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Effects of livestock exclusion on forest tree regeneration (Case study: Ramsar district 1– Iran)

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ABSTRACT: In order to study the effect of livestock removal on forest regeneration in Ramsar district 1 – Mazandaran Province, compartment 23 of 96 ha in size was selected. The required data were collected for two separate years (2000 and 2009) and compared together. To assess the regeneration abundance, the analysis was carried out in both years using systematic random sampling with the grid dimensions of 150 × 200 m and sample plot of 100 m^2. Within each sample plot, regeneration conditions were categorized in 4 classes: seedling with height less than 1.30 m, diameter at breast height 0–2.5, 2.5–7.5 and 7.5–12.5 cm. Results showed that the regeneration of tree species belonged to *Fagus orientalis*, *Carpinus betulus*, *Acer* spp., *Alnus* spp., *Tilia begonifolia*, *Ulmus glabra* and *Cerasus avium*. The comparison of the obtained results in two years (2000 and 2009) showed that the mean regeneration of all tree species increased in 2009 as it was reflected in all 4 diametric classes. There was a statistically significant difference between the means of tree regeneration abundance in 2000 and 2009 ($P < 0.01$, df = 8, $\chi^2 = 748.661$). Based on obtained results, the removal of livestock from the forest led to a significant increase in the regeneration establishment in a period of 9 years. The increase was more than 110% in 2009. It is concluded that the removal of livestock from the forest and the forest conservation plans are essential in regeneration establishment within the study area.

Keywords: livestock removal; forest regeneration; Ramsar district; diameter classes; forest management plan

Forests and pastures are the most important resources that play important roles in human life. The humans have always been dependent on these renewable natural resources to have a healthy life and obtain their needs such as fuels, water, food etc. The lack of vegetation cover can cause many difficulties for organisms. Improper interventions, illegal cutting and smuggling of woods are the main factors in forest destruction. Moreover, in the last few decades, the presence of livestock and forest dwellers has been the main challenge causing the forest destruction. The numbers of livestock are considered to be higher than the capacity of pastures. Iranian forest dwellers have always been deprived of minimal social services. This possibly leads to destroy the forest and pasture. Based on available data (e.g. Hamedi 2000), the number of animal units (AU) in Iranian forests (north of Iran) is estimated to be 1,381; 12,317 and 9,409 AU for mobile, semi-mobile and stationary livestock, respectively.

There has always been a tendency towards Iranian cattlemen's families to have a regular social structure. In spite of this, this kind of lifestyle is one of the most important dilemmas that have led to the failure of forest management plans. So far, various methods have been developed to tackle this issue but due to the ignorance of social difficulties in implementation of such plans they have not been successful. Moayeri (1988) studied the performance of Golband forest management plan and concluded that the plan had not been successful after ten years. According to Babakordi (1988); Etemad (1994); Shariatnezhad (1999); Asadi Atoii (2000) and Espahbodi and Mohammadnezhad (2000), the forest management plans have not reached their ideal conditions. It seems that the outbreak of regeneration problem would be one of these difficulties. For instance, the study of the quantitative and qualitative status of forest regeneration has demonstrated that the forest regeneration has not been established in district 2 of Gland Rood (Ismaili 1995). Namirannian et al. (2007) showed that one of the main limiting factors of forest regeneration is livestock grazing.

It is well known that livestock can compact soil, exacerbate erosion, consume and trample tree seeds,

seedlings and browse saplings, thereby preventing forest regeneration. Finally, the tree canopy thins out and disappears (Scowcroft 1983; Fleischner 1994; Blackmore, Vitousek 2000; Opperman, Merenlender 2000; Carolina, Javier 2001; Marcial et al. 2001). Grazing by animals can reduce forest productivity through a reduction in seedling growth rate and survival, and by changing the tree form (Wilkinson, Nielsen 1995; Bulinski, McArthur 1999; Miller et al. 2006).

In order to prevent and control the forest destruction by livestock, the plan of livestock removal from northern forests of Iran was proposed by forest, range and watershed management organization and implementation of the plan is still an ongoing process. It seems that the implementation of this plan has been useful to cope with some problems (Ashory Vanghah 2004; Azimi, Amiri Lomar 2008). On the basis of the above-mentioned problems, this paper aims to determine the effect of livestock removal on forest regeneration in Beneshki district 1 (Ramsar-Iran).

