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Assessment of Quantitative and Qualitative Characteristics of Golestan Province Forests in an 11-Year Period (Iran)

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Abstract

The impacts caused by natural factors and human interventions during specific sampling periods have substantial influence on nature and the selected management method. The present research was carried out in Golestan Province forests, Iran over an 11- year period and the obtained data was analyzed based on systematic random sampling method with fixed sample plots (0.1 ha). The data including species, DBH, height, qualitative degree in the first six-meter of the stem, percentage of canopy, and regeneration status in sample plots were measured and recorded for sampled trees. The results showed that the sample plots in Golestan Province forests increased from 1018 at the beginning of the studied period (1996) to 1114, at the end (2007). The inventory performed in 2007 showed that considering the percentage of canopy, the areal percentage of these forests increased in 0-30% and >80% canopy classes compared to those in 1996; however, there was a considerable reduction in the percentage of canopy in the given forests in 30-50% and 50-80% classes. Comparing the productive and non-productive forests indicated that the area of protection and conservation forests increased in 2007 compared to that of the year 1996. The results also revealed that the number and volume per hectare of trees in Golestan Province forests were dramatically reduced to 53.6n.ha and 1104.9m^3ha^{-1} respectively. This reduction was more remarkable for the main species of the studied forests including horn beam, chestnut-leaved oak, beech, and velvet maple. The highest reductions of number of tree species were observed in 20, 25, 30, 35, and 40cm diameter classes, while the variations of volume (vs. number) in diameter classes exhibited more fluctuations. Comparing the status of dead wood in the studied forests revealed that the highest number of dead wood (58.5%) and volume/ha (66%) occurred in horn beam compared to other species. The research also indicated that the highest abundance of regeneration pertained to seedling and sapling vegetation stages.

***Keywords*:** Forest structure, Quantitative and qualitative changes, Permanent sample plot, Golestan Province, Iran

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Introduction

Monitoring and assessment of data from overall inventories and forest management plans during short and long terms, and also studying changes in the structure and composition of the forests under management are the fundamental principles of forest resources management (Aghili, 2009). The results of the these assessments and their monitoring, besides revealing the variation rate of management plans efficiency, can be useful in making better decisions in terms of plans sustainability and implementation. In recent decades, sampling methods have witnessed much progress in environmental and natural resources sciences. One of the fields of study which is deeply dependent on statistics and sampling is forest sciences. Thus, the application of proper and in-time sampling methods in forest and also the possibility to repeat them in specific intervals can play a significant role in forest resources management. The assessment of quantitative and qualitative changes, the result of the impacts imposed by natural factors and human interventions during specific sampling periods have substantial influence on management method and tending operation of every region's forests. The analysis of the obtained data from specific sampling periods can be influential for revising management systems, utilization of natural resources, and short and long term planning to direct every country's main programs and politics of natural resources towards rehabilitation, development, and optimal utilization.

In terms of the assessment of forest management plans in Hyrcanian region, many studies have been carried out all emphasizing on the effect of forest management plans on the quantitative and qualitative changes in forest stands structure (Darvishsefat, 1975; Babakordi, 1978; Moayeri, 1978; Etemad, 1992; Kavoosi, 1996; Shariatnejad, 1999; Asadi-otouei, 2000; Aghili, 2009; Hasanzad-navroudi, 2009; Amiri *et al*, 2013; Etemad *et al*, 2013). The dynamics of forest structure was assessed in district one of Gorgan Shastkalateh forest in terms of the structure and composition of the district, type, and stand in a 30 year-period. The results of this research indicated that there were no statistically significant difference in the number of trees, basal area, and volume per hectare in the given period (Aghili, 2009). Evaluating the quantitative and qualitative changes resulting from the implementation of the forest plans in Potom District, Kheiroud-Kenar forest and comparing them with the inventories done in 1956, Darvishsefat (1975) reported that the standing volume per hectare had decreased by 10.1%. Hassanzad-navroudi *et al.* (2009) also showed that there was no significant difference between the average standing volume and basal area per hectare in the beginning (1995) and end (2005) of the given period. However, the standing volume and basal area per hectare had decreased after 10 years of implementing the forest management plan (Janbe-sara district, Guilan Province). Etemad *et al.* (2013) indicated that after implementing forest management plans (1972-1992), the tree height distribution curve was higher, and the volume of large trees (>55cm DBH) increased in

