

イランのブナ(*Fagus orientalis*)林の伐採後の再生過程

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論 文

Regeneration Process of *Fagus orientalis* Forests after Cutting in Iran

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AKBARINIA, M. and HUKUSIMA, T.: Regeneration process of *Fagus orientalis* forests after cutting in Iran. J. Jpn. For. Soc. 77: 170~178, 1995 The regeneration process of cut beech (*Fagus orientalis* L.) forests was studied in the central beech forest zone of northern Iran. A semi-natural forest (Plot 1) and two secondary forests (Plots 4 and 7) were studied. Plot 1 was cut 200 years ago and Plots 4 and 7 were cut 15 and 50 years ago, respectively. On Plots 4 and 7, a shade intolerant tree species (*Carpinus betulus* L.) attained 50 and 90 % in stem populations, respectively. On Plot 1, this species had only a 10 % occurrence. The community of Plot 7 was composed mainly of even-aged juveniles of *C. betulus* as the dominant species. On Plot 4, an even-aged population of matured *C. betulus* was co-dominant with *F. orientalis*. However, there were more individuals of *F. orientalis* in the canopy of Plot 4 than on Plot 7. Also on Plot 1, the populations of *C. betulus*, both in the canopy and in the lower stratum, were very small with *F. orientalis* as the dominant species. The population density of seedlings and saplings of *F. orientalis* on Plot 7 was less than on Plots 4 and 1. Although there were no seedlings and saplings of *C. betulus* on Plot 7, some seedlings and saplings of this species were present on the other two plots. Comparatively, *C. betulus* had a smaller population density of seedlings and saplings than did *F. orientalis* on all of the plots. It is suggested that after cutting, a large man-made gap was formed, and for the consequential great light availability, *C. betulus*, being a shade intolerant species, dominated this gap, and over time, its population decreased with a consequent increase in the *F. orientalis* population. Like the semi-natural forest (Plot 1), it is envisaged that in the future, *C. betulus* will be rare in the secondary forests (Plots 4 and 7) so that *F. orientalis* eventually will become a dominant species.

アキバリニア モスレム・福嶋 司：イランのブナ(*Fagus orientalis*)林の伐採後の再生過程 日林誌 77: 170~178, 1995 イラン北部、カスピ海に面したアルボーズ山脈に分布するオリエンツブナ(*Fagus orientalis* L.)林の分布域内において、ブナ林伐採後の年代を異にする林分に 50 m×50 m の 3 プロットを設置して、構造と後継樹の調査からブナ林への再生過程を調査した。各プロットは伐採後、約 200 年(プロット 1)、40~50 年(同 4)、15 年(同 7)であった。樹木構成では最も若いプロット 7 では同樹齢の *Carpinus betulus* は 90% の高い立木密度に生育し、プロット 4 で *F. orientalis* と混交して、同樹齢の *C. betulus* は 50%、1 では *F. orientalis* が優占して 10% にまで低下していた。このことから *C. betulus* は先駆種としての性質をもつと考えられた。林内照度がたいへん低いプロット 7 では *C. betulus* の実生・稚樹はまったく見られなかったが、他の二つのプロットには生育していた。一方、*F. orientalis* の実生・稚樹はすべてのプロットに生育していた。このことから、伐採という行為で、人によって作られた大規模なギャップは最初は耐陰性の弱い *C. betulus* の旺盛な生育を促すが、時間の経過による光循環の悪化はその種から耐陰性をもつ *F. orientalis* の増加に移行する。そして、最終的には長年月を経てプロット 1 に見られるようなブナ優占林へ再生するものと考察された。

I. Introduction

There are many reports on the regeneration process of beech forests in different parts of the world; especially on *Fagus sylvatica* L. in Europe (WATT, 1925; FLOWER, 1980; KOOP, 1987; MORGAN, 1987), *Fagus*

