Caspian J. Env. Sci. 2007, Vol. 5 No.1 pp. 35~40

CJES
Caspian Journal of Environmental Sciences

[Research]

Composition and structure of a *Fagus orientalis*-dominated forest managed with shelterwood aim (A Case study in the Caspian forests, northern Iran)

M. Tabari[1*], K. Espahbodi[2] & M. R. Poormadjidian[3]

1-Dept. of Forestry, Faculty of Natural Resources, Tarbiat Modares University, Mazandaran, Noor, Iran
2-Research center of Agriculture and Natural Resources, Mazandaran, Iran
3- Dept. of Forestry, Faculty of Natural Resources, Mazandaran University, Sari, Iran
** Corresponding author's E-mail: masoudtabari@yahoo.com*

ABSTRACT
Composition and structure of a three-storied *Fagus orientalis*-dominated forest was investigated in the Caspian forests, north of Iran. Circular sampling plots of 1000 m^2 occupied by advance growth and natural regeneration were randomly chosen where the initial cuttings (with shelterwood aim) were performed. Abundance of species at different growth stages and quality of seedlings and saplings were registered and basal area and standing volume determined. The measurements were carried out before the first shelterwood cutting (in 1974) and after the last shelterwood cutting (2004). The results after 30 years (in 2004) revealed that frequency, basal area and standing volume significantly enhanced for beech and reduced for hornbeam but did not statistically differ for alder, maple and other species. Sapling and thicket groups were observed in parts of the investigated site and where the mature trees were not felled. Generally, the research area was converted into an irregular uneven-aged 2-4-storied forest, owing to recruits, advance regeneration, aged trees and small and large pole groups maintained through the forest.

Keywords: Advance growth, *Fagus orientalis* Lipsky, shelterwood, stand structure, tree composition, uneven-aged forest

INTRODUCTION

Caspian forests with an area ~ 2,000,000 ha. are located between –20 and 2200 m a.s.l. in north of Iran (south of the Caspian Sea). Pure and mixed beech stands are one of the most important, rich and beautiful stands occurring on the northern slopes. The natural dense stands are found at 1000-2100 m and the best stands at 900-1500 m a.s.l. (Sagheb-Talebi *et al*., 2003). Beech is a most valuable wood producing species in the Caspian forests covering 17.6 per cent of the area and represent 30 per cent of the standing volume; it can grow taller than 40 m and exceed diameter at breast height larger than 1.5 m (Resaneh *et al*., 2001). Late frost, early heavy snow, and direct sunlight damage its seedlings. As a sapling, *Fagus orientalis* is much more resistant against frost, sunburn, and drought stress than European beech (*Fagus sylvatica* L.) (Svoboda, 1953).

During last four decades, *Fagus orientalis* stands in the Caspian forests have been managed chiefly using shelterwood system. In the most stands, shelterwood method has been replaced by selection method due to the technical reasons and particularrly regeneration problem in recent year (Sagheb-Talebi and Schütz, 2002). Some Iranian researchers reported different views on shelterwood. Marvi-Mohadjer (2006) shows that shelterwood is not a suitable method for Caspian forests, due to topography conditions. On the other hand, Biglar-Beygi (1985) declares that shelterwood will be satisfactory if recruits occupy 60 per cent of the compartment (regeneration) area. Taheri-Abkenar (1993) notes that at the end of a 30-year period, after removal felling, 75 per cent of the forest area had not sufficient regeneration, likely due to the seed cutting made in inadequate seed production year. Espahbodi (1994) demonstrates that unsuitable secondary thinning in beech stand has been, indeed, the main cause for berry (*Rubus fructicosus* L.) aggression and reproduction failing. Amani and Hassani (1998) state that in stands managed with shelterwood objecttives, technical defects in marking and harvesting have been the reasons for regeneration deficiency and herbal vegetation invasion. Similar happenings are also observed in *Fagus sylvatica* stands of Europe (Mosandl, 1984). In spite of this reality that establishment and growth of some tree species are not threaten under herbaceous vegetation with canopy density < 40 per cent (Mosandl and Kateb, 1988), establishment of *Fagus sylvatica* is poor in such an environment (Linhart and Whelan, 1980). Generally, there are a few investigations of the long-term influence on productivity, composition and structure in the Caspian forests, by harvesting) and silvicultural practices. This paper aims to evaluate the composition and structure of an uneven-aged old growth, beech-dominated forest, planned with shelterwood goal for three decades in the mountainous Caspian forests, north of Iran.

