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Investigation on the structure of young stands in the mountainous forest of Arasbaran (Northwest Iran)

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Keywords: Young stands; structure; composition; regeneration; mountainous forest; Arasbaran, Iran. FDK 222 : 228 : 568 : (55)

Abstract: The structure of young stands in different forest associations was studied at 134 sample plots in the protected area in the mountainous forest of Arasbaran (Iran). While the most mixed broad-leaved stands showed coppice with standards character, the juniper high stands showed a peculiar structure with trees arranged in clusters.

Abstract: Im Hochland von Arasbaran (Iran) wurde auf 134 Probeflächen in einem Naturschutzgebiet die Struktur von Jungbeständen verschiedener Waldgesellschaften untersucht. Während die meisten Laub- und Mischwaldbestände Mittelwaldcharakter zeigen, weisen die Wacholderbestände eine Rottenstruktur auf.

Introduction

Mountains occupy one-fifth of the world's land surface and large swathes of the upland areas are covered by forests. These forests have local, regional and, in some cases, global values; as centres of biological diversity, as sites for recreation and as stabilizers against land erosion (FAO, 1999). In semi-arid and arid regions these areas also play a crucial role in hydrology, wood production and socio-economical aspects.

For the main part the forests in the mountainous region of Arasbaran, located in East-Azerbaijan (northwest Iran), were managed by rural population for many decades. Moreover, only one management plan using coppice system, started in 1962, has been carried out. These activities have caused some changes in the composition, structure and origin of some parts of the forests. The importance of the biological diversity of the forests in this region led to its being declared a protected area to be managed under the Man and the Biosphere (M.A.B.) programme of the United Nations Educational, Scientific and Cultural Organization (Unesco) in 1972. In order to study the area, an experimental forest station located in Sutanchay was established by the Research Institute of Forests and Rangelands (RIFR) in 1990.

The woody plants of Arasbaran were studied by DJAVANSHIR (1976). EBRAHIMI (1995) carried out studies in this region, based on the phytosociological results of MOBAYEN & TREGOB-OV (1970) and SABETI (1976), and recognised several forest associations mainly formed by oak (*Quercus macranthera* Fisch & Meyer, *Q. petraea* Matt), hornbeam (*Carpinus betulus* L., *C. orientalis* Mill.), maple (*Acer campestre* L., *A. monspesulanum* L.), elm (*Ulmus glabra* Huds.), wild cherry (*Prunus avium* (L.) Moench), ash (*Fraxinus excelsior* L.) and juniper (*Juniperus communis* L., *J. foetidissima* Willd, *J. excelsa* M.B.). The main forest associations are pure oak (*Quercetum*), pure hornbeam (*Carpinetum*), mixed oak-hornbeam (*Quercocarpinetum*), mixed broad-leaved and needle-leaved species.

ALIJANPOUR (1996) studied the quantitative and qualitative characteristics of the old stands in the experimental forest station. His results showed that 2435 ha of this area are densely covered by forest stands; the portion of hornbeam within the old stands is the highest (51%), followed by oak (37%), maple (7%) and other species (5%).

The aim of the present investigation in the experimental forest was to study the structure and composition of young stands in different forest associations and to compare them with previous studies done on the old stands, in order to find relationships between regeneration and the original forest stands. Moreover, in addition to studying the protective func-

tion of the forests in this mountainous region, our goal was to assess whether the quality of the forest stands could be improved by converting coppice stands into coppice with standards and further to high stands.

Materials and methods

Materials

Arasbaran is located 200 km north-east of Tabriz and 8 km south of the border between Iran and Azerbaijan (Russia) at 38°50' North and 46°45' East. The total area of Arasbaran is about 9085 ha, extending between 450 and 2300 m a.s.l.

Annual precipitation varies between 300 mm and 500 mm, mainly as snow in winter. The number of foggy days is high, providing added moisture for the vegetation. The mean annual temperature varies between 14 °C in lower parts and 5 °C in upper parts. The minimum average of temperature in the coldest month of the year is -2 °C and the absolute minimum temperature falls to -34 °C. Following Emberger's classification, the climate is humid and cold (ALIJANPOUR, 1995). The soil type is mainly forest brown soil with a thin layer of humus. Soil texture is sandy and sandy-loam; pH varies between 7 and 8 (KARIMIDOUST, 1989; EBRAHIMI, 1995).