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grandifolia EHRH. in North America (CAIN, 1935; WILLIAMSON, 1975; CANHAM, 1988), and *Fagus crenata* BL. in Japan (MAEDA and MIYAKAWA, 1971; NAKASHIZUKA and NUMATA, 1982; HARA, 1985; YAMAMOTO, 1989). In relation to the role of disturbances on the regeneration process of beech, there are many reports available. Especially, the inhibiting role of dwarf bamboo on the regeneration process of *F. crenata* (NAKASHIZUKA, 1988); the effect of animal grazing on the regeneration of *F. crenata* (NAKASHIZUKA and NUMATA, 1982; HUKUSIMA *et al.*, 1992) in Japan and on European beech (*F. silvatica*, MORGAN, 1987) equally have been reported. Although the direct effect of human impact (cutting) on the regeneration of *F. crenata* has been reported in Japan (KAMITANI and YOSHIDA, 1991; HUKUSIMA *et al.*, 1992; AKBARINIA *et al.*, 1993; KOGASAKA *et al.*, 1993), in Iran there are hardly any reports of human impact on the regeneration of *F. orientalis* that is distributed over the eastern part of Europe, Turkey, and Iran (CZECZOTT, 1932).

The purpose of this study is give an understanding of the regeneration process of the Iranian beech forests, through analysing the regeneration patterns of three stands that experienced cuttings as large disturbance factors at different times in the past. This study seeks to demonstrate how beech attain its dominance after some years of recruitment. Hopefully, this information will be of importance to the better management and preservation of Iran's forests.

II. Study Area

There are two big mountain ranges in Iran, namely, the Alborz range (which runs northwest to northeast like a wall facing the Caspian Sea), and the Zagros range (which runs northwest to southeast), (Fig. 1). The Alborz range separates the northern part of Iran at the Caspian Sea shore, and this results in a humid region on the northern slope, where this investigation was made, and an arid region on the southern slopes of the range. This area, 800 km long and 20~70 km wide, is covered by deciduous forest along the sea shore slopes (Fig. 1). By TREGUBOV (1967), plant associations and communities, based on their altitudes and distributions on the northern slopes of the Alborz range, were identified. These include the Querco-Buxetum Association, that is distributed on the sea shore up to a 50 m altitude, the Querco-Carpinetum Association from 50 m to 200 m, and the Parrotio-Carpinetum Association from 200 m to 900 m. Furthermore, from 900 m to 2,000 m, the Arctostaphylo-Fagetum and Rusco-Fagetum Associations are featured. *Quercus macranthra* FIS. and MEY. and *Carpinus orientalis* MIL. communities are from 2,000 m to 2,800 m.

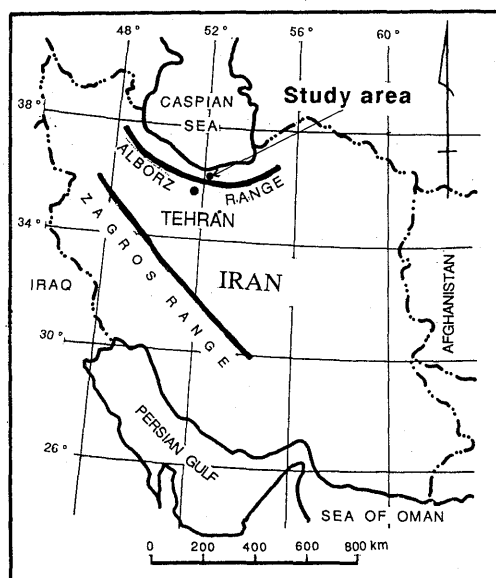


Fig. 1. Study area on the north slopes of the Alborz Mountains in Iran

The climatic data was obtained at weather stations close to the investigation area in Gilan and Mazandaran Prefectures. Knowing that there is a decrease of 0.55°C for every 100 m in altitude, to obtain the length of the growth months (above 10°C) in the beech forests, we calculated growth months, using temperature data. The beech forests of Iran have growth months of 4.5 months at upper altitudes and 6 months at lower altitudes, in fact the north of Iran is in the cool temperate zone. The snow accumulation at sea level is very small, but in some years it reaches a depth of approximately 30 cm. It should be noted that, as the altitude increases, the snow accumulation generally increases. As an example, in the beech forest zone (900~2,000 m), it reaches over one meter in depth in some years.