METHODS

Study area. The study area is located in Beneshki district 1 (Ramsar – north of Iran). District 1 is surrounded by forest stands of district 2 (Beneshki plan and Nesaroud river). From the east it stretches to the forests of Chalak Roud (district 1) while from the west to Ghalesh Mahaleh and from the south to the summit of Dozd Kooh. The surface area is about 2859 ha which belongs to watershed basin 30 in northern Iranian forests (Forest, Range and Watershed Management Organization 2002).

Parcel 23 (with a total area of 96 ha) was selected for study purposes. The study area (Parcel 23) is located towards the north and north-east. The minimum and maximum altitude is 1,100 and 1,600 m a.s.l., respectively. The common type of parent material is limestone and the soil type is rendzina or brown forest soil. Soil textures mainly consist of loam, clay-loam and clay. Depth of soil ranges from mid-deep to very deep. The soil structure is granular, prismatic and blocky. The type of humus is mull. The percentage of tree species (%) is as follows: *Fagus orientalis* (40%), *Carpinus betulus* (43%), *Alnus* spp. (12%) and other trees species (5%). Standing volumes of the given species are 21, 35, 34 and 10%, respectively (Forest, Range and Watershed Management Organization 2002).

Data collection and exploration. The effect of livestock exclusion on forest stand regeneration was studied in Beneshki district 1. For this purpose the necessary data were collected in two years (2000, 2009) and were then compared together. In order to assess the regeneration abundance, the inventory was carried out in both years using systematic random sampling with the grid dimensions of 150 × 200 m and sample plot of 100 m^2. The regeneration conditions were surveyed within each sample plot (following the species identification) and then classified in 4 classes: seedling of less than 1.30 m in height, diameter at breast height 0–2.5, 2.5–7.5 and 7.5–12.5 cm (Zobeiry 1994). In addition, some other characteristics were evaluated in the sample plot of 0.1 ha (both plots are identical from the centre). This survey was carried out on 32 sample plots with a total surface area of 96 ha. Once the required data were gathered, the effect of livestock exclusion on forest regeneration was analyzed. The chi-square test was used to determine the significance of differences between parameters.

RESULTS

Diametric distribution and standing volume

Fig. 1 shows the distribution of trees diameters in terms of different classes for parcel 23. The mean number of trees is estimated to be 188 in the given parcel. The standing tree volume is 305 sylve (ha) and percentage of tree canopy is estimated to be 70–80%.

Forest regeneration

The mean number of recruits (ha) is 1,647 in 2000 with a significant increase up to 3,480 in 2009. Fig. 2 shows an example of the regeneration establishment (parcel 23) in 2009. The following Figures 3–10 present the obtained results with regard to forest regeneration including total species and individual trees in different diametric classes.

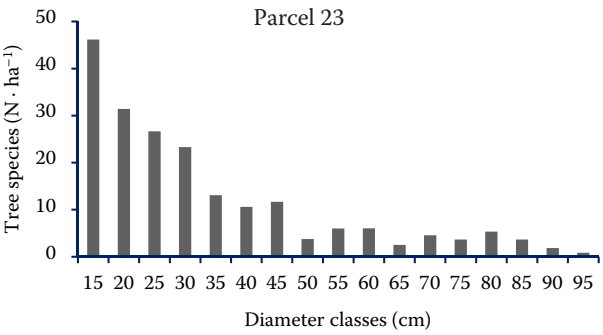

Fig. 1. Tree diametric distribution in different diameter classes

Fig. 2. Establishing the regeneration of parcel 23 in district 1 (Beneshki-Ramsar) in 2009

Regeneration of total trees

Abundance of total tree regeneration (*Fagus orientalis*, *Carpinus betulus*, *Alnus* spp., *Acer velutinum*, *Acer cappadocicum*, *Tilia begonifolia*, *Ulmus glabra*, *Fraxinus excelsior* and *Prunus avium)* in 2000 and 2009 is presented in Fig. 3.

