Hasankadi	789	0.0	1.2	4.2	8.5	12.4	17.8	19.8	19.7	16.0	11.7	7.4	3.5	10.6

ary (0.0 °C) and the highest one belongs to July (19.8 °C) and August (19.7 °C). The growing period duration in research field is 6 months (May–October). The climate diagram of Hasankadi prepared according to Walter method is presented in Figure 1.

The geologic structure in Hasankadi region has been formed in cretaceous and sub-cretaceous periods of II. Time (Mesozoic). That's why, bedrocks in the region have metamorphic and sedimentary structure. Especially in steep parts of the region, there are calcareous, lime, marl, schist and flysch structures. In less-inclined parts, there are sandstone and conglomerate formations (MTA 2012). Also in existing forest management plan and detailed silviculture plan, it is reported that the general soil structure of Hasankadi Forest Range District has stony, mildly deep, alkaline, sandy lime, loamy lime, and sandy loamy lime texture (Anonymous 2014).

Division 56c of Hasankadi is in II site class, and the actual stand type is Knd_1. Having west and northwest exposure, 56c has the 1330 m altitude, and the land slope

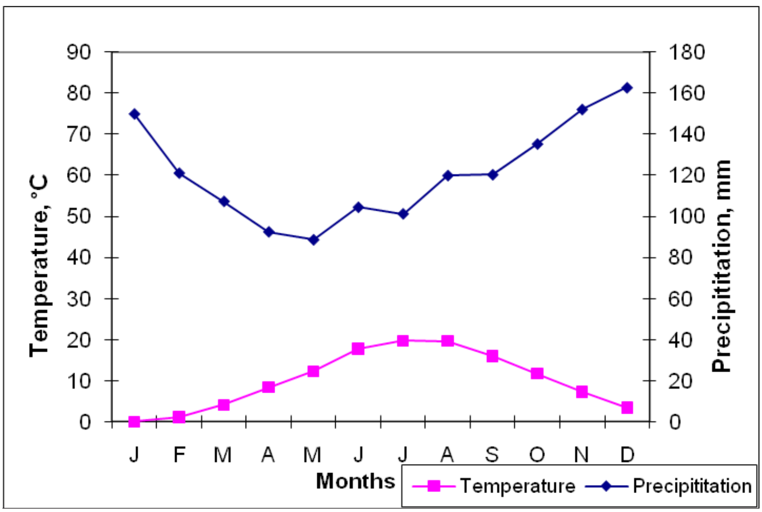

Fig. 1. The climate diagram of Hasankadi prepared according to Walter method.

varies between 30 % and 65 %. In this division, 2 gaps having 5.0 ha area have been opened in 2010, and the natural gap regeneration effort has been made. In 56c division, the insemination cutting has been performed in September. In this insemination cutting, a total of 14,516 m^3 final products have been obtained from beech. After the insemination cutting, a land preparation consisting of living cover removal and soil processing has been performed. In living cover removal processes, the rhododendron existing prevalently in forest has been cut into lines having 3 m of width, and the cutting has been performed at the level of soil surface. Then the cutting residuals have been gathered as 1m height clusters. The soil processing has been carried out in lines, where the living cover has been removed, via hoes.

Method

The beech regeneration gaps in 56c division, where the study has been carried out, have been shaped as oval, round, and rectangle through the insemination cutting in year 2010 (Figure 2).

On the other hand, 10 different gap sizes have been examined for each of gap shapes as I Gap: 100 m^2, II Gap: 200 m^2, III Gap: 300 m^2, IV Gap: 400 m^2, V Gap: 500 m^2, VI Gap: 600 m^2, VII Gap: 700 m^2, VIII Gap: 800 m^2, IX Gap: 900 m^2 and X Gap: 1000 m^2. Since the first germinations in 2011, the sapling counting has been carried out in 4 different directions (east, west, north and east) in gaps having various shapes and sizes. In order to determine whether there is a difference between gap shapes and gap sizes from the aspect of the number of juvenility, which is one of the most important criteria of success especially in natural regeneration efforts, variance analysis (ANOVA) and Duncan test have been applied. Also, in order to determine the relationships between gap shape and size and direction variables and the number of juvenility, the bilateral regression analyses have been carried out. SPSS statistical package software has been used in statistical analyses.