Namkhaneh district, Kheiroud-Kenar forest of Nowshahr. Also, the percentage of beech volume per hectare exceeded that of the programmed value, and as for the species of hornbeam and oak, the mentioned percentage increased to about the values of the ideal objectives. Today, most of the developed countries assess their forest resources every few years and provide forest managers, experts, and researchers with the obtained results. In Iran, the assessment of forest management plans, called revision plan, is carried out every 10 years of which the sixth-period of the ten-year studies performed in the Hyrcanian forests (1948 to 2006) can be mentioned (FRW, 2007). Since the overall inventories of the Hyrcanian forests, have been performed once every ten years, the inventory information of the ten-year period beginning in 2006 is not yet at hand. Thus, in this research, the data provided from the sampling period of 1996 to 2007 was used. To the best of the authors' knowledge, a research focusing on the assessment of the quantitative and qualitative characteristics of forest structure in a large scale (forests across a province) has not yet been conducted in Iran. Therefore, the present research was carried out in Golestan Province consisting of different sites including beech, hornbeam, alder, and ironwood towards shedding light on the quantitative and qualitative status of the mentioned forests which are more or less natural. The results of this research can also be significant for assessing the effect of implementing forest management plans. Thus, the aim of the present study is to assess the changes of the quantitative and qualitative characteristics of the Golestan Province forests in an 11-year period from 1996 to 2007.

Materials and Methods

The Hyrcanian vegetation zone, also called Caspian forest, is a green belt stretching over the northern slopes of the Alborz mountain ranges and covers the southern coasts of the Caspian Sea. This area stretches from Astara in the northwest to the end of the Golestan Province in the northeast of Iran. Based on the latest data from the Iranian Forests and Rangelands Organization (Anon, 2008), this area is approximately 800 km long and 110 km wide and has a total area of 1.85 million ha comprising 15% of the total Iranian forests that is 1.1 % of the country's area. The zone is rich and includes 130 woody species (trees and shrubs) dominated with hardwoods (Marvie-Mohajer, 2004; Sagheb-Talebi *et al*, 2013). The forest extends in the three provinces of Guilan, Mazandaran, and Golestan. Located in the north of Iran, Golestan Province covers 1.3% of Iran's overall area, and its latitudes and longitudes are 36° 24' to 38° 24' N and 52° 51' to 56° 21' E, respectively (Fig 1). The highest and lowest recorded points in this province are 3750 meters above and 27 meters below sea level, respectively; and its timber line is up to 2800m. Due to its particular geographic and natural condition, Golestan Province, with an average annual temperature of 17.9°C, has a high climatic diversity such that its annual rainfall and relative humidity vary between 150 and

850 mm and 17 and 100%, respectively. Natural resources of this province are managed by the government (1.396 million hectares) covering 68% of the whole province. Forests with an approximate length of 260 km stretching from Galougah city on the west to Golidagh region on the East, cover 451000 hectares (22.1% of the whole province) and forest area per capita is 0.28 hectare. Based on the latest sampling data available, 30.5, 19.5, 25, and 25% of the province's forests are second degree (standing volume of 200-350m^3ha^{-1}), first degree (standing volume of more than 350m^3ha^{-1}), third degree (standing volume of 100-200m^3ha^{-1}), and fourth degree (standing volume of less than 100m^3ha^{-1}), respectively (FRW, 2009).

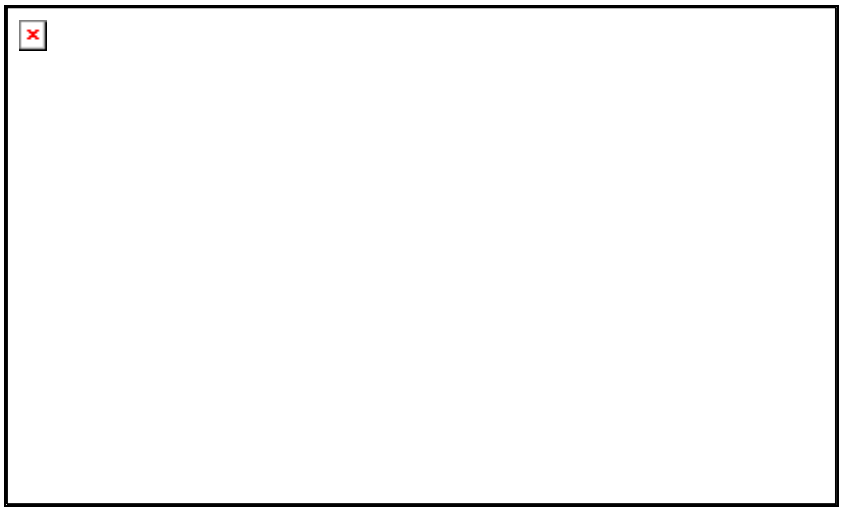

Figure 1. Location of the study site in the Hyrcanian Forests, northern Iran

The present study is based on the overall inventory data of the Hyrcanian forests financially supported and carried out by the Natural Resources Office of Golestan Province in the inventory periods of 1996 and 2007. Across the whole province forests, sampling was carried out using systematic random method with circular permanent plots of 1000m^2 whose centers were 5km apart from each other in east-west direction. For each sampling plot, species and diameter at breast height (DBH), height (m), qualitative degree of the first 6 meters of tree stems (Zobeiri, 2000), and the percentage of sample plot canopy were measured and recorded. Also, the regeneration of the species in four growth stages of seedling (>0.5m tall), sapling (0.5-1.30 m tall), thicket (>10cm in DBH), and pole stage (10-12.5cm in DBH) (Marvie Mohajer, 2005; Sagheb-Talebi *et al.*, 2005 and Amiri *et al.*, 2008) was studied in three forest stand forms each comprising high stand, coppice stand, and high and coppice stand classes. The percentage of forest canopy crown in the

studied sampling plots was classified in four classes (0-30, 30-50, 50-80, and >80%), and all the dead wood with diameters and lengths of more than 12.5cm and 2m were measured. To analyze the data, SPSS, 19 and Excel software were used.