MATERIALS AND METHODS

The experimental site with a fenced area of 226 ha is situated in the Caspian forests, under management of Behshahr Forest Service Office in north of Iran, (latitude is between 53º42´25″ and 53º42´50″ N and longitude is between 39º38'35″ and 39º39º'06″ E and 1250-1450 m a.s.l.). Dominant tree species was beech, 180-200 yrs old. Depending on the site conditions, hornbeam, alder, maple and other tree species, often as co-dominant, were occurred along with beech. The diameter at breast height (d.b.h.) and top height of the dominant trees were almost 80 cm and almost 35 m, respectively, corresponding to a mean annual production of c. 6 $m^3ha^{-1}y^{-1}$. The ground was rather sloppy on the experimental site, ranging from 2 to 65 per cent and in most parts 20-30 per cent. Mean subsoil water level was 100 cm below ground level, with seasonal variations of 60-160 cm. Based on Emberger (1932) classification, site is humid with cold winters, mostly covered by snow from November to February. Growing season occurs from April to September and vital drought period varies between 30 and 45 days in mid-summer (July and August). Mean annual precipitation is ~ 1400 mm and mean annual temperature ~ 10.4 ºC.

In 1974, in some parts of the research site (40 ha), occupied by natural regeneration and advance growth (d.b.h.<30 cm) and conducted with shelterwood aim (mainly by preparatory and seed cuttings), 40 circular plots of 1000 m^2 were chosen to inventory tree elements with different growing stages. The same inventory was repeated in the plots after 30 years (in 2004) when the last cuttings of shelterwood (thinning and removal) were applied.

In both dates, in the sample plots, frequencies of species at different growth stages (seedling phase to aged phase) as well as quality of seedlings at juvenile phase were registered, and basal area and standing volume assessed. The data measured after the last cutting (in 2004) was compared with those before the first cutting (in 1974). Likewise, structure of the primary forest and the harvested forest was compared descriptively. Typology and structure of the stands occurred after cuttings were represented.

The difference in growth rate of the characteristics measured (frequency, basal area and standing volume) of species before and after cuttings was analyzed using Student's *t* test at P < 0.05. Statistical analysis of ANOVA and Tukey's multiple range tests were accomplished at $p < 0.05$, using the SPSS software, version 12.5.

RESULTE

At the beginning of investigation, 49.3 per cent of tree abundance, 54.5 per cent of basal area and 58.4 per cent of standing volume allocated to oriental beech while for hornbeam the attributes were 36.5, 37.7 and 23 per cent, respectively (Table 1). At the end of period these attributes increased respectively to 82.5, 73 and 71 per cent for oriental beech, and reduced to 10.5, 17 and 11 per cent for hornbeam. In spite of increased saplings the average basal area of beech reduced, showing the presence of young thick beech stands. Tree abundance, basal area and standing volume of beech and hornbeam were significantly different in years before cutting (1974) and after cutting (2004). It was revealed that following cutting made in 2004 these attributes increased for beech and decreased for hornbeam. No significant difference of these characteristics could be detected for alder, maple and other broadleaves between the two dates (Table 2).

It is noteworthy that, at the end of the period, a considerable proportion of basal area and standing volume, particularly in 40-60 cm d.b.h., mostly including oriental beech, was retained through the forest area (Fig. 1 and 2). A big quantity of stockings was laid on sharp slope, where not any cutting was occurred during the study period. In some parts of the forest, never old growths and advance regeneration were cut. Besides that, in most of the forest area where the removal felling was conducted, 1-30-yrs old beeches were appeared.