The region is mountainous and about 75% of the area has slopes with a gradient of more than 40%. Table 1 illustrates the proportion of different exposures and slopes in the study area. About 27% of the area is covered with dense and semi-dense forests.

Table 1: Proportion of exposures and slope gradients in the study area.

Tabelle 1: Expositionen und Hangneigungen im Untersuchungsgebiet.

Exposure	N	NE+E	SE+SW	W	NW
%	25	15	8	12	40
Slope (%)	0-20	21-40	41-60	61-80	> 80
%	5	20	50	24	1

Methods

In order to study the structure of the young stands, the experimental forest called Sutanchay with a total area of 2400 ha was selected within the Arasbaran region. 134 main sample plots, each covering a surface of 100 m², were laid-out in the study area. The sampling network was 400 · 450 m. In every sample plot the following characteristics were studied: exposure, slope, altitude, forest type, canopy density, vertical pro-

file of the stand, as well as diameter at breast height (dbh), height and form (coppice or seed origin) of all trees with a diameter of less than 7.5 cm.

Moreover, one small sub-plot, an area of 4 m², was laid out in the center of every main sample plot in order to study some quantitative characteristics of coppice groups. These were: number of shoots per stump, stem base diameter and mean height.

After determining the proportion of tree forms (coppice or seed origin) and according to the results, a classification was carried out after HAMM (1986) for the coppice with standards as following:

- normal coppice with standards;
- coppice with standards, rich of standards in the upper layer;
- coppice with standards, poor of standards in the upper layer (or rich of coppice).

The phytosociological nomenclature in this study is based on the results of MOBAYEN & TREGOBOV (1970) and SABETI (1976), who studied the forest associations in different ecological regions of Iran.

Results

Forest types

Several forest types were identified in the area. According to the different ecological adaptability of species the forest types showed different presence range from lower to upper parts. Oak was widely distributed and juniper ranged from 400 to 1800 m a.s.l., both in mixed or pure stands (figure 1). *Cornus* spp. showed a very narrow distribution area, between 900 and 1000 m a.s.l.

Regeneration

The results showed that the mean density of seedlings and young stems varied between 63.04 ± 7.44 per sample plot (=100 m²). In other words, the density of regeneration varied between 5560 and 7048 per hectare. The percentage of species varied from 32% (hornbeam) to 1% (wild cherry).

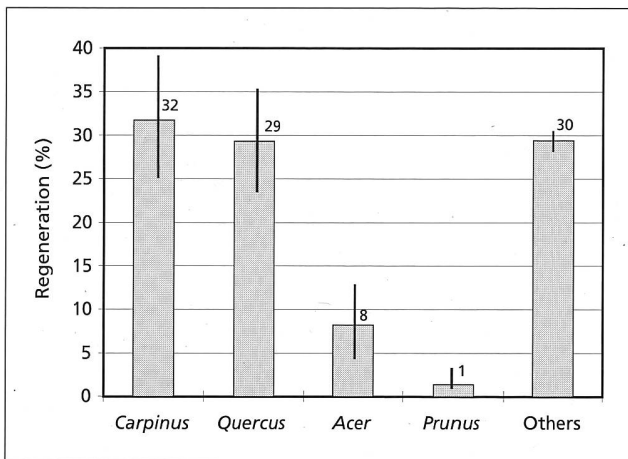


Figure 2: Percentage of regeneration among different species in Arasbaran.

Abbildung 2: Verjüngungsanteile der einzelnen Baumarten in Arasbaran.

Other species including *Fraxinus* spp., *Celtis* spp., *Ulmus* spp., *Prunus* spp., *Juniperus* spp., *Taxus baccata* L. and *Sorbus* spp. made 30% of regeneration (figure 2).

