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A quantitative study of pollarding process in silvopastoral systems of Northern Zagros, Iran

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Abstract

Aim of study: This research attempts to quantitatively describe the pollarding process in the northern Zagros, western Iran.

Material and methods: An inventory of all trees was conducted in three representative stands in the pollarded section (DBH ≥ 5 cm): DBH, total height, trunk height and crown diameters were measured. At the time of pollarding, 10% of the foliage stacks were randomly selected and weighed. The positions of each store tree (*i.e.* special trees capable of enduring the weight of a certain number of leafy branches (average 600 kg)) and horizontal distance of pollarded trees associated with each store tree was recorded.

Main results: The number and weight of foliage stacks resulting from pollarding of each tree correlated (0.48 and 0.43, respectively) with their crown diameter. The average dry weight of leaf biomass was 1,525.6 ±108.1 kg/ha and there was a significant difference between the selected stands. The average pollarded area and the average number of trees in the pollarded area of each store tree was 501.1±210.4 m^2 and 9.4±3.5 trees, respectively.

Research highlights: The number of pollarded trees associated with each store tree and the weight of stored foliage stacks on them are determined by the distance between pollarded trees and store trees, the number of trees around the store trees and the ability of selected store trees to bear the weight of foliage stacks.

Additional keywords: forest-grazing; oak; pollarding; tree fodder

Abbreviations used: DBH (diameter at breast height); FRWO (The Iran's Forests, Range & Watershed Organization).

Authors´ contributions: Conceived and designed the experiments: LG and HG. Performed the experiments: LG, LK and HG. Analyzed the data: LG, LK, HG and FP. Contributed reagents/materials/analysis tools: LG, FP and HG. Wrote the paper: LG, LK and FP.

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Introduction

Pollarding for providing tree fodder for livestock and/or wood for fuel or other uses is an ancient practice (Smith *et al.*, 2012). Pollarding was common in non-Mediterranean Europe, *i.e.*, Pyrenees, Alps and Basque country (Read, 2006). This tree management system is still found in Greece, Crete and Sicily (Eichhorn *et al.*, 2006). Harvesting of multi-purpose tree species to feed livestock has been reported in Asia (Thakur & Thakur, 2007; Rawat & Everson, 2013), Africa (Alemu *et al.*, 2013; Berhe & Tanga, 2013; Franzel *et al.*, 2014; Geta *et al.*, 2014; Guyassa *et al.*, 2014), South America (Argentina, Chile and Southern Brazil) (Peri *et al.*, 2016), and in USA (Burner *et al.*, 2006). Pollarding of oak trees (*i.e. Quercus libani* Oliv., *Q. infectoria* Oliv. and *Q. brantii* Lindl.), as a form of traditional forest management, has a long history (about 4000 years) that coincides with the development of traditional animal husbandry in the northern Zagros, western Iran (Fattahi, 1997). In the recent past this practice was conducted in west Azerbaijan and Kurdistan provinces (west of Iran) which always caused conflict between local people and the Iran's Forests, Range & Watershed Organization (FRWO). At the present time pollarding has been abandoned in Azerbaijan province and forests around Marivan city in Kurdistan province. It is conducted only in forests around of Baneh city in Kurdistan province where it is still an important practice and it is transferred from father to son without any change. In the forests of Baneh pollarding is supported by a fruitful traditional knowledge package which recently certified as a cultural heritage in Iran (Anonymous, 2005).

The Zagros forests of western Iran have an approximate area of 5.5 million ha (FRWO, 2015). In addition to having high ecological value, these forests have socio-economic significance as they provide subsistence needs for local residents: they supply forage for feeding livestock in winter and provide non-wood products such as oak acorns, oak galls and resin extracted from *Pistacia atlantica* trees. Based on the distribution of oak species, the Zagros forests are divided into the northern Zagros (the range of *Quercus infectoria* combined with one or both species of *Quercus libani* and *Quercus brantii*) and the southern Zagros (*Q. brantii* is the main tree species). The main occupation of local residents in the northern Zagros is animal husbandry; therefore, they highly rely on the forest to collect forage for their livestock (goat and sheep) and have developed a special form of traditional management for this purpose (Fattahi, 1997; Jazirehi & Ebrahimi Rastaghi, 2003). In the common local forestry in the northern Zagros, each rural household customarily owns an area of up to 40 ha of forest land (Ghazanfari *et al.*, 2003). Local foresters divide their stands into three sections with different areas but with equal annual fodder production. Pollarding is performed annually and sequentially with one section cut each year on a three-year rotation (*i.e.* a section having oak trees with three-year-old branches). After pollarding, the leafy branches of oak trees (Fig. 1a) are stacked together and fastened with a long twig (Fig. 1b). The foliage stacks are stored on special trees (store tree, hereafter) (Fig. 1c). Leafy branches are extracted from a store tree in winter to feed livestock (especially goat and sheep).