Table 1. Characteristics of the species (percentage), before and after cutting in the study site .

Species	Before cutting (1974)			After cutting (2004)		
	Frequency	Basal area	Standing volume	Frequency	Basal area	Standing volume
Oriental beech	49.3a	54.5a	58.4a	82.5a	73.0a	71a
Hornbeam	37.7a	36.5a	23.0b	10.5b	17.0b	11b
Alder	4.2b	4.9b	8.4c	3.5b	6.2b	6b
Maple	3.8b	2.8b	9.2c	2.0b	2.3b	8b
Other broadleaves	5b	1.3b	1.0c	3.5b	1.5b	5b

-Values in a column with the same letter are not significantly different at the 0.05 level of significance, according to Tukey's multiple range test.

Table 2. Growth rate (percentage) and significance of the characteristics measured of species, before (1974) and after cutting (2004), using student's *t*-test.

Species	Frequency	Basal area	Standing volume
Oriental beech	(+33.2)*	(+18.5)*	(+12.6)*
Hornbeam	(-27.2)*	(-19.5)*	(-12.0)*
Alder	(-7.0)ns	(+1.3)ns	(-2.4)ns
Maple	(-1.8)ns	(-0.5)ns	(-1.2)ns
Other broadleaves	(-1.5)ns	(+0.2)ns	(+4.0)ns

* = Significant at the 0.05 probability level, ns = Non significant
(Positive value and negative value in brackets respectively are the increased and the decreased growth rate of characteristics measured in after cutting over before cutting).

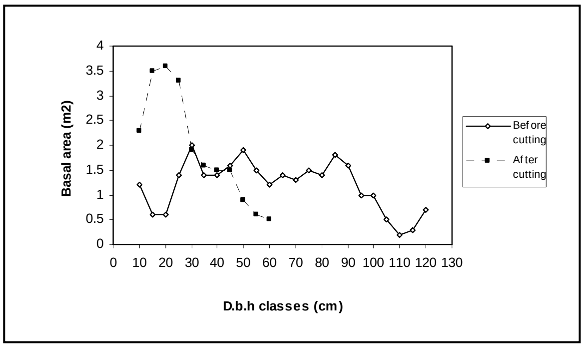

Fig. 1. Basal area of d.b.h. classes of the forest trees before cutting (1974) and after cutting (2004)

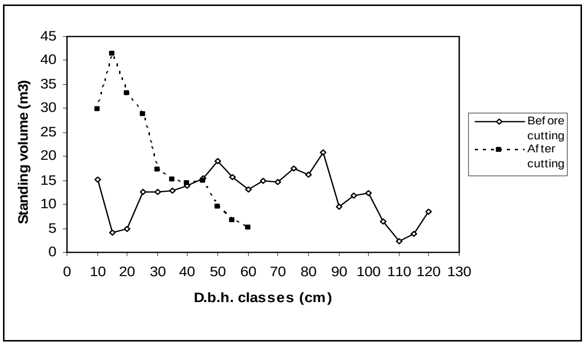

Fig. 2. Standing volume of d.b.h. classes of the forest trees before cutting (1974) and after cutting (2004)

1-Forest structure

At the end of the period, the maximum frequency occurs at 5 cm d.b.h., the minimum at 60 cm d.b.h. (Fig. 3). It is understood that in contrast the shelterwood objectives, the investigated area was not directed towards a homogeneous even-aged forest. In reality after the last cuttings (2004), aged individuals were decreased and thickets, small and large poles of 15-40 cm in d.b.h. increased. In addition, a great quantity of young individuals (< 15 cm in d.b.h.) was added to the study site. However forest structure did not differ predominantly and still remained uneven-aged. In total, following the cuttings at the end of period, different typology forms with even-aged and uneven-aged structures were occurred in the investigated area (Fig. 4).