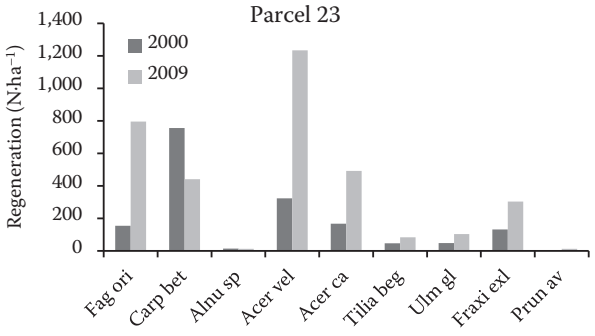

Fig. 3. The mean number of recruits in different tree species

Based on the results, there is a significant difference (at a 0.01 confidence level) between the mean numbers of recruits in the years 2000 and 2009 (df = 8, χ^2 = 748.661). Fig. 4 presents the mean number of total recruits (ha) in different classes in 2000 and 2009.

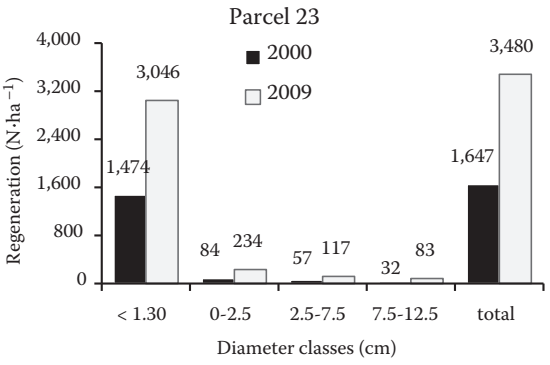

Fig. 4. The mean number of recruits in different diameter classes

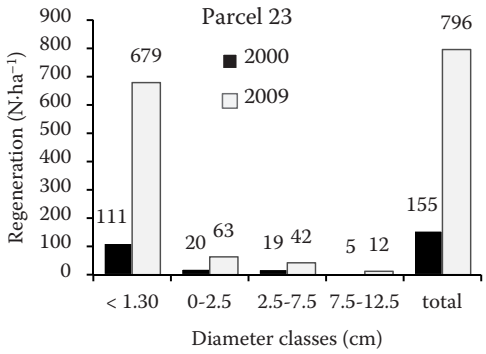

Fig. 5. The mean number of recruits (ha) for *Fagus orientalis* in different classes

The chi-squared test shows a significant difference (at a 0.01 confidence level) between the numbers of total recruits (ha) in different classes in 2000 and 2009 (df = 3, χ^2 = 37.24).

Regeneration conditions for different species

Fig. 5 illustrates the mean number of recruits (ha) for *Fagus orientalis* in different classes in two different years (2000 and 2009). Based on the chi-square test, there is a significant difference (at a 0.01 confidence level) between the mean numbers of recruits (different classes) for *Fagus orientalis* (ha) in 2000 and 2009 (df = 3, χ^2 = 16.70).

In Fig. 6 the mean number of recruits (ha) is presented for *Carpinus betulus* in different classes in 2000 and 2009. The statistical test (chi-square) shows that there is a significant difference (at a 0.05 confidence level) between the mean numbers of recruits (different classes) for *Carpinus betulus* (ha) in 2000 and 2009 (df = 3, χ^2 = 10.694).

Fig. 7 presents the mean number of recruits (ha) for *Acer insigne* in different classes in 2000 and 2009.

According to the chi-squared test, there is a significant difference (at a 0.01 confidence level) between the mean numbers of recruits (different classes) for *Acer insigne* (ha) in 2000 and 2009 (df = 3, χ^2 = 42.848).