Results

Results indicate that the total number of permanent sampling plots in Golestan Province forests was 1018 in 1996, whereas this number increased to 1114 (0.1ha) in 2007 sampling. It is important to note that the mentioned number excludes Golestan National Park. Hence, considering the number of plots needed for the quantitative and qualitative assessment of the park's forest zone, the total number of the province's required sampling plots is assumed to be 1207. Based on the type of the sampling plot, Table 1 displays plots status in 1996 and 2007. Natural forest stands and treeless lands own the largest and smallest number of the sampling plots in the two inventories, respectively. As observed in Table 1, the results also indicate that based on the collected permanent plots, the percentage of Golestan Province forests area (in both 1996 and 2007 inventories) is varied in sites including mixed natural and broad-leaf forest stands, outskirts of villages, orchards, and highly sloped and reserved points. Compared to the inventory carried out in the year 1996, the number of the collected sampling plots increased in outskirts of villages and orchards, forest stands neighboring rangeland (Ecotone), woodland, and conservation and protection forest stands in 2007 and decreased in the natural forest stands, empty lands in forests, and afforestation and reforestation areas. Also, the highest increase and reduction in the number of the sampling plots are related to the conservation and natural forest stands, respectively (Table 1).

Table 1. Percentage of Golestan Province forests area based on canopy crown in a period 11 years

Sample plot condition	1996	%	2007	%
Natural forest stands (managed and unmanaged)	427	44.6	401	36
Afforestation and reforestration (needle and broad-leaved stands)	66	1.77	20	1.79
Outskirts of villages and orchards	149	14.6	201	18.0
Forest stands neighboring rangland (Ecotone)	31	3.05	33	2.96
Woodland (poplar and bamboo plantations)	172	16.9	204	18.31
Empty lands in forests	19	1.87	14	1.26
Conservation and protection forest stands	154	15.1	213	19.12
Other*	0	0	28	2.52

*marginal villages, farms, gardens and etc.

Comparison of the Percentage of Forests Area Based on Canopy Classes

Figure 2 demonstrates the percentage of Golestan Province forests area based on canopy classes in the two sampling periods of 1996 and 2007. The results indicate that compared to the inventory conducted in the year 1996, the area of

forests with canopy of 0-30% and above 80% has increased in 2007, whereas in 30-50% and 50-80% canopy classes, the area of has decreased. This may imply that the area of thin forests is increasing such that compared to 1996 sampling period, the area of forests with 30-80% canopy crowns has decreased in 2007. The results also show that over the 11-year inventory period, the highest decrease in the canopy of Golestan province forests has respectively occurred in 30-50% and 50-80% classes, while canopy classes of 0-30% and above 80% have increased (Figure 2).

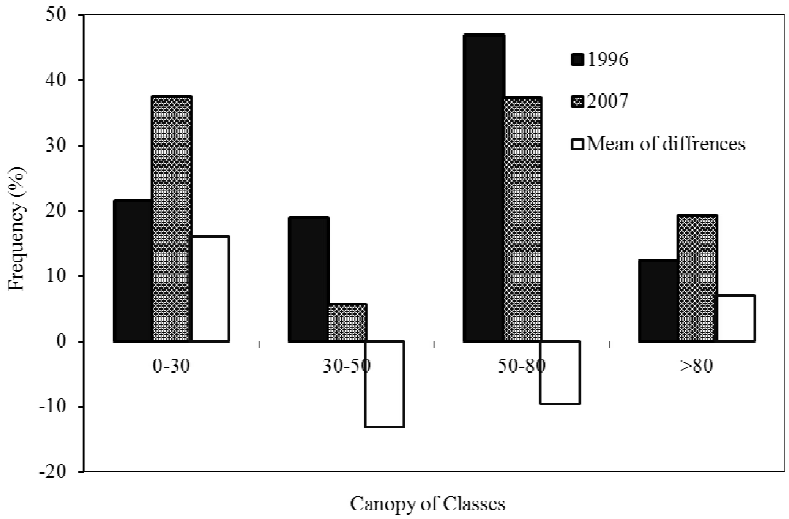

Figure 2. Comparison of the percentage of Golestan province forests area based on canopy classes