The results of previous studies assessing the impact of pollarding in northern Zagros indicate a negative effect of this practice on biometric indices of oak trees (DBH, total height, trunk height, crown area, crown vitality and health), species diversity, seed and coppice regenerations, and stand density (the tree number and basal area per hectare) (Shakeri *et al.*, 2009; Ghahramany *et al.*, 2012; Ranjbar *et al.*, 2012; Valipour *et al.*, 2014) and a positive effect on diameter increment of *Q. libani* and *Q. infectoria* (Ghahramany *et al.*, 2016; Rostami Jalilian *et al.*, 2016).

The biomass of different tree parts has been examined in many studies (Pinkard *et al.*, 1999; Basuki *et al.*, 2009; Schmidt *et al.*, 2009; Ruiz-Peinado *et al.*, 2012; Beedy *et al.*, 2016). A review of previous studies on pollarded stands indicates that there has been limited research on leaf biomass (*i.e.* the most important non-wood product of pollarded forest stands in the northern Zagros). They also show that there is a lack of information about production potential, the amount of harvestable tree fodder and quantitative description of the pollarding process in the traditional management system. This study aims to quantitatively describe the common traditional pollarding process in the northern Zagros forests, western Iran. Therefore, we analyzed the pollarding process in order to collect information necessary to identify the weaknesses and strengths of this system. The specific questions in this research were: (1) do the biometric indices of pollarded trees predict the number and weight of harvested foliage stacks from them?; (2) is there a correlation between size of store trees and fresh weight of foliage stacks stored on them?; (3) is there a correlation between tree size and the amount of leaf biomass (tree fodder) harvested from it?; and (4) are there significant differences among pollarded stands in the studied indices?

Material and methods

Study area

The study area (35°50'58" to 35°53'08" northern latitude and 45°48'58" to 46°54'03" eastern longitude) is located at the northwest of Kurdistan province in northern Zagros, western Iran. This region has an average elevation of 1,550 m above sea level

Figure 1. Pollarded tree (a), foliage stacks resulting from pollarding (b), piled foliage stacks on store tree (c). Photo by: L. Khedri. Western Iran, northern Zagros, Kurdistan province

with an area of about 50,000 ha covered with forest (Anonymous, 2005). *Q. libani*, *Q. infectoria* and *Q. brantii* are the main tree species in these forests. In the study area, the oak trees have coppice origin. The study area has a Mediterranean climate with 7-year mean annual rainfall and temperature of 647 mm and 11.4°C, respectively (Valipour *et al.*, 2014).

Based on the latest declaration (2017) of Statistical Center of Iran (https://www.amar.org.ir/english), the current population of the study area (*i.e.* Baneh city) is 158,690 people. The urban and rural populations are 115,325 and 43,365 people, respectively. Forest, rangeland and agricultural lands cover 66.2% (*i.e.* 87,400 ha), 11.7% (*i.e.* 15,455), and 22% (*i.e.* 29000 ha) of the total land area, respectively.

In the study area due to lack of fertile agricultural soils, difficult topography and agricultural water shortages, livelihood of local communities in current underdeveloped conditions is very dependent on livestock. In this region animal husbandry strongly depends on local woody food sources due to deficiency of rangeland management. Goat is the main livestock species and the main food source is tree fodder from oak trees. As there is no nomad way of life in the area, the current husbandry system has caused the shortage of fodder, especially in the cold season. Therefore local people rely highly on the forest to collect forage for their livestock feeding. In the last two decades people's livelihoods has changed. Trade with Iraq has increased and therefor local people are involved in business across borders. As the result, the rural population in the area has decreased due to migration to the cities around the region (Anonymous, 2005).