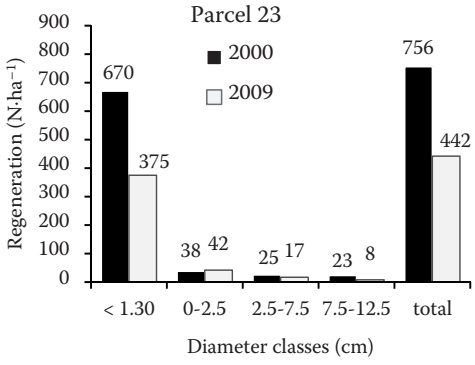

Fig. 6. The mean number of recruits (ha) for *Carpinus betulus* in different diameter classes

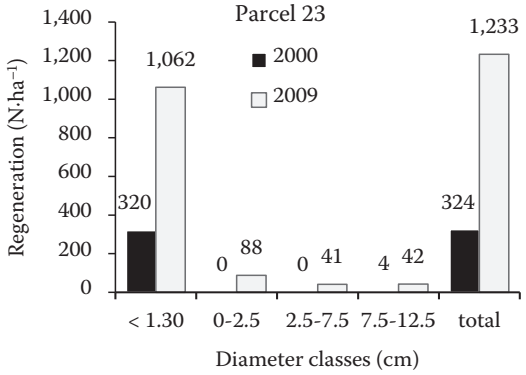

Fig. 7. The mean number of recruits (ha) for *Acer insigne* in different diameter classes

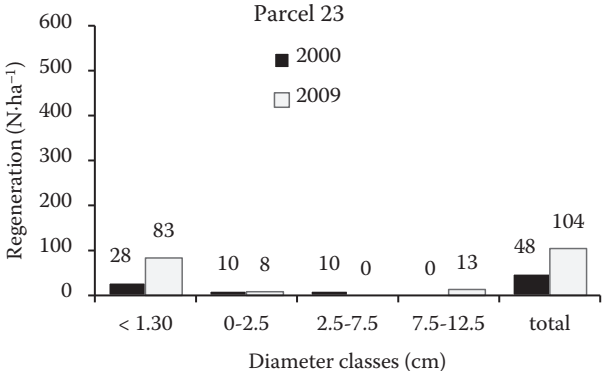

Fig. 9. The mean number of recruits (ha) for *Ulmus glabra* in different classes

In Fig. 8 the mean number of regeneration (ha) is shown for *Acer cappadocicum* in different classes in 2000 and 2009. Here, also the applied statistical test shows that there is a significant difference (at a 0.01 confidence level) between the mean numbers of recruits of different classes for *Acer cappadocicum* (ha) in 2000 and 2009 (df = 3, χ^2 = 13.768).

Fig. 9 presents the mean number of recruits (ha) for *Ulmus glabra* in different classes in the studied period (2000–2009). The chi-squared test shows that there is a significant difference (at a 0.01 confidence level) between the mean numbers of recruits of different classes for *Ulmus glabra* (ha) in 2000 and 2009 (df = 3, χ^2 = 34.530).

Fig. 10 illustrates the mean number of recruits (ha) for other tree species in different classes in 2000 and 2009. Based on the applied test, there is a significant difference (at a 0.05 confidence level) between the mean numbers of recruits of other tree species (ha) in different classes in 2000 and 2009 (df = 3, χ^2 = 10.729).

DISCUSSION AND CONCLUSIONS

The obtained results showed that the given forest is categorized as uneven-aged high forest. The plans implemented for the removal of livestock from the forest demonstrate that there was a significant increase concerning the forest regeneration so that the condition of regeneration was improved at the end of 10 years. By implementation of livestock exclusion, conservation and management plans, the mean forest regeneration of the study area (parcel 23) increased more than 110% from 2000 to 2009 (Fig. 2). This confirms that the removal of livestock from the forest has enhanced forest regeneration. The regeneration condition of different species showed that the number of recruits increased between 2000 and 2009 for most species; probably the main reason for the lower regeneration of *Alnus* spp. *Alnus* spp seems to be a pioneer species so that it is able to grow very rapidly on the border of roads as well as in disordered soils (Meilleur, Bergeron 1992; Horgan et al. 2002; Mataji et al. 2009; Hassanzad Navroodi et al. 2010). We proposed the circular sample plots of 100 m^2 in size to assess the forest regeneration. The obtained results in this regard seemed to work out perfectly. Zobeiry (1994) used the same methods and obtained similar results.