Comparison of the Percentage of forests Area Based on Forest Type

In the inventory conducted in the year 2007, the status of Golestan Province forests was assessed in two classes of production and non-production (rehabilitation, protection, and conservation) forests, while in 1996, the classification was based on production and conservation forests. The results indicate that the area of the province's forests, based on forest type, is different in the two sampling periods, namely the area of production and conservation forests shows a decrease in 2007 inventory (Fig.2). It should be noted that the statistical analysis of data from the inventory of the year 1996 was only based on the data obtained from production forests while in 2007, the analysis was based on production and non-production (rehabilitation, conservation, and protection) forests. Figure 2 reveals that over the recent 11 years, the area of rehabilitation and protection forests has increased by 26.99% and 23.06%, respectively; however,

production forests have undergone a remarkable decrease (38.56%). It also shows that the area of protection and conservation forests has had a positive and upward trend considering the classification of the forest type in 2007.

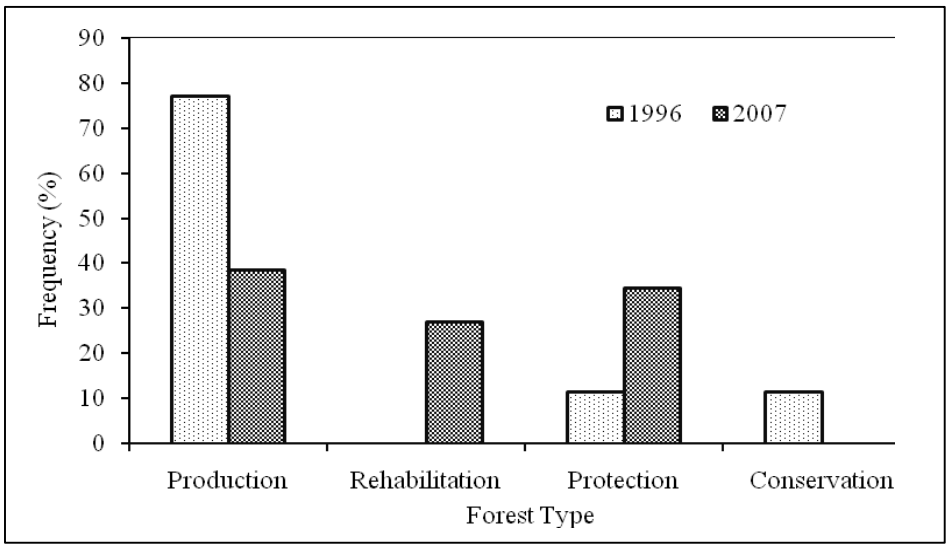

Figure 3. Comparison of the percentage of Golestan province forests area based on forest type

Table 2 shows the area of Golestan province forests based on forest form during the 11-year sampling period. As observed, the area of high stand and high and coppice stand forests have respectively, decreased by 18.83% and 10.50% at the end of the sampling period, whereas, the area of coppice stand forest has had a substantial increase in 2007 (29.33%).

Table 2. Comparison of the percentage of Golestan province forests area based on forest form

Forest Type	1996	2007	Mean of differences
High Stand	57.33	38.5	-18.83
High and Coppice Stand	37.5	27	-10.5
Coppice Stand	5.17	34.5	+29.33

Comparison of Standing Volume and Number of Trees per Hectare Based on Species and Diameter Classes

Table 3 shows the number and volume per hectare of standing trees based on Golestan province forests tree species in an 11-year sampling period. The results indicate that through the recent 11 years, contrary to Juniper and Italian cypress, tree species and specifically hornbeam, oak, velvet maple, and beech have decreased in terms of the total number (53.9 $n.ha^{-1}$) and volume (104.9m^3ha^{-1}). Based on the results presented in Table 3, over the 11-year sampling period, the highest decrease in number (28.43 $n.ha^{-1}$) and volume (44.83 m^3ha^{-1}) belongs to hornbeam, whereas in the same period, the highest increase in number and volume per hectare pertains to Italian cypress. The number of hornbeam, oak, ironwood, and beech is in order of 28.43, 12.78, 9.10, and 2.54$n.ha^{-1}$ showing that the tree stems have undergone a frequency decrease at the end of the sampling period compared to that in the beginning (Table 3).