Methods

After explaining the objectives of the research to customary owners of pollarded stands (land managers) and carefully evaluating the forest stands, three pollarded stands were selected for this study (Table 1). Data were collected from selected stands in two stages. In the first stage, before pollarding (in August 2014), the locations and boundaries of the stands and their sections were separately determined using a GPS device GARMIN 78 S (accuracy: ±10 m). An inventory of all trees (DBH ≥ 5 cm) was conducted in the section to be pollarded (*i.e.* the section containing oak trees with three-year-old branches) of each stand: DBH (using caliper), total and trunk heights (using clinometers Suunto PM-5) and crown diameters in two perpendicular directions (using measuring tape) were measured. In the second stage of data collection (early September 2014), at the time of pollarding by land managers, the total number of harvested foliage stacks and pollarded trees were counted and 10% of the foliage stacks of each pollarded tree were selected randomly and weighed using a digital scale (20 g accuracy). The positions of each store tree and all pollarded trees whose foliage stacks were stored on each store tree were recorded using GPS. Horizontal distance of trees belonging to the nearest store tree was measured.

Table 1. Main characteristics of studied stands

Characteristics	Stand No.		
	S1	S2	S3
Area, ha	2.3	1.0	1.0
Slope, %	19	22	25
Altitude (m.a.s.l.)	1751	1720	1733
Aspect	East	East	East
DBH ± SD, cm	31.1±9.3	31.2±10.1	33.4±10.6
Total height ± SD, m	5.8±1.5	5.5±1.4	5.2±1.2
Trunk height ± SD, m	1.7±0.3	1.6±0.2	1.6±0.4
Crown height ± SD, m	4.1±1.4	3.8±1.3	3.7±1.2
Crown area ± SD, m^2	12.6±9.6	7.9±6.2	8.2±5.7

SD: standard deviation

Data analysis

Dry weight of the foliage stacks (branch and leaf biomass) piled on each store tree was calculated by multiplying fresh weight of the foliage stacks by coefficient of 0.64 (Khosravi, 2010). Dry weight of the foliage stacks piled on each store tree was multiplied by coefficient of 0.23 (Khosravi, 2010) to calculate the dry weight of the leaf biomass (tree fodder) stored on it.

The maps of pollarded area (*i.e.* the area of pollarded stand in which harvested foliage stacks are stored on the store trees) for each store tree in each pollarded stand were separately drawn using ArcGIS 9.3.

To test for normality in the distribution of data we used Kolmogorov–Smirnov test (Lilliefors, 1967). Correlation among number and fresh weight of harvested foliage stacks from each pollarded tree and biometric indices of pollarded trees and correlation between size of store trees and fresh weight of foliage stacks stored on them was evaluated by Pearson correlation coefficient. Number and fresh weight of harvested foliage stacks resulting from pollarding of each tree were compared using the Kruskal-Wallis and Mann-Whitney U tests. Fresh weight of a foliage stack, number and fresh weight of harvested foliage stacks in diameter classes, DBH and total height of store trees, fresh weight of foliage stacks piled on each store tree were compared using a single-way ANOVA and post hoc Tukey test. Differences for fresh weight per foliage stack and leaf biomass (tree fodder) among studied stands and tree size (diameter classes) were compared using a factorial ANOVA. All statistical analyses were performed by SPSS16 and Microsoft Excel 2007.

Results

Main characteristics of studied pollarded stands

The main tree species in the studied stands were *Q. libani* (in all stands pooled: 63.1% and 63% on the basis of tree number and basal area per hectare, respectively) and *Q. infectoria* (32.5% and 33.7% on the basis of tree number and basal area per hectare, respectively). The fraction of companion species (*Q. brantii, Pyrus* spp. and *Pistacia atlantica*) was 4.4% and 3.3% of the all studied stands based on tree number and basal area per hectare, respectively. The majority of trees (in all stands pooled: 81.1%) belong to the diameter class of 17.5-42.5 cm. The average number of trees in the first, second and third stands was 142, 157 and 144 trees/ha and the basal area was 11.9, 13.2 and 13.4 m^2/ha, respectively. Table 1 presents the main characteristics of the studied stands.