With regard to the form of regeneration, most of the young stems (71%) originated from vegetative propagation (coppice). Young stems originating from seeds accounted for only 29% of the total regeneration (table 2), i.e., only about one-third of total regeneration originated from seed.

Table 2: Frequency of different species in relation to regeneration origin.

Tabelle 2: Häufigkeit der Verjüngungsarten nach Baumarten.

Species	Seed origin		Vegetative (coppice)		Sum	
	n	Freq. (%)	n	Freq. (%)	n	Freq. (%)
Oak	367	14.3	2202	85.7	2569	100
Hornbeam	481	17.3	2296	82.7	2777	100
Wild cherry	102	85.0	17	15.0	120	100
Maple	442	61.8	273	37.2	715	100
Juniper	378	73.9	134	26.1	512	100
Others	1120	43.4	1462	56.6	2582	100
Total	2512	28.7	6251	71.3	8763	100

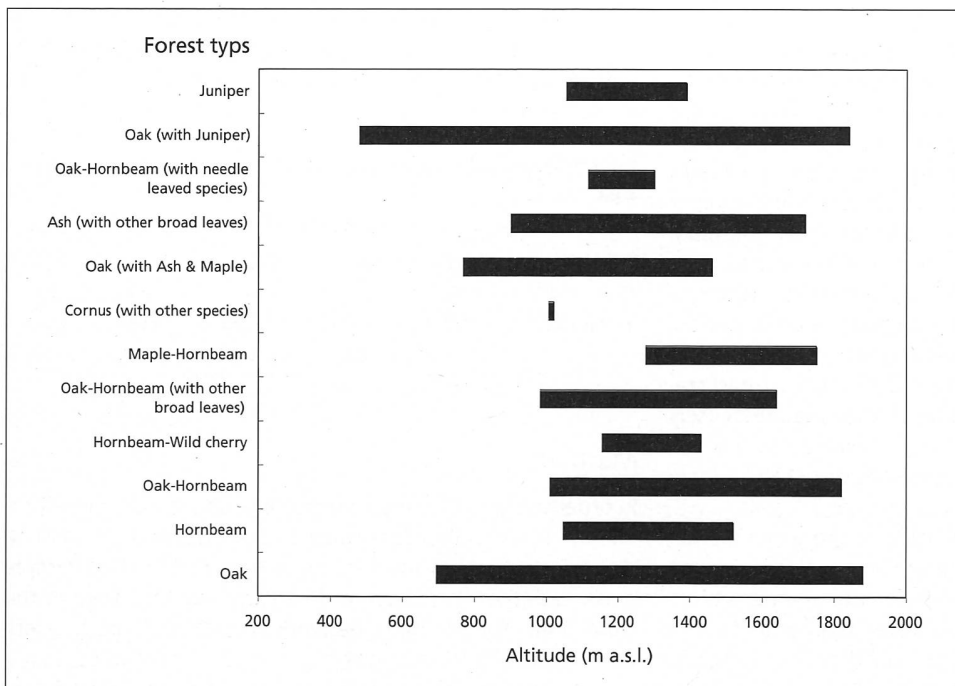


Figure 1: Presence of different forest types in Arasbaran in relation to altitude.

Abbildung 1: Höhenverteilung der verschiedenen Waldtypen.

Description of some main forest types

I) Pure Oak (*Quercetum*)

This forest type covers 15% of the study area, corresponding mainly to the north and north-west and only rarely to the west or south-west exposures. This type is composed of two oak species: *Quercus petraea* Matt, distributed from 650 to 1650 m a.s.l. and *Quercus macranthera* Fisch & Mayer, distributed in colder sites above 1650 m a.s.l. There was a transitional zone between the distribution areas of these two oaks where we found mixed oak stands with other broad-leaved species. Oak stands were mainly one or two-story stands (figure 3). Table 3 illustrates the frequency of oak and other tree species in this forest type. Only 17% of young stems were of seed origin.