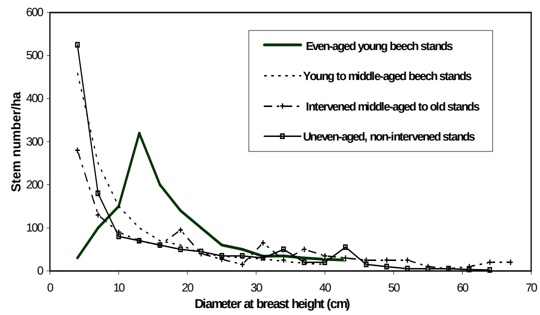

Fig. 3. The numbers of the trees per hectare by size classes in the forest before cutting (1974) and after cutting (2004)

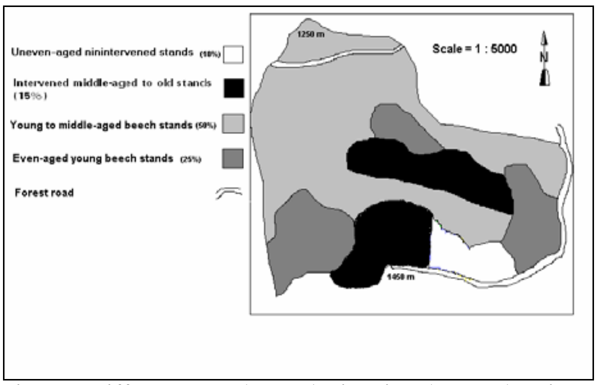

Fig. 4. Different stand typologies in the study site, occurred after cutting (in 2004)

In fact, by integration of similar forms four typology forms were assessed and classified as below:

a) Uneven-aged, non-intervened old stands

This form with reverse J-curve model of d.b.h. distribution (Fig. 5) observes on slopes of 40-60 per cent, occupying 10 per cent of the research site. In reality, sharp slopes and landslide risk are the reasons for preventing felling. It should be also cited that in forest planning a small harvesting was prescribed for these stands but not any intervention was carried out during the period, due to the sharp inclination and landslide risk.

These stands represent a four-storied stru-cture, being distinguished by dominant aged beeches, co-dominant middle-aged beeches, dominated thin thick-ets, and suppressed thick saplings.

b) Intervened middle-aged to old stan-ds

This form with reverse J-curve model of d.b.h. distribution (Fig. 5) is observed in 15 per cent of the investigated area. There are evidences presenting that primary cuttings (preparatory and seed cutting) were cond-ucted by removal of beeches and hornbe-ams. It looks like that following the primary cuttings, abrupt invasion of luxuriant berry (*Rubus fructicosus*) and fern (*Petridium aquilinum*) was a limiting factor to apply the subsequently felling, specially thinning felling. Three-storied stands are mostly located on moist exposures with moderate to sharp inclination (20-60 per cent).

c) Young Even-aged beech stands

This form with inverse V-curve model of d.b.h. distribution (Fig. 5), showing a homo-genous formation, occurs in 25 per cent of the investigated area. Landscape lacks the parent trees while it has been mostly covered by advance regeneration from beginning of the research time and in parts occupied by recruits. It is now presented as even-aged, one-storied small pole groups. Though this form is found on various gradients of the geographical directions however it mostly appears on the gentle slopes. Quality of the stands in varying places is different. Competition among individuals is relatively severe. Snow and wind damage on saplings is completely obvious.

d) Young to middle-aged beech stands

This form with inverse J-curve model of d.b.h. distribution (Fig. 5) appears in 50 per cent of the investigated area. The stands are mostly two-storied but in parts the three-storied structure is observed. In this form upper-storey is adapted with middle-aged beeches, middle-storey with dense small pole groups and under-storey with thickets and saplings of beech. Indeed, during the research period almost all regeneration cuttings were implemented in these stands. The aged beeches and hornbeams were felled but middle-aged beeches and other trees with d.b.h. 25-45 cm maintained, whereas the patches of young beeches were appeared. Generally the stands were mainly established on wet exposures (nort-hern, west and east northern) with slight to moderate gradient (<30 per cent). No prominent damage of snow and wind affected saplings.

