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Investigation of Qualitative and Quantitative Regeneration based on the Gap Regeneration size in Different Beech Types of Hyrcanian Forest

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ABSTRACT: Whereas in seed origin forests and in close-to-nature silviculture, the future of forests depends on the stable establishment of saplings planted in the gaps; hence, the current study was done by selection sampling method with the aim of qualitative and quantitative investigation of natural regeneration based on the gap area in two different beech (*Fagus orientalis* Lipsky) forests: pure beech forest and beech with other species, in three areas of 0.5-1, 1.5-3 and 4-6 R, totally amounting to 60 gaps for two different beech types(30 gaps per type) in Sourdar Anarestan forest management plan, Mazandaran province, North of Iran. For sampling, five plots 4×4 and five micro plots 1×1 were used per each gap and regeneration in them was counted, measured and statistically analyzed. Number of saplings in different gaps was significantly different at 0.01for both types. The number of saplings in small and medium area gaps was higher, whereas that of the larger ones was lower. Concerning the mean area of gap with beech forest types, there was significant difference at 0.01.The area of gaps created in the mixed beech stand was more than that in the pure beech forest and according to Duncan's test, maximum gap area was aspect east and then aspect eastern north and west. Also, results showed that as the gap area increased, the number of saplings and their quality decreased for each type. Therefore, maximum the best gap area of 5to6 R can be suggested to secure the future of the planted saplings.

Keywords: Gap area, *Fagus orientalis*, Pure and mix beech stand, Iran

INTRODUCTION

Nowadays, what is known as the forest or forest stands across the world is in fact the result of development phases of regeneration in that forest over the past eras. The present condition of regeneration in an area is like a mirror showing the future feature of the forest in that location; thus any kind of change occurring in the natural regeneration condition will alter the feature of the future forest stands. Along this objective, to implement the close-to-nature silviculture and to reach sustainability and auto-regulation in forests, shape of the natural forest and processes occurring in the area of gap regeneration must be used and considered as the initial reference for sustainable forest management (Van Dermr *et al.*,1999). Determining the area of gaps for appropriate establishment of natural regeneration, which is among the most important success factors in implementation of forest management, is an inevitable issue in the sustainable management of forests. The extremely high importance of forest gaps made researchers to pay great attention to it and carry out wide studies on it over the last decades.

The results of the investigation done by Mousavi *et al.* (2003) on determining the gap area of the canopy to enhance the natural regeneration of beech, showed that the studied variables of regeneration were limited concerning the establishment and growth in the larger gaps (9to11 R), but had more optimal conditions in the smaller ones (1, 2, 4, 5 R) in which, harvest is, generally, done in the form of single tree. Studies done by Ghorchi Beigi (2001) on the qualitative and quantitative characteristics of beech saplings in Ramsar forests showed that the saplings existing in the cluster of 2 to 5 R had more appropriate quality compared to other gap areas. Shahnavazi *et al.* (2005) investigated natural regeneration in gasps formed in Golband beech forests quantitatively and qualitatively. Results showed that as the gap area increased, the frequency of saplings declined for all species, the least amount of which was experienced in gaps with the area of more than 10 R.

The highest frequency of beech species was observed in 2 to5 R gaps. In investigating the regeneration condition of regenerated gaps in Asalem forests of Guilan, Amanzade *et al.*, (2006) declared that the minimum and maximum gap areas were 89 and 2276 m^2. meters, respectively. As gap area increased, the number of beech saplings, and to some extent that of water beech saplings decreased in such a way that in gaps measuring more than 1000 m^2 meters in area, no beech sapling was found. The study carried out by Gagnon *et al.*, (2004) on the characteristics of gaps and regeneration in them, showed that the gaps had no regular geometric shape. The height and density of the saplings had no relation with the shape of the studied gaps. Moreover, the collar diameter of the saplings had a significant relation with the shape of the gaps but had no relation with the height and diameter average of trees surrounding the gaps. Albanecsi *et al.*, (2005) investigated the effect of gap area on the environmental situation and regeneration conditions of silver-fir stands in Italy. Their results showed that gaps measuring 210 sq. meters in area had allocated the highest sapling height to themselves, significantly. Naaf and Wulf (2007) investigated the effect of gaps area on the amount of light, graze and vegetation in European beech forests. To this aim, 56 gaps measuring 116 to 1410 m2 in area were studied. Results showed that there was a significant positive correlation between number of weed species, the amount of relative light, grazing and the gap area. Also, as the gap area and grazing increased, density and regeneration of beech declined. Dolorowolsk and Veblem (2008) investigated the role of gaps in the regeneration process of Abies species in the central regions of Poland. Their study showed that different gap areas had no effect on the number of saplings and small saplings of tree species, whereas in gaps with different species mixture inside the gap, there was a significant relation between density of saplings and small saplings. In this direction, the present study was done with the aim of determining the appropriate area of regeneration gaps in order to obtain the optimal quality and quantity of regeneration in different beech types dominated by different ecological conditions, so as stands stability in long term can be achieved through proper marking and regeneration cutting.