Table 3. Comparison of number and standing volume per hectare of trees based on species

Species name	$N.ha^{-1}$			Volume ($M^3.ha^{-1}$)		
	1996	2007	Mean of differences	1996	2007	Mean of differences
Fagus oreintalis	10.11	7.57	-2.54	24.21	19.04	-5.17
Carpinus betulus	69.95	41.52	-28.43	112.76	69.93	-44.83
Quercus castaneifolia	34.52	21.74	-12.78	49.5	26.72	-22.7
Alnus subcordata	2.83	2.68	-0.15	11.5	5.75	-5.7
Acer velutinum	4.75	2.7	-2.05	17.46	5.93	-11.53
Acer cappadocicum	2.76	2.64	-0.14	4.23	2.82	-1.43
Tilia platyphyllos	3.41	1.61	-1.8	13.8	6.65	-7.1
Ulmus glabra	2.34	0.95	-1.39	1.08	0.63	-0.46
Diospyros lotus	2.95	2.06	-0.89	14.66	7.65	-7.01
Parrotia Persica	26.11	16.17	-9.94	0.97	0.31	-0.66
Juniperus Spp	4.6	2.46	-2.13	0.61	0.98	0.38
Cupressus horizontalis	0.74	8.18	7.44	0.14	0.92	0.78
Other Species	7.48	8.83	0.86	4.52	5.14	0.62
Total	172.5	118.6	-53.9	255.4	150.5	-104.9

Figure 4 shows distribution in diameter classes of Golestan Province forest trees. As observed, the highest variation in number per hectare has occurred in thin diameter classes (15-35cm). In diameter classes of 15, 45, 55, 80 and 90, the number per hectare has increased, while in the other diameter classes, the number per hectare of the trees has decreased. As for the volume distribution per hectare of diameter classes, the variations are in a sinusoidal shape such that compared to the beginning of the sampling period, at the end of the given period, an increase in

volume per hectare is observed in diameter classes of 20-25, 45-55, 80, and 90-100cm. However, in other diameter classes, the volume per hectare of trees has decreased at the end of the sampling period compared to that in the beginning (Figure 5).

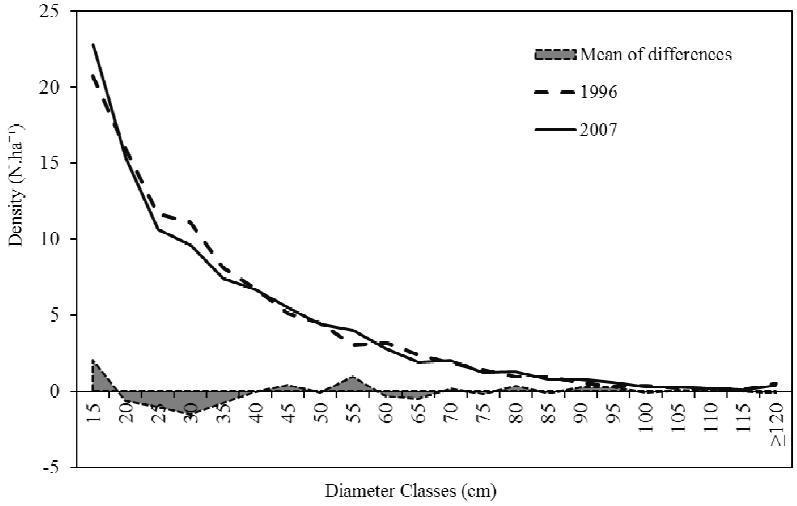

Figure 4. Distribution of Number of trees in DBH classes of the main species in Golestan Province forests in two sampling periods of 1996 and 2007

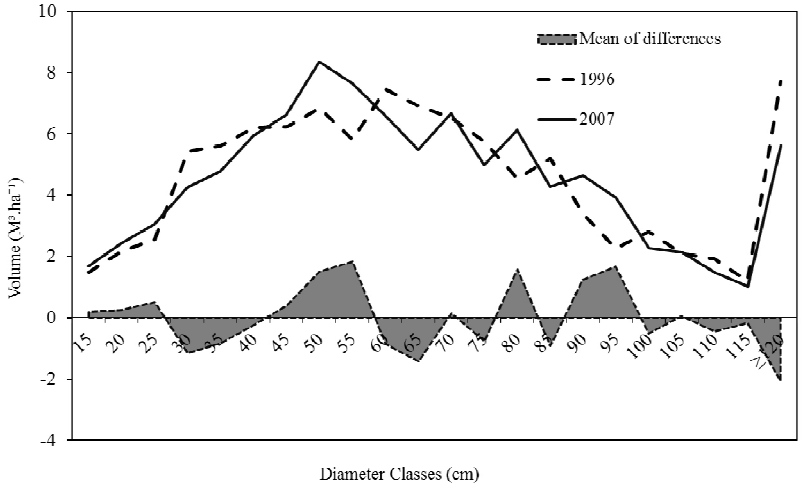

Figure 5. Volume distribution in DBH classes for the main species in Golestan province forests in two sampling periods of 1996 and 2007

Comparison of Dead Wood Characteristics in Golestan Province Forests in an 11-Year Period