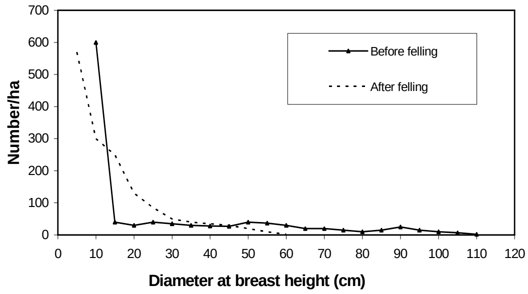

Fig. 5. D.b.h. distribution of trees (per hectare) at four different stands, conducted after the last cutting (in 2004)

2-Regeneration quality

In 15 per cent of the investigated area particularly on the sharp slopes young beeches were appeared with poor quality and more or less as uprooted, crown breakage, forked and bend stems. About 75 per cent of recently established individuals, particularly saplings were injured by snow and wind. The damage was least where the advance regeneration, playing the shelter role for recruits, was accepted. Owing to strong competition, young beeches were observed with tall stem and big h:d ratio.

DISCUSSION AND CONCLUSION

By comparison of present condition of forest with target of shelterwood system, it is concluded that generally after 30 years the forest structure is still multi-storied, while the main aim of the forest planning was to create a regular even-aged, young one-storied forest. Indeed, natural regen-eration would have been appeared throu-ghout the forest if the shelterwood method had been performed accurately and comp-letely. As a matter of fact, beech number increased in some parts of forest and the forest became some to extent young. Furth-ermore, a great number of saplings were injured by snow and wind as well as intensive exploitation where the over-stor-ey removed.

Generally, four different stand structures created following the last cut-tings (in 2004) were formed mainly owing to:

a) Accepting the advance regeneration;

b) Reserving the individuals on sharp slopes;

c) Retaining the aged trees in different parts of the investigated site;

d) Avoiding the secondary thinning in places occupied by *Rubus* and *Petridium*;

e) Likely, defect in prescribed formula for tree marking and harvesting could be the reason for interferences reduction.

Gentle gradient is, normally, the main factor for success of the shelterwood method. The experience of this method is observed in Europe, particularly north of Germany, north of France and Denmark (Marvi-Mohadjer, 2001).

Generally, shelterwood is adapted in forests with deep and light soils and slight to moderate inclinations (< 40 per cent) (Mossadegh, 1996). Under these conditions ground is favorable for regeneration establishment when applied shelterwood fellinngs (Dorostkar, 1984). As mentioned-above, the study site has various geogr-aphical directions (northern, eastern, east northern, west and west southern). Like-wise, slope gradient ranges between 2 and 65 per cent whereas the majority of forest area is laid on gradient > 40 per cent.

Harsh gradient as well as dense *Rubus* and *Petridium* could likely be the reasons for being reserved individuals on different exposures and scattered points of the for-est. Generally a young homogeneous even-aged beech forest which principally is the main goal in the shelterwood method could not be achieved, owing to mentioned-above conditions, acceptance the advanced-growth seedlings and saplings and other tree individuals and groups as well as the maintenance of trees on slopes.

In contrast, an irregular uneven-aged two to four-storied forest occurred. As a whole, concer-ning to above problems, it is revealed that for exploitation and management of mountain beech stands of the Caspian forests, other silvicultural methods, such as tree selection and group selection methods, instead of shelterwood method, can be advised. Of course, it may be admitted that the group selection with removing 2-4 mature trees can be a more suitable method for management of beech stands (Sagheb-Talebi and Schutz, 2002). This can be owing to following cases:

(i) the stand structure (ii) the tolerance of *Fagus orientalis* to shade (iii) its big crown dimensions [with a width 5-12.5 m (Amani and Hassani, 1998)], and (iiii) the satisfy-actory development of its natural regen-eration in groups < 500 m² (Sagheb-Talebi and Schutz, 2002, Tabari *et al*., 2004). In gaps smaller than 600 m² its seedling establishment will be satisfied if tending practices particularly cleaning herbal veget-ation is carried out (Tabari *et al*., 2005).