Result and Discussion

In close to nature silviculture implementations based on protecting the ecological balance and biodiversity in natural and artificial regeneration efforts carried out in order to ensure the sustainability of forests being the most important resource which can renew itself naturally, the shapes, sizes and directions of gaps have direct effect on success of regeneration efforts because regeneration efforts are made

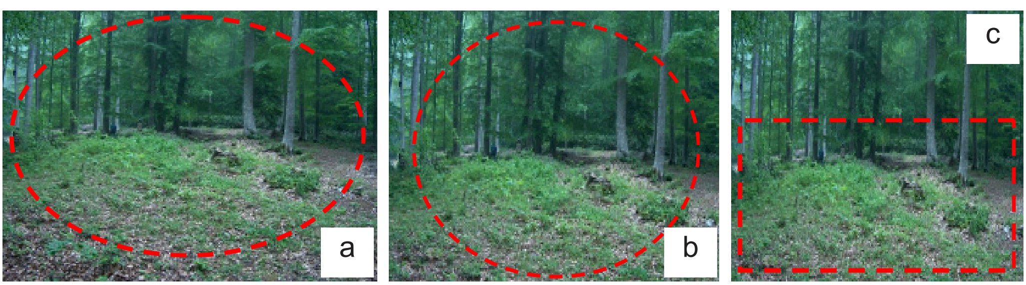

Fig. 2. The front section of opened gaps' shapes (a: Oval, b: Round, and c: Rectangle).

in small-sized areas (gaps) (Reza 2004, Peter 2004, Lars and Burghard 2004). In natural gap oriental beech regeneration experiment established in Hasankadi Forest Range District, the relationship between the shape of gap and the number of juvenility has been investigated firstly. As a result of variance analysis implemented for this purpose, it has been determined that there is a significant relationship between the gap shape and the number of juvenility (P<0.01). As a result of Duncan test performed within this context, it has been found during 4 years of investigation on oriental beech juvenilities that the juvenilities are seen frequently in oval-shaped gaps, and this is followed by circle- and rectangle-shaped gaps, respectively (P<0.05) (Figure 3).

When Figure 3 is interpreted, it is seen that there is a 98% linear relationship between gap shape and the number of beech juvenilities as a result of bilateral regression analysis (R^2=0.98). In a study carried out on this topic on common beech in Germany, it has been determined that the beech juvenilities showed more frequent distribution in gaps opened in oval and diamond shape because the life-environment and the light physiology provide better conditions in these shapes rather than round, square- and rectangle-shaped gaps (Lüpke 2006, Madsen et al. 2006, Mataji et al. 2006).

In this study, the relationship between the gap direction and the number of beech juvenilities has been examined as well. As a result of variance analysis (P<0.01), it has been determined that there is a statistically significant relationship between gap directions. That's why, as a result of Duncan test (P<0.05), it has been found that the number of beech juvenilities is more dense in northern regions, and consequently, north takes the 1st place in terms of the number of juvenilities, and is followed by south, west, and east, respectively (Figure 4).

Considering the results of bilateral regression analysis presented in Figure 4, it is seen that there is a 96 % linear relationship between the number of juvenilities and the direction of gap (R^2=0.96). Accordingly, as the direction of gap changes from shadowy exposures to sunny exposures, the significant decrease occurs in the number of juvenilities of oriental beech (Figure 5).

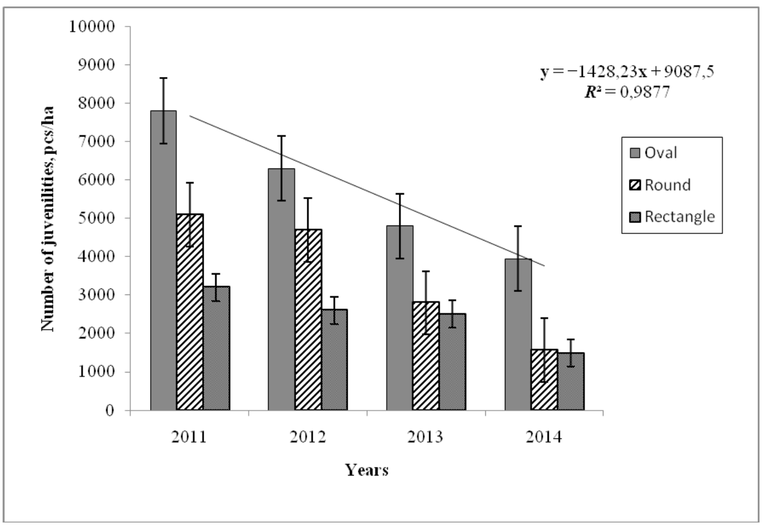

Fig. 3. The relationship between gaps shapes and the number of beech juvenilities.