This study was conducted in the central beech forest of the Rusco-Fagetum Association (Fig. 1) of the Hyrcanian floristic province (TAKHTAJAN, 1986). Seven plots (50 m×50 m in size) were

selected to clarify the effect of grazing, topography, and cutting on regeneration. Among them, three plots (Plots 1, 4, and 7) which had experienced cuttings at different times and had the same recovery process were selected for this study. Plots 1, 4, and 7 are located on gentle slopes, at elevations of 1,250, 1,400, and 1,200 m, respectively, in the same area (preserved area of central Alborz). Except for the times of cuttings, the other factors such as topography, altitude, size of plot, pressure of cutting were approximately the same. According to the Forest Agency of Iran, Plot 1, is a semi-natural forest because it had an intensive selective cutting more than 200 years ago and had individual beech trees in different dbh classes up to 100 cm as dominant species and one large *Quercus castaneifolia* MEY. (dbh > 250 cm) as a remnant tree. Plots 4 and 7 also experienced intensive selective cutting about 40 to 50 years and 15 years ago respectively, hence on these plots, a few big trees still remain. Soil conditions, especially the acidity, color, and the depth of each layer on these plots are very similar. In addition, their bedrocks are calcareous.

III. Methods

The species of all the living and dead stems taller than 4 m and having diameters at breast height (dbh) of more than 4 cm were identified as trees on each plot. A crown projection map was drawn for every plot.

Each plot was sub-divided into 25 quadrats (10 m × 10 m each). On each plot, two belts (10 m × 50 m) with the largest and smallest density of seedlings and saplings (seedling here denotes an offspring with a height of less than 30 cm, and a sapling is a tree with a dbh of less than 4 cm and a height of less than 4 m and more than 30 cm) were selected for detailed study. On each belt, the numbers of saplings and seedlings, diameters at the base (D_0), as well as their heights were measured. The ages of the seedlings were determined by counting the numbers of annual bud scars (YAMAMOTO, 1989; NAKASHIZUKA and NUMATA, 1982). The relative percentage of illuminance on Plot 7 was measured, using photoelectric MINOLTA T1-H illuminometers 1 m above the forest floor as well as on an open site near this plot on an overcast day (unfortunately because of the absence of open sites near Plots 1 and 4, this could not be done). To determine the mortality rates on the plots, the stems of dead trees and juveniles (young trees with dbhs of 4~10 cm and heights lower than 13 m) were enumerated on all three plots.

IV. Results

1. Tree composition

The number of trees as well as the total basal area (TBA) on each plot are shown in Table 1. The dbh distribution is shown in Table 2. For the recent intensively cut plots (4 and 7) the densities of *F. orientalis* were very small when compared to Plot 1 (Table 1). Plot 1 which was a semi-natural forest had the greatest stem density, while Plot 7 that was cut more recently (15 years ago) had the smallest density. From Table 1, *F. orientalis*, *C. betulus*, *Q. castaneifolia*, *Acer velutinum* BOISS and *Alnus subcordata* were found on all plots, but their densities and TBA were different. On Plot 7, the number of *C. betulus* and *A. subcordata* in contrast to *F. orientalis* were more, and *A. subcordata* and *C. betulus* had smaller populations on Plot 4. Plot 7 was dominated by a well-developed and even-aged population of young *C. betulus* due to cutting as the main disturbance factor. Also, in spite of the presence of some mother trees of *F. orientalis* (dbh > 120 cm), a comparatively small population of their seedlings was observed on Plot 7.