It can be also suggested that in the forests managed with shelterwood obje-ctive and retained with different structures or typology forms proper silvicultural prac-tices should be implemented for each stand form to guarantee the stability, sustainab-ility and health.

REFERENCES

Amani, M. and Hassani, M., (1998). An investigation typology of the stands of *Fagus orientalis* at the two research projects. Trials of uneven-aged and even-aged methods at Sangdeh (northern Iran), *J. Pajouhesh & Sazandegi*, **37,** 4-27.

Biglar-Beygi, B., (1985). Evaluation of silvicultural methods in the Caspian forests. *Symposium of Forest Policy, Publication of Forestry Technical Bureau.*

Dorostkar, H., (1984). Complementary Silvi-culture. In press, *University of Gorgan, Iran*, pp. 115.

Emberger, L. 1932 Sur une formule clima-tique et ses applications en botanique. La Meteorologie, No. 92-93, Paris, France.

Espahbodi, K. and Mohammad-Nejad, Sh., (2001). *Evaluation one of main silvicu-ltural methods in north forest of Iran*, pp. 271-290.

Linhart, Y.B. and Whelan, R.J., (1980). Woodland regeneration in relation to grazing and fencing in Coed Gorswen, North Wales. *J. Appl. Ecol.*, **17,** 827-840.

Marvi-Mohadjer, M.R., (2001). Suitable method of silviculture in north forests of Iran In: Nation symposium on north forests and sustainable development, Forest and Range Organization Publis-hers, pp: 214-218.

Marvi-Mohadjer, M. R., (2006). Silviculture. Tehran University Press.

Mosandl, R., (1984). Löcherhiebe im Berg-mischwald. *Forstliche Forschungsberic-hte München.* No **61,** 298 pp.

Mosandle, R. and Kateb. H.El., (1988). Die Verjüngung gemishter Bergwälder - Praktische Konsequenzen aus 10 jahriger Untersuchungsarbeit. *Fortw. Cbl.*, **107,** 2-13.

Mossadegh, A., 1996. Silviculture. Univer-sity of Tehran, *College of Natural Reso-urces*, Karadj, Iran, pp. 481.

Resaneh, Y., Moshtagh, M.H. and Salehi, P., (2001). Quantitative and qualitative study of north forests. In: Nation Sem-inar of Management and Sustainable Development of North Forests, Ramsar, Iran, August 2000, *Forest and Range Organization Press*. Vol. **1,** 55-79.

Sagheb-Talebi, Kh., Sajedi, T. and Yazdian, F., (2003). Forests of Iran. *Research Inst-itute of Forests and Rangelands*. Techn-ical Publication No. 339, pp. 28.

Sagheb-Talebi, Kh. and Schütz, J.Ph., (2002). The structure of natural oriental beech (*Fagus orientalis*) forests in the Caspian region of Iran and the potential for the application of the group selection system. *Forestry* **75 (4),** 465-472.

Svoboda, P., (1953). Len sí dřeviny a jejich prosity I.SZN. *Praha*, pp. 110 .

Tabari, M., Sagheb-Talebi, Kh., Mousavi, S.R., Poormajidian, M. R. and Akbarinia, M., (2004). Determining gap size to favor natural regeneration in a dominant orie-ntal beech forest, In: *Proceeding of Improvement and Silviculture of Beech, IUFRO 7th Beech Symposium*, Tehran, Iran, May 11-16, 2004, p. 74.

Tabari, M., Fayaz, P., Espahbodi, K., Stael-ens, J. and Nachtergale, L., (2005). Resp-onse of oriental beech (*Fagus orientalis* Lipsky) seedlings to canopy gap size. Forestry, **78 (4),** 443-450.

Taheri-Abkenar, K., (1993). Assessment of results of shelterwood system in Kileh-Sara, M.Sc. Thesis, *Tarbiat Modares University*, pp. 154.