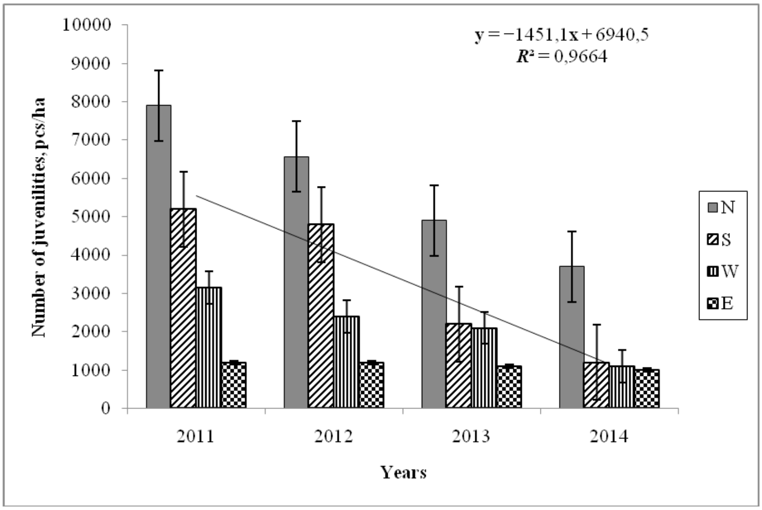

Fig. 4. The relationship between gap directions and beech juvenilities.

Bartın and Devrek regions, it has been determined in natural beech gap regeneration study that juvenilities comes more frequently in significantly shadowy exposures (N, NE and NW), and that significant drying indications are observed in beech juvenilities in sunny exposures (Özel 2007). On the other hand, in a study on oriental beech gap regeneration fields in Iran, it has been found that the number of beech juvenilities in north and east directions having the optimum ecological conditions for regeneration are higher, and those juvenilities can retain in land (Talebi 1995, Schütz 1999, Mataji et al. 2006,

Thus, the best growth conditions of oriental beech consist of shadowy exposures, deep, organic-matter-rich, moist, sandy-loamy-lime textured soils (Ata 1981, Çepel 1982, Peters 1992, Agestam 1995, Barnes et al. 1998). In another research on this topic carried out in Turkey's

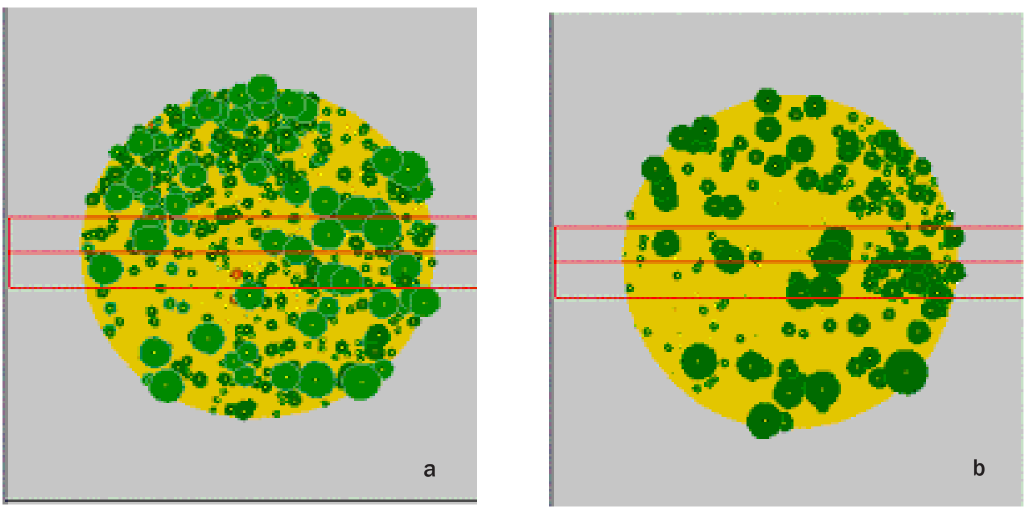

Fig. 5. The distribution of juvenilities in gaps located in shadowy (a) and sunny (b) exposure.