We also studied the total number of deadwood including standing and fallen dead wood. The cause of having dead wood is mostly the old age of trees, fire, pests and diseases, and in some cases flood. The results obtained from the present research indicate that hornbeam species comprised the highest number per hectare of dead wood in the beginning and end of the period such that in the whole Golestan Province forests, the mentioned number is 0.7 (Fig.5). Figure 6 reveals that the number per hectare of oak, alder, and ironwood dead wood in the beginning of 1996 period is larger than that of the end of 2007 sampling period, while for beech, hornbeam, and date plum, the given number at the end of the period is larger than that of the beginning. The results also indicate that number per hectare of elm and maple dead wood is only observed in the inventory carried out in the year 1996 and and in 2007 there is no dead wood of such species (Fig. 5). As seen in Figure 6, volume distribution per hectare of dead wood is varied among the tree species of Golestan Province forests such that hornbeam has the highest value of dead wood volume per hectare in both 1996 and 2007 inventories. In contrast, date plum has the least value of dead wood volume per hectare. The results, show that compared to the beginning of the sampling period, dead wood volume per hectare of beech, hornbeam, chestnut-leaved oak, and Siberian elm has increased at the end of the mentioned period, whereas dead wood volume per hectare of the other species has remained constant throughout the period. Deadwood volume per hectare of maple, alder, and elm species can only be observed in 1996 (Figure 7).

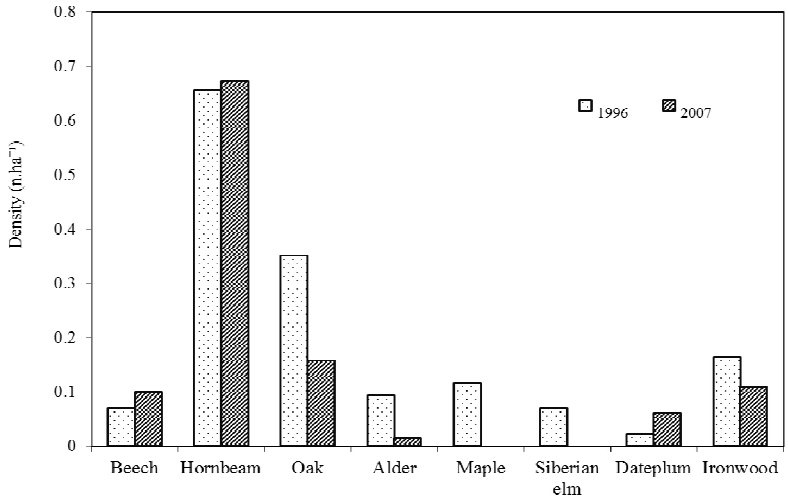

Figure 6. Changes in the density of dead wood from 1996 to 2007 in the Golestan province Forests

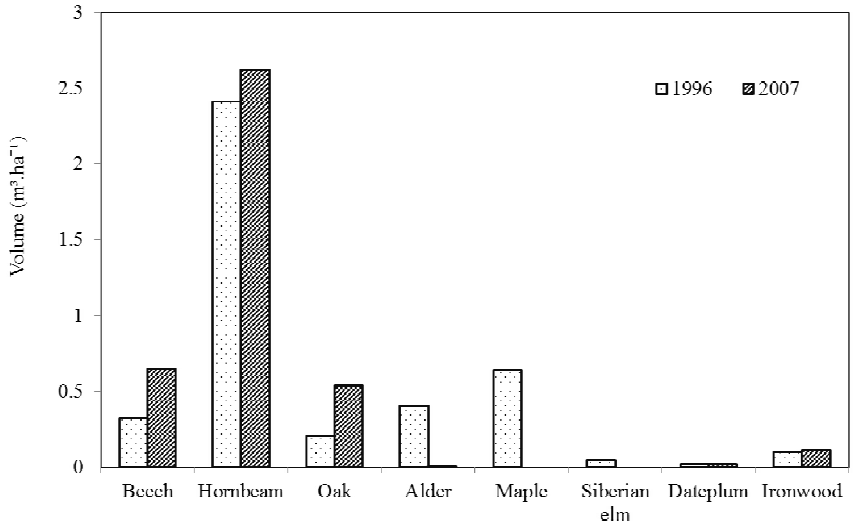

Figure 7. Changes in the volume of dead wood from 1996 to 2007 in the Golestan Province Forests

Regeneration Condition of Golestan Province Forests in an 11-Year Sampling Period

Since the regeneration data of Golestan province forest was not measured at the beginning sampling period of 1996, the regeneration data measured in 2007 inventory was employed. The regeneration data of species was categorized in four vegetation stages of seedling, sapling, thicket, and pole in two coppice and high stand forest forms. As observed in Table 6, the highest frequency of species regeneration is in seedling vegetation stage in which hornbeam, Cappadocia maple, oak, and beech have the highest frequency of regeneration in high stand forest form, while the highest frequency of seedlings in coppice stand form belongs to ironwood species (530n.ha^{-1}). Also, beech, alder, elm, ash, wild cherry, Italian cypress, and date plum exhibited no seedling regeneration in high stand forest form. In other vegetation stages (sapling, thicket, and pole), beech, hornbeam, and oak hold the highest number per hectare of regeneration in high stand forest form. Among other species, Ironwood has the highest number per hectare in coppice stand forest form (Table 6). Also, the results indicate that hornbeam has the largest number of regeneration in high stand forest form. In coppice stand forest form, ironwood with a sum of 1059 sprouts per hectare has the highest frequency of regeneration. As a whole, it can be said that the highest and lowest frequency of regeneration in Golestan Province forests belongs to hornbeam (broad-leaved tree) and yew (needle-leaved tree), respectively.