II) Pure Hornbeam (*Carpinetum*)

This forest type covers 12% of the study area, corresponding to the exposures with good light conditions, mainly on the north-west and south-west slopes. It was distributed between 1000 and 1500 m a.s.l. This type was also composed of two species: *Carpinus betulus* L. and *C. orientalis* Mill. Table 3 shows the frequency of hornbeam and other species and figure 3 illustrates the structure of this forest type, which is mainly a single story stand. Only 20% of young stems were of seed origin.

III) Mixed oak-hornbeam (*Querco-Carpinetum*)

This forest type covers 27% of the study area, mainly on north-west and west exposures, and is distributed from 1000 to 1800 m a.s.l. Stems originating from young seed account for 26% of the total regeneration. Other species are also found in this forest type (table 3). Figure 4 illustrates the structure of mixed oak-hornbeam forests, which are mainly composed of two-story stands, with oak vegetating in the upper layer and the hornbeam in the under-story.

IV) *Juniperetum*

Various juniper species are distributed between 1000 and 1400 m a.s.l. mainly on north-west, west and south-east exposures. This forest type covers 2% of the study area and was formed by scattered *Juniperus foetidissima* Willd and *J. communis* L. trees. The site conditions for regeneration are relatively hard; however, most of the young seedlings (74%) originated from seed. Only *J. foetidissima* produced coppice shoots and it is interesting that this species is able to regenerate vegetatively. Juniper stands show a one-story mountainous collective structure where trees are arranged in clusters. Table 3 and figure 4 show the frequency of the species and the structure of this forest type.

V) Mixed oak-hornbeam-conifers

This forest type covers 3% of the study area, mainly on north-west and north-east exposures, and is distributed from 1100

to 1300 m a.s.l. Yew (*Taxus baccata* L.) and Juniper (*Juniperus communis* L.) make up 14% of composition in this forest type (table 3). The condition for seed born regeneration is better here than the above-mentioned types which account for about 33% of regeneration. Oak and hornbeam cover the upper layer, while yew and juniper vegetate in the under-story (figure 4).

Frequency of regeneration in relation to exposure and slope gradient

The largest relative frequency of regeneration was observed on north-west (42.1%) and north (22%) exposures and the least relative frequency on south-east and south-west exposures (10%). The relative frequency of regeneration in relationship with slope gradient showed that the highest frequency of regeneration was observed on slopes with 41 to 60% gradient, while the slopes with more than 81% gradient were the poorest slopes (table 4).

Table 4: Relative frequency of regeneration in relationship with exposure and slope gradient in the study area.

Tabelle 4: Relative Häufigkeit der Verjüngung in Abhängigkeit von Exposition und Neigung.

Exposure	N	NE+E	SE+SW	W	NW
Freq. of reg. (%)	21.5	14.8	10.1	11.5	42.1
Gradient (%)	0-20	21-40	41-60	61-80	> 80
Freq. of reg. (%)	8.9	16.8	51.5	22.4	0.4

Quantitative characteristics of coppice sprouts

From 218 studied stumps, 1324 coppice shoots were measured in the whole. On average, each stump produced six shoots (table 5). Among the species studied, hornbeam and oak showed the highest ability to produce coppice shoots with 8.9 and 6.4 shoots, respectively. Wild cherry also showed this ability, but it was the least among the species.

Table 5: Some quantitative characteristics of coppice sprouts among the studied species.

Tabelle 5: Quantitative Charakteristiken von Ausschlagssprosslingen im Untersuchungsgebiet.

Species	Number of stumps	Number of shoots	Mean No. of shoots per stump	Mean height of shoots (m)
Hornbeam	52	462	8.9 ± 3.1*	4.4 ± 0.6*
Oak	86	549	6.4 ± 1.9	3.5 ± 0.5
Ash	26	107	4.1 ± 1.3	3.7 ± 0.8
Maple	20	64	3.2 ± 1.1	4.6 ± 1.1
Wild cherry	6	13	2.2 ± 0.8	1.5 ± 0.9
others**	28	129	4.6 ± 1.3	3.0 ± 1.1
Total	218	1324	6.1 ± 1.1	3.7 ± 0.3

* = Confidence limit in $P \leq 0.05$

** = *Juniperus* spp., *Celtis* sp. and *Cornus* sp.

The mean height of all shoots was 3.7 m (± 0.3 m). Coppice shoots produced by maple were the tallest shoots among the species and those of wild cherry the shortest (table 5).