2. Stand structure

Figure 2 shows that Plot 1 had the largest percentage of *F. orientalis* canopy cover because it had many trees in the larger dbh class (dbh > 70 cm, Table 2). This was followed by Plot 4 with two old-growth trees of *F. orientalis* (dbh > 110 cm) and some mature and juvenile trees (dbh < 110 cm). Plot 7 with four old-growth trees of *F. orientalis* in the canopy (dbh > 110 cm) as remnant trees had the smallest canopy cover percentage. On Plot 1, there were many individuals of *F. orientalis* especially, between 4~9 m and between 25~41 m in height. Here also *C. betulus* had a height structure similar to *F. orientalis* but with a very small population. There was an individual of *Q. castaneifolia* more than 45 m in height, and some *Acer laetum* and *A. velutinum* with 21~40 m heights. These species, constituted two strata, that is, under and upper canopies. On Plot 4, *C. betulus* and *F. orientalis* trees were dominant. Most of them had heights of

Table 1. The total basal area (TBA, m² ha⁻¹) and number of tree individuals (N.I.) per plot (0.25 ha)

Species	Plot 1		Plot 4		Plot 7	
	TBA	N.I.	TBA	N.I.	TBA	N.I.
<i>Fagus orientalis</i>	36.06	73	17.78	32	20.49	11
<i>Carpinus betulus</i>	1.47	9	19.00	48	18.60	327
<i>Quercus castaneifolia</i>	20.42	1	3.28	5	27.15	1
<i>Alnus subcordata</i>	5.22	1	1.00	2	2.83	22
<i>Acer velutinum</i>	3.41	3	1.60	6	3.63	2
<i>Acer latum</i>	2.93	3	—	—	0.19	2
<i>Ulmus glabra</i>	3.37	3	—	—	—	—
<i>Prunus avium</i> L.	—	—	0.34	1	0.25	1
<i>Crataegus ambigua</i>	—	—	—	—	—	1
<i>Mespilus germanica</i>	—	—	—	—	—	1
Totals	72.88	93	43	94	73.14	368

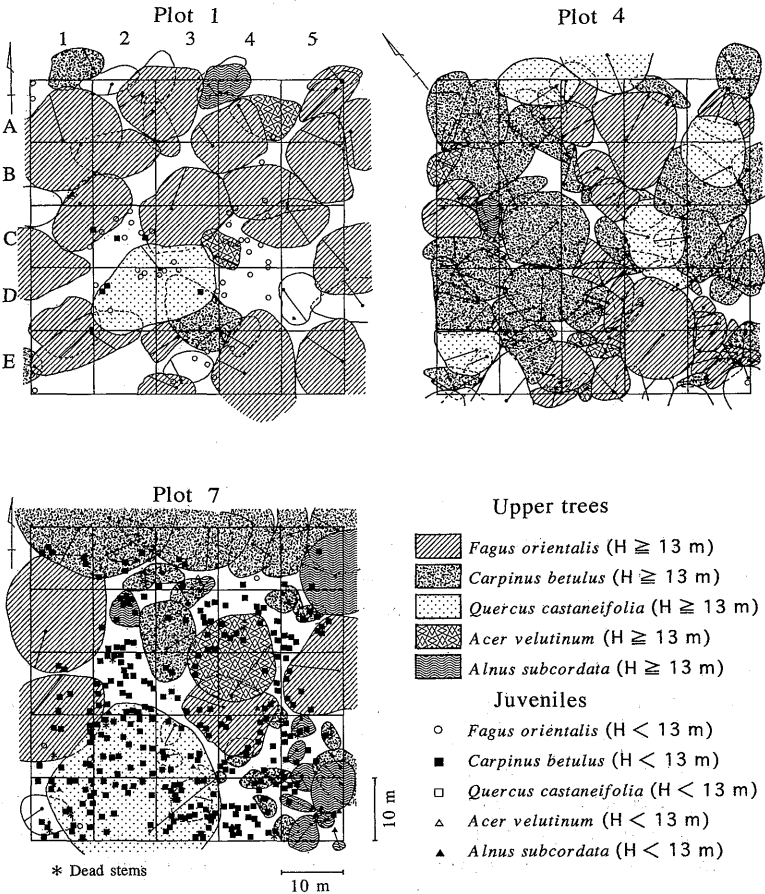


Fig. 2. Crown projection maps of three studied plots

between 25 and 38 m, but the former in the under canopy, had more trees between 7~20 m in height than did *F. orientalis*. In fact on this plot, there were tree species in different height classes such that it was difficult to recognize any specific layer. On Plot 7 there were comparatively many trees, at least four times as many