MATERIALS AND METHODS

Site of study: This study was done in the area of basin 49 in districts 1, 2 and 3 of management plan of Anarestan Lavij, with a total area of 7356 ha is located in east of city Noor, Mazandaran province, in Caspian Region. It is a mountainous forest, which is extended from 350 to1900 meters above sea level. Due to its proximity to moisture sources of Caspian Sea, it enjoys from good site and productivity conditions, in such a way that at high elevations, especially in districts 2&3, it is foggy (summer fog) and beech community has established there broadly. In most zones, its soil is alkaline due to the original marl and lime stones. The soil texture is composed of high clay percentage, clay loam to silty clay loam; as a result the soil is of poor to medium permeability and drainage. These are among the factors limiting this soil. The highest annual rain of 750 mm occurs in fall and continues in February and March in the form of snow. Studies on drought coefficient and Ambrotermic diagram show that in the studied area, the minimum time duration to use suitable days, is 160 days per year (Anonymous, 2007). Due to site conditions and topographic, different degrees of grown types were observed in this zone. So, this forest management plan is considered as the wood production pole in the region.

Method: At first 1:1000 and 1:2500 topographic maps of the area studied in Lavij forest management plan, wherein the selection system of silviculture was performed, was prepared. Then, by using vegetation forest type's maps and through numerous forest trips, two different types; i.e. pure beech forest and beech with other species were specified. In the form of data collection and selected sampling method, 30 gaps were determined in three areas of 0.5-1, 1.5-3 and 4-6 R, in each type and their position was recorded by GPS. Then through measuring the larger and smaller diameters of gaps by using plastic rope, their area was calculated. At the next stage, 10 square-shaped plots (five plots 4×4 and five micro plots 1×1) were determined in the four aspect and the central gaps (Fig.1). Efforts were made that the regeneration gaps be selected in different slopes (0, 5, 10, 15, 20, 100 percent) and different of land form (Upper hillside, lower hillside, middle, open and closed valleys, skid trail) with respect to the topographic conditions of the studied scope. In total, the quantitative and qualitative regeneration information of 300 plots and 300 micro plots, amounting to 600 selected plots, were recorded in the relevant forms. Then Kolmogorove- smirnov data normality test was performed on the quantity data. At the next stage, the data were statistically analyzed by one way ANOVA test and comparison of means tests and Kruskal-Wallis test was used for qualitative data. In this study, were use Excel and SPSS software.

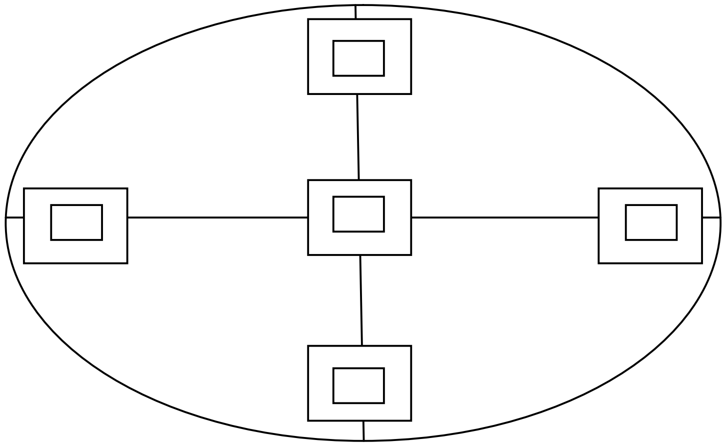

Fig. 1. Method of sampling plots and micro plots in each gap.

RESULTS

The data have been analyzed in two sections of quantitative and qualitative specifications.

Quantitative Specifications: Gap area: Results obtained from variance analysis, showed that concerning the gap area, with a probability of 99%, there was significant difference between mean beech forest types, aspect, stand structures and the topographies .Also, this analysis showed that type of species had no significant effect on the gap area (Table 1).

Based on the comparison made between beech forest types through using independent t-test, it became clear that the area of gaps created in beech with other species stand was more than the pure beech stand, in such a way that the former, with the area of 828 m^2, had larger gap area compared to the latter with the mean area of 573 m^2. And in this regard, a significant difference was observed between two stands (Table 2, Fig. 2).

Table. 1. Results obtained from analyzing the variance of different treatment levels effect on gap area.