Table 6. Structural characteristics of regeneration of main species in the Golestan Province Forest

Species	Vegetation Stages									
	Sapling (>.5m tall)		Seedling (0.5-1.30m tall)		Thicket(>10 cm DBH)		Pole stage (10-12cm, DBH)		Total	
	High stand	Coppice	High stand	Coppice	High stand	Coppice	High stand	Coppice	High stand	Coppice
Beech	649	0	159	1	39	0	15	3	862	4
Hornbeam	1063	4	165	9	45	2	19	1	1293	15
chestnut-leaved oak	532	15	51	6	21	0	26	0	631	22
Alder	2	0	2	0	0	0	0	0	4	0
Velvet maple	776	2	77	0	17	0	18	0	888	2
Cappadocia Maple	663	4	101	11	16	1	15	0	795	16
Lime tree	93	24	10	0	2	0	0	0	106	24
Mountain elm	7	0	4	0	2	0	1	0	14	0
Ash	6	0	0	0	0	0	0	0	6	0
Siberian elm	101	31	18	0	5	0	3	0	128	31
Wild service	38	0	18	0	17	0	1	0	74	0
Wild Cherry	4	0	2	0	1	0	0	0	7	0
Caspian honey locust	4	4	0	10	0	0	0	0	4	14
Date plum	201	0	102	6	12	3	2	0	318	10
Persian silk tree	4	4	0	0	0	0	0	0	4	4
Hyrcanian maple	2	6	5	0	0	0	1	0	7	6
Hornbeam spp	32	40	55	61	6	23	2	20	95	144
Caucasian walnut	104	0	6	2	2	0	0	0	111	2
Yew	0	0	0	0	0	0	1	0	1	0
Hyrcanian pear	0	0	0	2	2	2	0	0	2	2
Iron wood	105	530	86	345	21	128	6	56	217	1059
juniper	1	7	0	6	0	6	0	6	1	26
Italian cypress	0	0	2	0	7	0	10	0	19	0
Caucasian Oak	6	2	3	0	0	1	0	0	9	3
Caucasian hackberry	2	0	1	0	0	0	0	0	3	0
Total	4396	673	867	459	215	165	120	86	5597	1384

Discussion

Forest ecosystems are one of the most vital natural blessings that have served human beings since very early centuries. Having been quantitatively and qualitatively degraded due to population growth, extension of civilizations, conversion of forest to agricultural land, development of industries and cities, grazing, and fire, forests are also being increasingly exposed to the recent generation's interventions which highly threaten the existence of natural forests in near future.

This paper reports variation in some structural characteristics of Golestan province forests in an 11-year period. Today, it is advised to implement the different guidelines of forest ecosystems management based on comprehension of the natural disturbances and human interventions affecting on forest management, and thus minimizing the ecological differences between managed and unmanaged natural forests (Angres *et al.*, 2005). Information about the composition of tree species in forest ecosystems helps in prediction of the type and abundance of the

species, the importance of species for silivcultural operation, and the future status of stands. As observed, the composition of tree species in Golestan Province forests has undergone significant changes through the given sampling period such that compared to the beginning of the sampling period (1996), the frequency of endemic and exotic planted species increased at the end of the period (2007). The frequency of the industrially valuable species namely beech, oak, alder, and hornbeam decreased at the end of the given period. One of the reasons behind the reduction of frequency in these species lies in the excessive utilization of the forest management plans implemented for the last 50 years in this area. Esteghamat (2000), Suh and Lee (1998), Webb and Sah (2002), Patto (2007), Angres *et al.* (2005) and Amiri *et al.* (2008) reported that compared to natural stands, combination of the dominant tree species in utilized stands exhibited some changes such that in most cases, the endemic and dominant species were replaced by the undesirable forest floor herbal species.

The results of this research were based on the differences of plot number and structural characteristics of the stands in Golestan Province forests over the past 11-year periods, and in particular the sampling periods of 1997 to 2007. The total number of plots was 1018 in 1996, while the same figure reached 1114 in 2007. At the beginning of the sampling period (1996), the statistical analysis was carried out on the basis of production forests, whereas in 2007 inventory, Golestan Province forests were classified as production and non-production. The number of plots in production forests was 427 in 1996, but this figure reduced to 401 in 2007 (the forests of Golestan Province national park were not sampled in 2007 inventory). Data analysis revealed that the total area of production forests, rangelands, and empty spots in forests decreased in 2007 compared to the year 1996. In contrast, as observed in Table 1, the total area of shrub lands and protection and conservation forests has increased.