Forest type	Frequency (%)									Total
	oak	horn-beam	maple	wild cherry	<i>Junip. foet.</i>	<i>Junip. com.</i>	yew	other species		
Pure oak	71.3	6.2	6.8	1.2	–	–	–	14.5	100	
Pure hornbeam	6.3	72.0	2.4	4.0	–	–	–	15.3	100	
Oak-hornbeam	25.8	51.4	4.5	0.4	–	–	–	18.0	100	
Oak-horn.-con.*	30.6	41.1	–	–	–	3.5	10.5	14.3	100	
Juniper	20.3	–	–	–	46.4	33.3	–	–	100	

* = Oak-hornbeam-conifers

Table 3: Frequency of tree species in five main forest types of Arasbaran.
Tabelle 3: Häufigkeit der Baumarten in den fünf wichtigsten Waldtypen in Arasbaran.

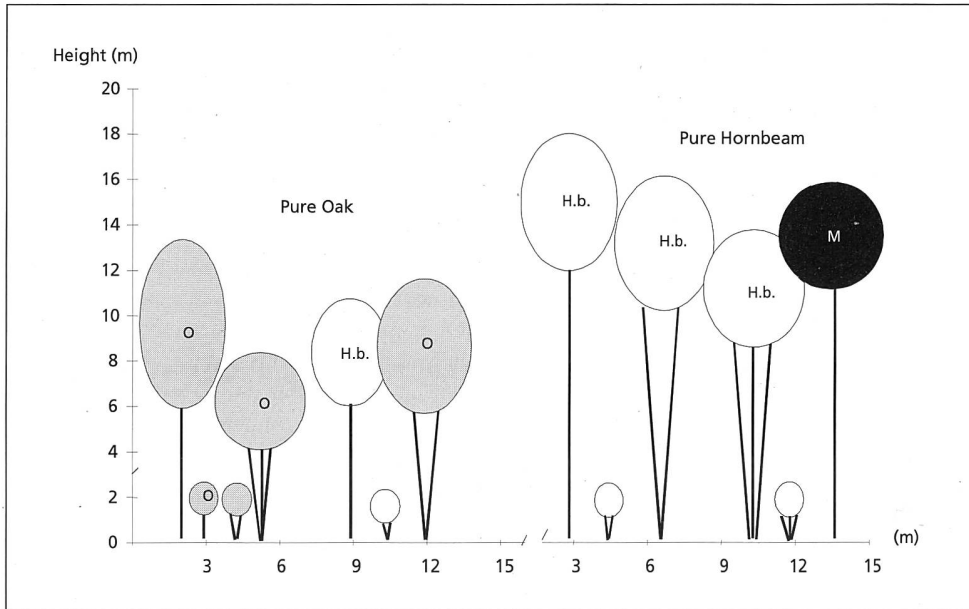


Figure 3: Structure pattern of pure oak and hornbeam stands in Arasbaran (O = Oak, H.b. = Hornbeam, M = Maple).

Abbildung 3: Struktur der reinen Eichen- und Hainbuchenbestände in Arasbaran.