Quantitative description of pollarding process

The number of pollarded oak trees per hectare in the first, second and third studied stands were 61, 61 and 57, respectively. Number and fresh weight of harvested foliage stacks and dry weight of tree fodder versus diameter classes are presented in Table 2. The average fresh weight of a foliage stack in the first, second and third stands were 6.2, 5.8 and 7.0 kg, respectively (Table 3). The results of factorial ANOVA comparing fresh weight of a foliage stack indicated that differences among stands were significant ($F_{(2,238)}$=7.035; p<0.01) (Fig. 2), but there was no distinction in fresh weight of a foliage stack in diameter classes ($F_{(2,238)}$=1.957; p=0.568), and the interaction between diameter classes and stands was not significant ($F_{(2,238)}$=3.145; p=0.224).

The average number of foliage stacks resulting from pollarding of each tree in the first, second and third stands were 11.1, 9.7 and 8.1, respectively (Table 3). There was a significant difference among the studied stands in this index (χ^2 =31.055; p<0.01). The results of the Mann-Whitney U test comparing the number of foliage stacks from each tree are presented in Table 4. The results of ANOVA comparing number of

Table 2. Number and fresh weight of harvested foliage stacks and dry weight of tree fodder versus diameter classes in studied stands (S1, S2, S3)

Diameter classes (cm)	Number of harvested foliage stacks per tree			Fresh weight of harvested foliage stacks (kg/tree)			Dry weight of tree fodder (kg/ha)		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
17.5	8	7.5	4.3	47.6	43.1	38.6	35.8	39.6	63.1
22.5	9.7	10.5	5.1	59.4	74.9	30.2	279.7	275.8	86.5
27.5	10.1	11	6.4	63.3	49.7	45.9	453.4	137.1	262.9
32.5	11.8	9.9	6.5	77.2	58.4	46.1	479.9	295.6	188.3
37.5	10.8	9.1	6.6	71.4	49.5	51.3	255.6	410.1	104.9
42.5	14.3	11.1	8.7	89.9	64.5	61.2	203.2	296.9	350.4
47.5	13.6	8.7	12.3	73.0	45.0	78.4	137.6	124.3	96.2
Total	78.3	67.8	49.9	481.8	385.1	351.7	1845.2	1579.3	1152.3

Table 3. Summary statistics of tree fodder (leaf biomass) in the studied stands

Indices	Mean ± SE		
	S1	S2	S3
Fresh weight of foliage stack (kg)	6.2±0.1	5.8±0.2	7.0±0.2
Number of harvested foliage stacks from each tree	11.1±0.4	9.7±0.6	8.1±0.8
Fresh weight of harvested foliage stacks from each tree (kg)	70.3±3.3	56.4±4.4	57.3±5.9
Number of store trees (trees)	18	6	5
Number of pollarded trees in pollarded area of each store tree (trees)	8	11	12
Fresh weight of pilled foliage stacks on each store tree (kg)	559.0±40.3	629.6±69.0	710.6±99.5
Number of pilled foliage stacks on each store tree	89.2±5.5	107.5±7.7	100.4±12.3
Dry weight of tree fodder (kg/ha)	1845.2±88.4	1579.3±131.5	1152.3±104.5

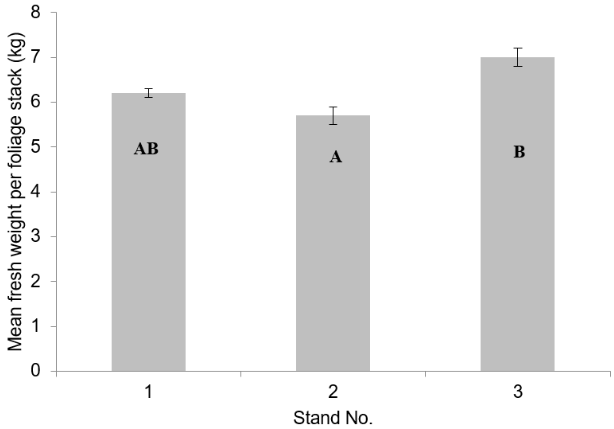

Figure 2. Tukey test comparing fresh weight per foliage stack in studied stands (means with different letters have significant difference at the 5% level.)

harvested foliage stacks in the diameter classes (Table 2) showed that there was no significant difference among them ($F_{(6,14)}$=1.380; *p*=0.289). The number of harvested foliage stacks from each pollarded tree had maximum correlation (0.48) with crown diameter (Table 5).