Shanjani et al. 2011). In regeneration efforts made according to both classic and close to nature silviculture studies, there is a very strong relationship between the size of regeneration area and the success of regeneration (Çolak et al. 2003). Especially from the aspects of easy organization and the optimum transportation opportunities, the most appropriate size of regeneration field should be determined (Ata 1995, Genç 2004). In this study carried out in division 56c in Hasankadi region, the relationship between beech juvenilities in the gaps opened in various sizes and the size of gaps has been examined and it has been tried to determine the optimal gap size. Within this scope, 10 different gap sizes have been examined. As a result of performed variance analysis (P<0.001 confidence level), it has been found that there are statistically significant differences among gaps in terms of the number of juvenilities in gaps. After determining this difference, Duncan test has been implemented in order to categorize the various-sized gaps according to the number of juvenility. Then, as a result of this test, it has been determined that 400 m^2, 500 m^2 and 600 m^2-sized gaps are in 1st category in terms of the number of juvenility, while ones having sizes of 100 m^2, 200 m^2 and 300 m^2 are in 2nd category, and the ones having sizes of 700 m^2, 800 m^2, 900 m^2 and 1000 m^2 are in 3rd category (Figure 6).

According to Figure 6, considering the ecological conditions in 4th, 5th and 6th Hasankadi regions taking place in 1st category as a result of Duncan test, they constitute the optimal gap sizes. In a study carried out on this topic in oriental beech forest in Hazar Sea's shore in Iran, it has been determined that the optimal regeneration gap size varies between 300 m^2 and 700 m^2 (Mataji et al. 2006, Sefidi et al. 2011). Hence, in another study carried out in western Black Sea region, it has been determined that juvenilities cannot find adequate amount of living space in gaps up to 300 m^2, they cannot profit optimally from equal shelter situation especially, and the living cover problem arises in beech gap regeneration fields larger than 600 m^2 because equal insemination cannot be ensured (Özel 2007).

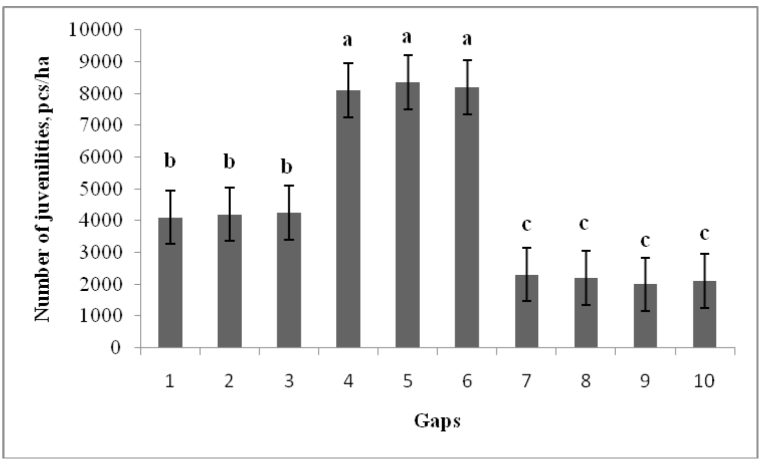

Fig. 6. The relationship between gap sizes and the number of juvenilities.

Suggestions

In ensuring the sustainability of forests of oriental beech, which is one of the original forest tree species of Turkey, the close-to-nature silviculture approach based on actual ecological balance should be adopted. In this context, the regeneration studies should be carried out in smaller lands and as smaller gaps. The shape of gaps in those gap regeneration efforts should be close to oval in order to profit from equal shelter situation and optimum light conditions. Otherwise, the possibility of important problems in retaining of beech juvenilities in land increases because the enough profit cannot be obtained from soil moisture and optimal light conditions. On the other hand, by ecological requirements of species, it will be better to open the gaps especially in shadowy exposures, to ensure that the stand closure is not so ruined if the gaps have to be opened in sunny exposures and the regeneration has to be carried out in that medium, and to protect the equal-shelter situation. This situation is especially important in order for living cover layer consisting especially of rhododendron not to cover the surface of the land. On the other hand, the criteria of "regeneration area size", which always had important effect on the success of regeneration efforts, also affects the success of gap regeneration studies being results of close to nature silviculture approach. That's why, it would be better to determine the optimal gap size by taking the actual ecologic conditions in natural and artificial gap regeneration studies and the silvicultural requirements of species into account. Hence, in parallel with the results obtained from this study, choosing the gaps size as 400-600m^2 for natural gap regeneration activities on beech in regions having ecological conditions similar with Hasankadi region will be useful for both controlling every phase of work organization and placing and holding the oriental beech juvenilities healthy in the regeneration field.

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