Amiri *et al.* (2009) indicated that in the studied stands of Loveh oak forest (Golestan Province), the density and canopy of trees have had major role in the formation and thus future status of a forest. Density is, on the one hand, an influential factor in the assessment and prediction of forest status (Patto, 2007), and on the other, an effective aid for the overall assessment of the site's natural status, and canopy structure. The role of canopy cover in forest is very important in terms of hydrology, forest floor, soil conservation and erosion, and the occurrence of runoffs. The results of the present study exhibited that the area of forests having 0–30% canopy crowns has increased by 16.23% by the end of the studied sampling period (i.e. reaching from 21.47% in 1996 to 37.54% in 2007). The mentioned increase in the forest area is considered as a positive point with regards to soil conservation, reduction of soil erosion, and increased reserves in forest floor soil. The area of forests having >80% canopy has increased at the end of the sampling period. Overall, compared to 1996, the area of Golestan Province forests having

30-80% canopy decreased by 22.99% in 2007. It should be noted that a major part of utilization from forest management plans has been implemented within the above-mentioned canopy crown range. Compared to the beginning of the sampling period (1996), the ratio of high stand, and high and coppice stand forests reduced by 19.23% at the end of the sampling period (2007), whereas the area of coppice stand forests increased by 29.33% at the end of the same period indicating a significant reduction of quality in Golestan Province forests which degraded from uneven-aged high stand form to uneven-aged high and coppice stand form.

Comparative sampling analysis of the results derived from the two overall inventories from Golestan Province forests revealed that in terms of number and volume per hectare, the tree species reduced by $54.27 n.ha^{-1}$ and $104.91 m^3/ha^{-1}$, respectively. During the sampling period, the mentioned reduction was more considerable in species such as horn beam, maple, and beech, compared to others'. In contrast, since Juniper and Italian cypress were not logged and were more importantly considered as protection and conservation species, these species experienced an increase in number and volume per hectare. This point adds to the role of these valuable species as forest reserves. It should be, however, mentioned that the number and volume per hectare of Juniper and Italian cypress did not show an increase in all the diameter classes. As observed in Table 3 and Figures 5 and 6, the volume per hectare of the above-mentioned tree species show an increase in diameter classes of 15-25, 45, and rarely 120cm, while considering number per hectare, Juniper and Italian cypress exhibit a reduction in the same diameter classes through the sampling period. Concerning the percentage distribution of tree number and volume in varied diameter classes, the structure of the studied forests presents sinusoidal variations over the 11-year sampling period. In this regard, the results indicate that the percentage distribution of trees volume in diameter classes increase for beech, horn beam, and iron wood, while the other species including oak, alder, velvet maple, and lime exhibit a reduction in volume percentage over the same sampling period. Regarding density in diameter classes of 15-30 and >85cm, the percentage distribution of trees number per hectare increase at the end of the studied sampling period (2007) compared to that in the beginning (1996). Comparing the two performed inventories, the mean number per hectare reduces from 172.5 to 118.6 stems. Etemad *et al.* (2013) reported that trees number per hectare reduced in a 10-year period (1983-1992), being more noticeable in low diameter classes. In other diameter classes, in spite of higher utilization, trees number per hectare increased. Factors affecting trees number per hectare could be listed as follows: lack of thick enough saplings given the measurement standards, intra- and inter-species competition, wind fall, uprooting, pests and diseases, grazing, and road construction.

In terms of the quantitative and qualitative condition of forest regeneration, the frequency of existing saplings in Golestan province forests is varied. As the results

indicate, the frequency of seedlings and saplings <130cm in height, shows the highest rate of regeneration amongst the other vegetation stages. In seedling vegetation stage, for high stand forest form, hornbeam (1063 stems) and velvet maple (776stems) and for coppice stand forest form, iron wood (530stems) have the highest frequency of regeneration amongst the whole tree species existing in Golestan Province forests, and as for the other vegetation stages (both high and coppice stand), beech, hornbeam, chestnut-leaved oak, ironwood, date plum, alder, and Cappadocia maple exhibit the highest frequency of regeneration.

Conclusion

Since the existing broad-leaf species comprise the highest proportion of Golestan Province forests with regard to number and volume per hectare, the higher frequency percentage of the recorded species is not expected. Generally, it can be suggested that the quantitative and qualitative variations of Golestan Province forests have been significantly considerable over the 11-year sampling period. It is; however, estimated that quantitative and qualitative structural status of these forests will undergo far less variations in future through the shift of Hyrcanian forests management system from shelter-wood system to selection and close to nature systems, and as well the decrease in harvest volume of forest wood products.

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