Table 2. Number of tree individuals in each dbh (cm) class distribution per plot

Species	Plots	dbh class distributions																	
		4	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	200	250
<i>Fagus orientalis</i>	1	50	4	1	1	—	—	4	5	4	4	—	—	—	—	—	—	—	—
	4	1	9	9	8	3	—	—	—	—	—	—	1	1	—	—	—	—	—
	7	7	—	—	—	—	—	—	—	—	—	—	2	1	—	1	—	—	—
<i>Carpinus betulus</i>	1	6	—	1	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
	4	—	12	15	10	7	1	2	—	1	—	—	—	—	—	—	—	—	—
	7	265	55	—	1	—	3	—	1	2	—	—	—	—	—	—	—	—	—
<i>Quercus castaneifolia</i>	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
	4	—	—	—	4	—	1	—	—	—	—	—	—	—	—	—	—	—	—
	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
<i>Alnus subcordata</i>	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
	4	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
	7	13	4	4	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
<i>Acer velutinum</i>	1	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—
	4	—	—	4	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
<i>Acer latum</i>	1	—	—	—	1	1	—	—	1	—	—	—	—	—	—	—	—	—	—
	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Ulmus glabra</i>	1	—	—	—	1	—	—	1	1	—	—	—	—	—	—	—	—	—	—
	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Prunus avium</i> L.	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Crataegus ambigua</i>	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Mespilus germanica</i>	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

more than on Plots 4 and 1, but most of them (90%) were even-aged juvenile trees of *C. betulus* with heights of 4~13 m. There were some other big overstory trees such as *F. orientalis*, *Q. castaneifolia*, and *A. velutinum* with heights between 40 and 50 m. Thus here three strata were recognized as follows: 1-the upper canopy, 2-the middle layer, and 3-the lowest juvenile trees layer.

3. Light intensity and its influence

The measurements of illuminance were made at 37 points on Plot 7 both under a dense understory and on a relatively open area. Table 3 shows that, relative illuminance was more significant ($p < 0.01$) on the almost open area (no trees and no subtrees). The least relative illuminance was recorded under the dense cover of two strata composed of a tree layer as well as a subtree layer. Under the tree layer of *C. betulus* with no subtree (juvenile) layer, the illuminance had a significant level at $p < 0.05$; thus it showed that the subtree layer plays an important role by reducing the relative illuminance on this plot. Furthermore, Table 3 shows that the upper-tree layer had not much effect on the illuminance of the forest floor because the presence or absence (gap) of this layer did not show any significant level of light intensity versus the presence of a subtree layer. Relative illuminance under tree-layer species showed a significant level at $p < 0.05$ under a *C. betulus* trees layer versus the absence of a subtree layer.

4. Seedling and sapling populations after cutting

The density of seedlings and saplings of *F. orientalis* was the largest on Plot 4 and the smallest on

Plot 7 (Table 4). Nevertheless, it had the greatest densities on all of the plots when compared to the other species. There were no seedlings and saplings of *C. betulus* and *A. subcordata* on Plot 7 in spite of the great presence of these species in the tree and subtree layers. The density of *C. betulus* seedlings on Plot 4 was very small when compared to those on Plot 1. The distribution of seedlings of *Acer velutinum* was similar to those of *F. orientalis* on all of the plots, even though their densities and D_0 class distributions were different. Also, many of its seedlings were one-year-old, whereas those more than two-years-old were rare. There were many saplings of *Crataegus ambigua* MEY. (a pioneer species) on Plot 7, but no individuals of this species were found on Plot 4, with only one individual on the gap of Plot 1. *Ulmus glabra* HUDS. despite the lack of mother trees had many seedlings and saplings on Plot 7.