The average fresh weight of foliage stacks harvested from each pollarded tree in the first, second and third stands were 70.3, 56.4 and 57.3 kg, respectively (Table 3). The results of Kruskal-Wallis test for this comparison indicated that differences among pollarded stands were significant (χ^2 =17.571; *p*<0.01). The results of Mann-Whitney U test for this comparison are presented in Table 4. The results of ANOVA, comparing fresh weight of harvested foliage stacks in the diameter classes (Table 2), indicated that their differences were not significant ($F_{(6, 14)}$=1.135; *p*=0.392). Fresh weight of foliage stacks harvested from each tree has maximum correlation (0.43) with crown diameter (Table 5).

The dry weight of leaf biomass (tree fodder) harvested from the first, second and third stands were 1,845.2, 1,579.3 and 1,152.3 kg/ha, respectively (Table 3). The results of factorial ANOVA comparing tree fodder showed that there was a significant difference among stands ($F_{(2,244)}$=5.682; *p*<0.01); there was a significant difference among diameter classes ($F_{(10,244)}$=2.356; *p*<0.05) and there was a significant interaction among stands and diameter classes ($F_{(15, 244)}$=2.321; *p*<0.01).

Store trees

The number of store trees per hectare (*i.e.* special trees with thick branches at a height of about one meter above ground capable of enduring the weight of a certain number of leafy branches (average 600 kg)) in the first, second and third stands were 7.8, 6 and 5, respectively. The average DBH of store trees in the first, second and third stands were 31.2±8.7, 40.1±7.9 and 33.9±7.2 cm, respectively. Distribution of store tress in diameter classes indicated that most of them (in all stands: 86.2%) have DBH greater than 25 cm (Fig. 3). The average total height of store trees in the first, second and third stands were 6.5±1.4 m, 6.5±1.3 m and 6.6±1.2 m, respectively. There was no significant difference in DBH ($F_{(2,26)}$=2.573; *p*=0.096) and total height ($F_{(2,26)}$= 0.032; *p* =0.968) of store trees between the studied stands. There was a significant

Table 4. Results of Mann-Whitney U test comparing number and fresh weight of harvested foliage stacks from each tree in the studied stands (S1, S2, S3)

Indices	Statistical criterion	S1-S2	S1-S3	S2-S3
Number of harvested foliage stacks from each tree	Z	-0.12	-2.019	-1.639
	p-value	0.905	0.043	0.101
Fresh weight harvested foliage stacks from each tree	Z	-0.863	-2.801	-1.732
	p-value	0.388	0.005	0.083

Table 5. Correlation among number and fresh weight of harvested foliage stacks from each tree and its biometric indices

		DBH (cm)	Total height (m)	Crown height (m)	Crown diameter (m)
Number of foliage stacks harvested from each tree	Pearson correlation	0.25	0.44	0.42	0.48
	p-value (2-tailed)	<0.001	<0.001	<0.001	<0.001
	N	272	272	272	272
Fresh weight of foliage stacks harvested from each tree	Pearson correlation	0.21	0.40	0.38	0.43
	p-value (2-tailed)	<0.001	<0.001	<0.001	<0.001
	N	272	272	272	272

correlation between DBH of store trees and fresh weight of foliage stacks stored on them (r= 0.43; p<0.05).

The summary statistics of the number and fresh weight of foliage stacks stored on each store tree are shown in Table 3. The results of ANOVA showed that there was no significant difference between the number and fresh weight of foliage stacks stored on each store tree in the studied stands ($F_{(2,26)}$=1.584; p=0.224; $F_{(2,26)}$=1.506; p=0.240, respectively).