Sources	**Gap Area**				
	Sum of Square	df	Mean Square	**F**	Sig.
Beech Stands	537099/276	1	537099/276	**29/827**	** **0/000**
Aspect	2941623/252	4	735405/813	40/895	** 0/000
Structure	4567090/740	4	1141772/685	63/492	** 0/000
Topo	820964/557	4	205241/139	11/398	** **0/000**
Species	95904/820	9	10656/091	0/593	ns 0/804

ns. Non-significant **significant at 0.01

Table 2. Results obtained from the comparison between the means of mixed and pure beech forests with respect to gap area using independent-test.

Stand	Mean	Variance	Sig.
Pure stand	573/7124	-254/55931	0/000*
Mixed stand	828/2718		

*significant at 0.05

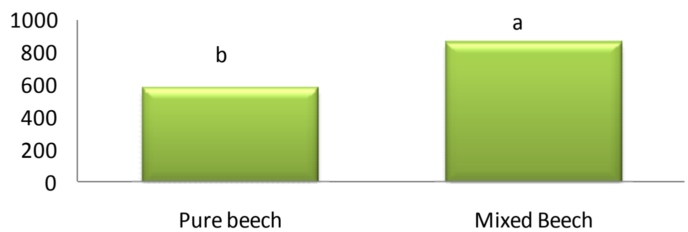

Fig. 2. Comparison between the mean gap areas based on the type of beech forest.

Based on Aspect: Comparison between aspects by using Duncan's test at the significance level of 0.05 showed that the highest gap areas were aspect east, eastern north and west with mean values of 856, 787and 765 m^2, respectively and the lowest gap areas were aspect western north and north, with the mean values of 565, 2367 and 670 m^2, respectively. Statistically, there was significant difference in formed gap (size and area). But, no significant difference was observed between the west and east north aspect with respect to the areas of the formed gaps (Fig. 3).

Based on topographic conditions: Also, the gap area was different for different topographies, in such a way that according to the Duncan's comparison test (at level of 0.05) larger gaps were observed in the middle hillside and flat zones, with the means of 809 and 801 m^2, respectively. Statistically, they were placed in one group while terrace region, with the mean of 326 m^2 had the least gap area and in this regard, it was significantly difference from other regions (Fig. 4).

Qualitative Specifications: In this study, to investigate the qualitative specifications of trees, in addition to the descriptive statistics, Kruskal-Wallis test was used to compare the parameters. In this direction, each studied factor was ranked based on the quality (excellent, good, medium and bad). In general, 42.4%, 10.6% and 0.6 % of trees were of excellent, good and medium qualities, respectively (Fig. 5). This shows the optimal quality of the studied area's forests.

Based on the Kruskal-Wallis test, tree qualities were not significantly different regarding beech forest types, aspect, topography and stand structure. But there was a significant difference in the quality of trees of different species at level of 0.01 (Table 3).

Table 3. The results of Kruskal-Wallis test to compare the parameters (beech forest type, aspect, stand structure, topography and species) based on the quality level.

Variables	*Kruskal-Wallis*	Df.	Sig.
Beech Stands	3/093	2	**ns 0/213**
Hill Aspect	3/170	2	**ns0/205**
Structure	3/501	2	**ns0/174**
Topography	2/592	2	**ns 0/274**
Species	19/755	2	**0/000****

ns. Non-significant **significant at 0.01

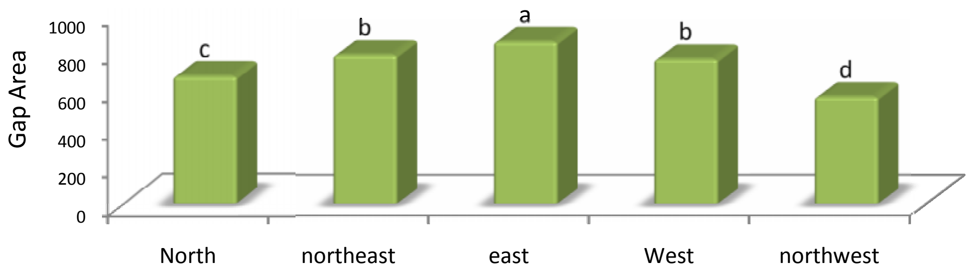

Fig. 3. Comparison of means in different aspects with regard to gap area through using Duncan's multiple range test ($p<0.05$).