After the plans were successfully implemented in the study area, the rate of regeneration (at a 0.01 confidence level) increased for most tree species: *Fagus orientalis* > 410%, *Acer velutinum* > 280%,

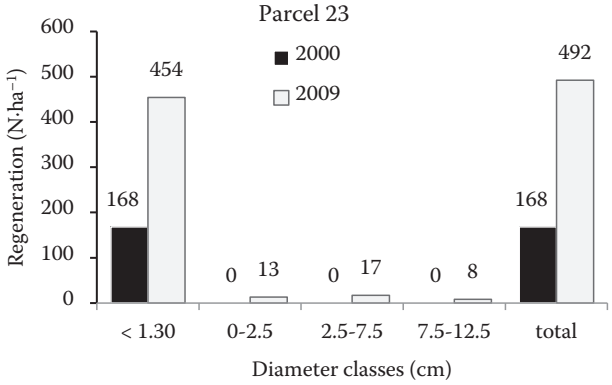

Fig. 8. The mean number of recruits (ha) for *Acer cappadocicum* in different diameter classes

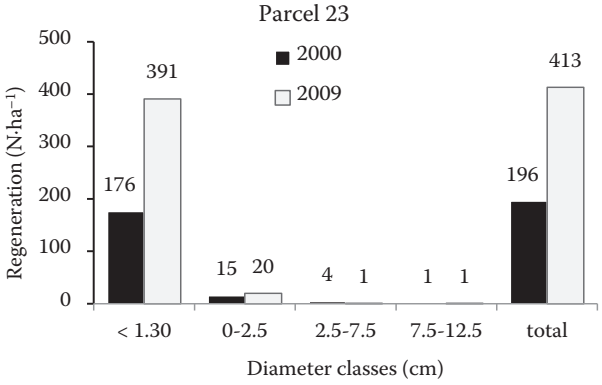

Fig 10. The mean number of recruits (ha) for other tree species in different classes

Acer cappadocicum > 75%, *Ulmus glabra* > 115%, *Fraxinus excelsior* > 130% and *Prunus avium* > 225%. This indicates that the grazing of cattle had a negative effect on tree species regeneration (Shakeri et al. 2009). Namirannian et al. (2007) stated that grazing is the main restrictive factor of regeneration. In 2009, *Fagus orientalis* showed high regeneration (410%) relative to 2000. The successful regeneration of *Fagus orientalis* could be attributed to its habitat where the conditions are suitable for the growth and regeneration of the species. Razavi et al. (2012) demonstrated that the optimal range of altitudes for beech is from 900 m to 1,500 m a.s.l. Hassanzad Navroodi (2001) also showed that the most suitable altitude for the establishment of *Fagus orientalis* would be in the range of 1,000 to 1,200 m a.s.l. During 10 years, the removal of cattle from the forest has shown a considerable increment in the mean number of most recruits (taking into account different tree species and various regeneration classes). The only exception was *Carpinus betulus*, so that the establishment of regeneration has not been favourable for the given species. The mean regeneration abundance ($N \cdot ha^{-1}$) of all species in different diametric classes showed a significant rise in 2009 relative to 2000. Where the height of seedlings was lower than 1.30 m, there was an increase about 100%. When the diametric class lies between 0 and 2.5 cm, there is an increase over 175%. There are increments above 105% and 160% for 2.5–7.5 cm and 7.5–12.5 cm classes, respectively. According to Asadi Atoii (2000), the support of forest regeneration (during 10 years) would be one of the main factors to enhance the species regeneration.

This study also proved that the highest number of recruits (percent per ha) belongs to important species from qualitative and commercial aspects. It seems that this fact is a suitable sign regarding development and improvement of the forest in our study area. As a conclusion, the removal of livestock from the forest (based on a successful implementation) would improve the establishment of tree regeneration. This will in turn guarantee the future of the forest. It also seems that the removal of livestock from the forest as well as the confinement and implementation of conservation plans in the forests play an important role in regeneration establishment in the study area. With the implementation of these plans, the regeneration establishment of all tree species (N/ha) was increased in all diametric classes. We also conclude that in the north Iranian forest and other forests with enough moisture and temperature the removal of obstacles can help the regeneration establishment.

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