The mean pollarded area of a store tree in the first, second and third stands were 432.3±189.2, 526.9±188.3 and 717.0±179.9 m^2, respectively. The results of ANOVA showed that there was a significant difference between the pollarded area of store trees in the studied stands ($F_{(2,26)}$=4.605; p<0.05).

The average tree number in the pollarded area of each store tree (*i.e.* the pollarded trees whose foliage stacks are stored on a store tree) in the first, second and third stands was 8, 11 and 12 trees, respectively (Table 3). There was significant difference in tree number in pollarded area of each store tree in the studied stands ($F_{(2,26)}$=5.494; p<0.05). In the first stand, the maximum distance between a store tree and the far end of its pollarded area was 54.7 m. This value was 46.5 m in the second stand and it was 61 m in the third stand.

Discussion

Based on the results, the number of pollarded oak trees per hectare (61, 61 and 57 for the first, second and third stands, respectively) is about half of the number of total trees in the studied pollarded stands. Due to a reduction in the number of livestock and longer periods of livestock grazing on the forest floor because of climate change which has led to milder winters, less fodder is needed to be stored for winter compared to previous years. Moreover, cutting leafy branches of oak trees in summer to daily feed livestock has become more common in recent years because there has been warmer summers and less forage on the forest floor. Another important point is that although customary ownership of pollarded stands is inherited by children, due to the spread of smuggling (*i.e.* the illegal transportation of objects, substances, and goods carried out by rural people across an international border with Iraq) in the study region in recent years, the younger generation is no longer willing to follow the path of its ancestors and, as a result, animal husbandry has declined in the region. Accordingly, pollarding is not nowadays conducted as commonly (Khosravi, 2010).

There was a significant difference in fresh weight of a foliage stack (in all stands pooled the average was 6.3±1.6 kg) among pollarded stands (Table 3), but there was no distinction in this index among diameter classes. The difference in the weight of a foliage stack in the pollarded stands can be attributed to the physical power of the person who prepares the stacks. Previous studies reported that the fresh weight of each foliage stack ranges between 7.5 and 12.5 kg (Azizi Baneh, 2015) and 1.6 - 5.1 kg (Khosravi *et al.*, 2012).

The average number and fresh weight of foliage stacks harvested from each tree in the study area was 10.0±5.6 stacks and 63.9±40.9 kg/tree, respectively. There was a significant difference among the studied stands in average number and weight of foliage stacks resulting from pollarding of each tree, but there was no significant difference among diameter classes (Table 2) in these indices. The number and weight of foliage stacks resulting from pollarding of each tree showed low correlation (0.25 and 0.21, respectively) with their DBH (Table 5). Due to pollarding and periodically harvesting of the tree crown, branches and leaves will not have the same opportunity to grow compared to the diameter and pollarded oak trees have a small crown despite of old age and large DBH (Ranjbar *et al.*, 2012).

There was no significant difference in number and fresh weight of foliage stacks (in all stands pooled the average was 94.8±23.6 stacks and 595.0±176.2 kg, respectively) stored on each store tree in the studied

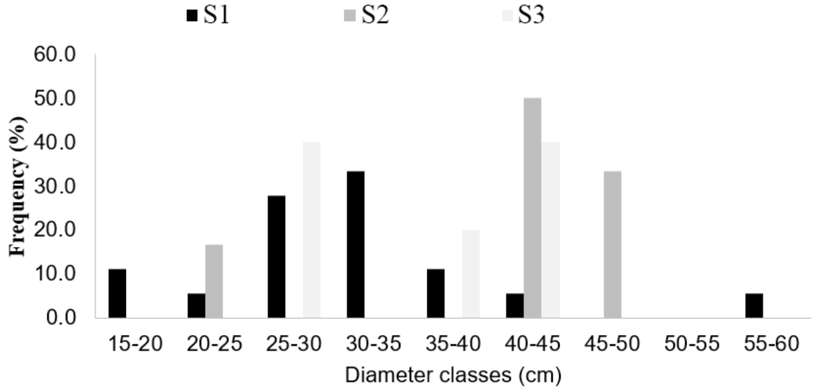

Figure 3. Distribution of store trees in diameter classes in studied stands

stands. In another study the number of foliage stacks piled on each store tree was estimated between 56 and 147 (Khosravi *et al.*, 2012).