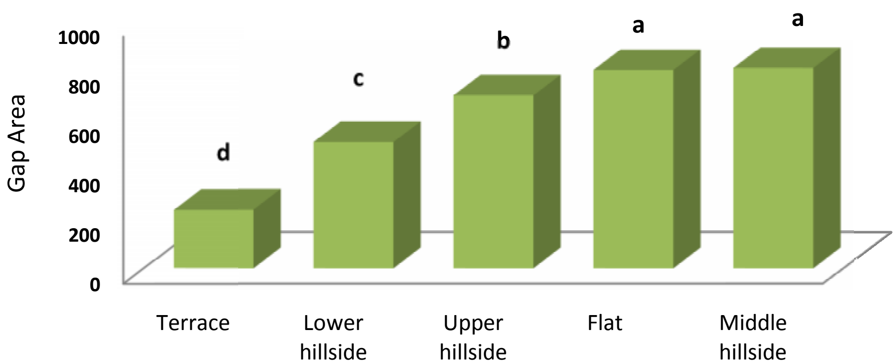

Fig. 4. Comparison of means in different topographic levels with respect to gap area through using Duncan's multiple range test ($p<0.05$).

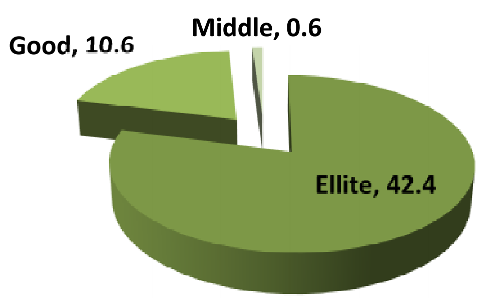

Fig. 5. Qualitative contributions of trees in the site of study.

DISCUSSION

Gap regeneration plays an important role in the evolution and dynamics of temperate forests. Therefore, research and investigation on their appropriate amount of area can play a substantial role in leading the forests toward establishment of climax species and in making the stands sustainable in long term. Results obtained from this study showed that the gap formed in mixed beech stands were larger than those formed in pure beech stands.

The highest and the lowest amounts of gap areas were observed in eastern and west northern aspects, respectively. It was also found that larger gaps were formed in middle hillside and flat areas and the smallest gaps were created in terrace area. The lowest amounts of gap areas were observed for *Alnus glutinosa*, *Acer cappadocium* and *Fagus orrientalis* species, whereas the highest ones were observed for *Parrotia persica*, *Carpinus betulus*, *Acer velutinum*, *Tilia begonifolia* and other forest species; but this difference was not significant statistically.

Also, no significant difference was found between the beech forest types, aspects, stand structures and regional topographies regarding the number of saplings. But there was a significant difference between different species at level of 0.01; in such a way that the highest number of saplings was that of beech species. Number of saplings and the extent of regeneration were higher in west north, north and east north aspects compared to other aspects. Concerning the topography, the highest regeneration was observed on hillsides. Besides, results showed that as gap area increased, the number of beech saplings decreased. In other words, better gap regeneration for beech occurred in the small gaps. This is in consistency with studies conducted by Burger *et al.,* (2001), Sagheb Talebi *et al.,* (2001) & Amanzadeh *et al.,* (2006). They believed that as gap area increases, other photophilic weed species like *Rubus caesius* L, Grasses, Artemisia sp. and Urtica dioica cover the gap surface and make it difficult for beech to establish and regenerate. On the other hand, as gaps increase in area, the amount of light shed on them increases by 10% (Chazdon and Field,1987) whereas, the amount of light shed on areas of closed canopies is between 0.4 and 2%. This increase of light leads to the introduction of invader species.

Results of Mousavi *et al.,* (2003) concerning *Fagus orientalis* showed that no significant difference was found between mean collar diameter of beech saplings in 1to2 R and 4to5 R gaps, whereas the difference was significant in 9to11 R gaps ,accordingly the above findings are consistent with results this studies. In other words, it can be said that in performing selection system, single-tree harvest and creating gaps measuring less than 600 m2 in area provide- against a group cutting trees- more proper conditions for growth and establishment of beech saplings. The reason is that areas larger than that do not lead into the increase of number, quality improvement and height growth of beech saplings and only result in diameter saplings increase which is not so much necessary in the early stages of beech growth. So, increase of gap area only leads to introduction of invader weed species and endangers the continuation of growth stages of beech species. In this direction, the studies conducted by Ghadiripour (2003), Galij *et al.,* (2007) and Shahnavazi *et al.,* (2005) confirms the results obtained here.

CONCLUSIONS

In general, it may be said that based on the study done on the appropriate area of gaps as well as the quality and quantity of regeneration in them, silviculture cutting ,tending of forest and harvest of trees as per the annual mass approved by the forest management plans, must not be done in large levels; instead by taking into consideration the aspect and regional topography, small to medium groups of gaps measuring 500 to 600 m^2 or less in area must be created in the exploited stands. In this way, through regulating the amount of light shed on each gap, an optimal level of quality and quantity improvement can be achieved and the continuation of production and sustainability of stands can be secured in long term.

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