5. The mortality rate of trees on each plot

From Table 5, the mortality rate of *U. glabra* on Plot 1 was large because of insect attack (based on information from the Forest Agency of Iran). Plot 4 had four dead stems of *C. betulus* with dbhs of more than 14 cm. However, although *F. orientalis* was co-dominant with *C. betulus* on Plot 4, there was no dead

stem of this species on this plot. The density of the dead stems on Plot 7 was large (11 stems), and these were all juveniles. Among the dead stems on Plot 7, *C. betulus* had the most (6 stems), although it's proportion of the total stems of the same species was very small. Then *A. subcordata* with three dead stems was next. Of note is that all of the dead stems on Plot 7 had dbhs of less than 10 cm and heights of less than 12 m. On Plot 7, all of the dead stems were located in subquadrats where light intensities were comparatively small (Fig. 2). Furthermore, on these subquadrats, the density of living *C. betulus* juveniles was comparatively more

Table 3. Mean $\pm$ SD of percentage of relative light intensity under tree layer, subtree layer, and gap on Plot 7

Tree layers	Subtree layers	
	Present	Absent
Present	7.1 $\pm$ 2(12) ^a	10 $\pm$ 1.5(10) ^b
Absent	7.3 $\pm$ 0.1(4) ^a	29 $\pm$ 0.5(5) ^c

Notes: Average relative light intensity followed by same letter are not significantly different (*U*-test, $p > 0.05$). Number in parenthesis refer to sample numbers. SD, Standard deviation.

Table 4. Mean number $\pm$ SD of seedlings and saplings of species in subquadrates of the strips with the greatest densities on the plots

Species	Plot 1	Plot 4	Plot 7
<i>Fagus orientalis</i>	55.6 $\pm$ 5.5	143.4 $\pm$ 62	30.4 $\pm$ 7.3
	7.2 $\pm$ 8.8	73.6 $\pm$ 46	14.6 $\pm$ 3.3
<i>Carpinus betulus</i>	14.2 $\pm$ 12	3.8 $\pm$ 5.6	— —
	1.1 $\pm$ 1.3	— —	— —
<i>Quercus castaneifolia</i>	0.8 $\pm$ 0.1	1.1 $\pm$ 2.1	— —
	0.2 $\pm$ 0.4	— —	— —
<i>Acer velutinum</i>	5.4 $\pm$ 4.3	148.4 $\pm$ 47	3.8 $\pm$ 6.7
	5.2 $\pm$ 4.5	133.4 $\pm$ 45	3.2 $\pm$ 5.5
<i>Acer latum</i>	4.4 $\pm$ 3.4	0.4 $\pm$ 0.5	0.6 $\pm$ 0.8
	1.2 $\pm$ 1	— —	0.2 $\pm$ 0.4
<i>Ulmus glabra</i>	2.1 $\pm$ 1.5	— —	1.4 $\pm$ 1
	0.8 $\pm$ 1	— —	— —
<i>Crataegus ambigua</i>	0.2 $\pm$ 0.4	— —	5.8 $\pm$ 2
	— —	— —	— —
<i>Sorbus torminalis</i> L.	0.2 $\pm$ 0.4	0.6 $\pm$ 0.8	— —
	— —	— —	— —
<i>Mespilus germanica</i>	0.2 $\pm$ 0.4	0.2 $\pm$ 0.4	— —
	— —	— —	— —

Note: The upper rows of numbers within each species represent the total number of seedlings and saplings, and the lower rows of numbers represent 1 or 2-year-old seedlings.

Table 5. Mortality of each species on every plot with their heights and dbhs; also dead stems (%) of each species or total dead stems (DST), and dead stems (%) within each species (DSS)

Plots	Species of dead stems	Heights (m)	dbhs (cm)	DST (%)	DSS (%)
1	<i>Fagus orientalis</i>	32	70	33.3	1.4
	<i>Ulmus glabra</i>	30	33		
	<i>U. glabra</i>	28	77	66.7	66.7
4	<i>Carpinus betulus</i>	18	19		
	<i>C. betulus</i>	15	30	100	8.3
	<i>C. betulus</i>	15	17		
	<i>C. betulus</i>	7	14		
7	<i>C. betulus</i>	10	12		
	<i>C. betulus</i>	8	7		
	<i>C. betulus</i>	7	5	54.5	1.8
	<i>C. betulus</i>	6	7		
	<i>C. betulus</i>	6	4		
	<i>C. betulus</i>	5	6		
	<i>Alnus subcordata</i>	10	9		
	<i>A. subcordata</i>	10	8	27.3	13.6
	<i>A. subcordata</i>	10	7		
	<i>Fagus orientalis</i>	10	9	9.1	9.1
	<i>Prunus caspica</i>	6	9	9.1	100

than on other subquadrats.