The average dry weight of leaf biomass (tree fodder) harvested from the studied stands (with a density of 148 trees/ha) was 1,525.6±108.1 kg/ha. The results showed that there was a significant difference in dry weight of tree fodder among pollarded stands and diameter classes (Table 2). The dry weight of leaf biomass in other pollarded stands (with a density of 552 trees/ha) in the same region as this study was estimated as 2,400 kg/ha (Azizi Baneh, 2015). The dry weight of leaf biomass of *Q. brantii* in Yasouj forests, western Iran was estimated 1,317.3 kg/ha (Adl, 2007) and leaf biomass of *Q. libani* in Zagros forests was reported as 1,000 kg/ha (Khosravi *et al.*, 2012). The variations in these values can be a result of differences in forest density, soil type, forest structure, age and weather conditions (Clark & Clark, 2000; Lehtonen, 2005).

In the studied stands there were 9.7±7.2 store trees to store foliage stacks of pollarded trees. The average DBH and total height of store trees in the studied stands were 33.5±8.8 cm and 6.5±1.3 m, respectively and there was no significant difference in DBH and total height of them. There was a significant correlation between DBH of store trees and fresh weight of foliage stacks stored on them. The store trees are special trees with thick branches at a height of about one meter above ground capable of enduring the weight of a certain number of leafy branches (average 600 kg). The position of each store tree in the stand is determined by customary owners of pollarded stands and is fixed for years.

The average pollarded area per store tree was 501.1±210.4 m^2. The maximum distance between a store tree and the furthest end of its pollarded area was 29.2±2.0 m in the studied stands. The average number of trees in the pollarded area of each store tree was 9.4±3.5 trees. Khosravi *et al.* (2012) estimated the number of pollarded trees associated to each store tree was 27 trees. The number of pollarded trees associated to each store tree and the weight of stored foliage stacks on each store tree are determined by the distance between pollarded trees and the store tree, the number of trees around the store tree and the ability of a store tree to bear the weight of foliage stacks. The pollarded areas of store trees, the number of pollarded trees per hectare and non-pollarded areas in the studied stands indicate that cutting leafy branches of oak trees in summer to daily feed livestock has become more common in recent years. Moreover, cutting leafy branches of *Q. infectoria* and *Q. libani* trees in the non-pollarded areas was also conducted for harvesting of manna (*i.e.* a sweet sap).

Conclusions and future prospects

In this study we are addressing a quantitative description of the pollarding process (*i.e.* the unique forest management system supported by indigenous people) in the northern Zagros, western Iran. Pollarding is the most common practice in the study area and has a long historical background. Pollarding has been formed based on traditional knowledge of customary owners of pollarded stands as local forestry, which always caused conflict between local people and the Iran's Forests, Range & Watershed Organization (FRWO). This practice is also worldwide in many semiarid regions, where livestock farmers depend on tree foliage to overcome the strong seasonality of herbaceous forages.

This study can enhance our understandings about this kind of traditional management. Describing the traditional system of pollarding makes it possible to accurately assess and resolve the potential problems of this system and paves the way for sustainable forest management. While respecting the knowledge of local foresters, the strengths and weaknesses of this traditional management practice should be identified and, along with resolving its weaknesses and reinforcing its strengths, it should be combined with modern silvics knowledge to achieve the objectives of sustainable forestry. In the traditional pollarding with the aim of providing tree fodder, each year the crown area of a section which covers one third of a pollarded stand reduces severely. Although the reduction in crown area is slightly restored in the coming years with the growth of new branches, the crown is pollarded again before complete restoration. As a result, the crown area of oak trees in pollarded stands always undergoes severe fluctuations. The pollarded trees never find the opportunity for complete recovery. Accordingly, the pollarded stands are heavily exposed to risks such as direct radiation of sunlight on the forest floor and soil erosion. Moreover, the lack of regeneration, which threatens the survival of forest, is the main problem of pollarded stands in the study area. Therefore, it is recommended that planting and maintenance of seedlings (by fencing regeneration sites and preventing the entry of livestock into these areas) should be a precondition for local foresters before exploiting the forest in order to ensure forest regeneration in the region.

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