V. Discussion

As a result of the intensive cuttings on Plots 4 and 7, large gaps were created. According to RUNKLE (1982), BROKAW (1985) and OLIVER and STEPHENS (1977), in a large gap, great light intensity on the forest floor promotes the establishment of shade intolerant species. From Tables 1 and 2, it can be seen that after cutting, *C. betulus* invaded the gap and hence had the largest densities on Plots 4 and 7. Its population dominance on Plot 7 and co-dominance on Plot 4 implies that its density gradually decreased with time. Finally, there were few trees and saplings of this species in the semi-natural beech forest (Plot 1). From this evidence, it can be concluded that *C. betulus* is a shade intolerant species that played a pioneer role here. This confirms the report of KOOP and HILGEN (1987), that considered this species as a pioneer in beech forests. Also, this result verifies the report of WHITMORE (1989), that as a forest matures, sunlight

becomes critical, and pioneer species gradually die after some decades. This is confirmed from Table 5, where it is obvious that *C. betulus* was the only species on Plot 4 that perished. The density of saplings and seedlings more than three years old of the climax species (*F. orientalis*) was great under the *C. betulus* mature trees on this plot. This coincides with the report of WHITMORE (1989), that pioneer species only regenerate in large gaps. When a mature canopy of a pioneer enters the degenerate phase, small gaps are formed and then these gaps will later be closed by the growth of the climax species which become established under these pioneer species. Other pioneers like *Crataegus ambigua* and *Mespilus germanica* L. that were found on Plot 7, would have died after some decades, and hence were absent on Plot 4. These species may appear again with natural gap formation as in the gap of Plot 1. Again from Table 5, the mortality rate of *C. betulus* was more on Plot 4 than on Plot 7; hence as the forest matured the competition between individuals became more competitive, especially for space. Thus, with increasing heights and dbhs, their crowns also became larger and required more space (space competition, KEDDY, 1989). Consequently, their biomasses decreased within any given space occupied after cutting. Table 3 shows that the remnant mother trees had no significant effects on the light intensity of the forest floor ($p > 0.05$), but the subtree layer had a significant effect ($p < 0.05$) on the light intensity of Plot 7. Hence it can be concluded that while there were some big mother trees, their densities were so small that they had no influence on the light intensity on the forest floor. The small densities of present mother trees on Plots 4 and 7 were not sufficient for a good recovery of *F. orientalis*, because MAEDA and MIYAKAWA (1971) reported that for a good regeneration of beech, thirty-two individual mother trees must be left on each hectare after cutting. HIROTA and KAMITANI (1993), reported that for a successful regeneration of *F. crenata*, more than 50 mother trees/ha are necessary. However, here there remained only four mother trees of *F. orientalis* on 0.25 ha. This was too small for a good recovery of this species. Also from Table 3 it can be concluded further that as a result of the presence of a well-developed subtree layer (juveniles) on Plot 7, the light intensity on the forest floor was very small.

Therefore, there were no seedlings and saplings of *C. betulus* here (Table 4). Thus the absence of seedlings and saplings of this species on Plot 7 shows that death is the ultimate fate of the shade intolerant seedling under the current light conditions of this plot. *F. orientalis* had many seedlings and saplings on all three plots. Hence, it further can be suggested that the pattern of regeneration of these forests (Plots 4 and 7) will change so that *F. orientalis* gradually will increase and become dominant after a long interval as was Plot 1. This will be due to the fact that dominance of trees in the overstory change with time as a result of different growth strategies of the species established immediately after cutting (BORMANN and LIKENS, 1979). The population of *C. betulus* seedlings on Plot 4 showed that lateral light under the canopy of mature *C. betulus* was more available than under the *F. orientalis* canopy. For Plot 1, because of the straight light in the gap, the seedling densities of both species (especially > 3 year-olds) were more than on other parts of the plot.

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