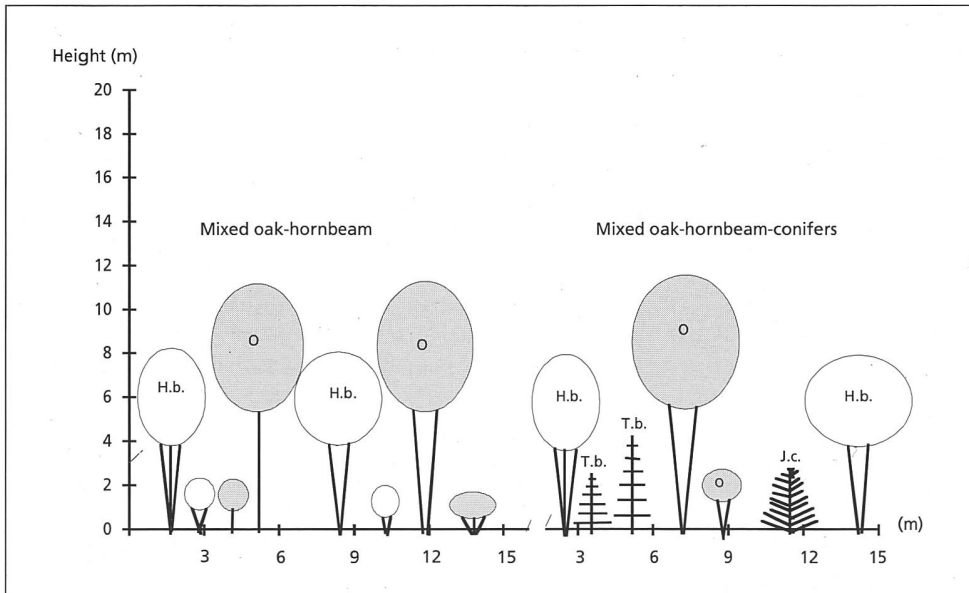
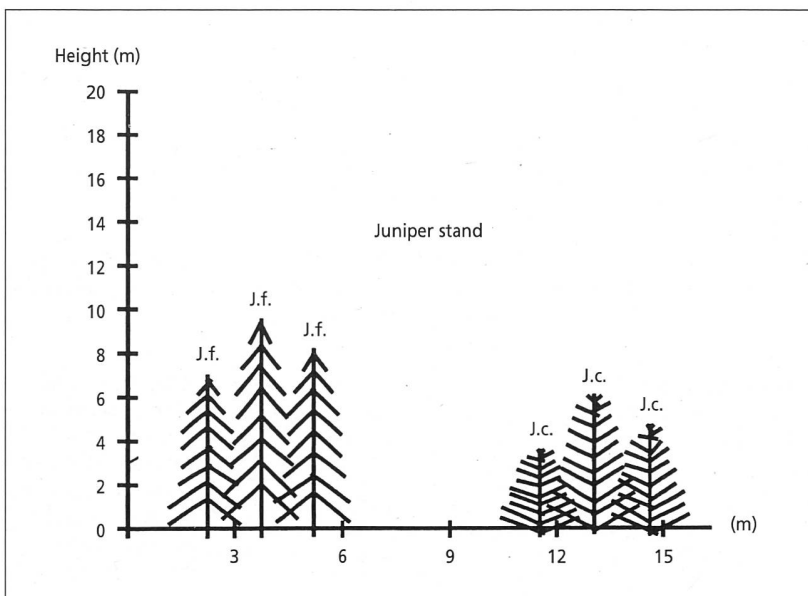


Figure 4: Structure pattern of mixed oak-hornbeam, mixed oak-hornbeam-conifers and juniper stands in Arasbaran (O = Oak, H.b. = Hornbeam, J.f. = *Juniperus foetidissima* Willd, J.c. = *J. communis* L., T.b. = *Taxus baccata* L.).

Abbildung 4: Struktur der Eichen-Hainbuchen-, der Eichen-Hainbuchen-Nadel-Mischbestände sowie der Wacholderbestände in Arasbaran.



The relationship between diameter and height of trees (trees with seed origin as well as coppice shoots) indicated that there is no significant difference in height between standards and coppice individuals in the young stage. The estimated values for coppice shoots were slightly lower than the standards (table 6).

Table 6: Regression model between diameter and height among trees with seed origin and coppice shoots.

Tabelle 6: Zusammenhänge zwischen Durchmesser, Höhe und Verjüngungsart.

Origin of trees	N	Regression model*	R ²	Prob > F
coppice	193	$H_1 = 2.06 \cdot d^{0.65}$	0.62	0.0001
seed (standard)	83	$H_2 = 3.42 \cdot d^{0.6}$	0.76	0.0001

*) H = height, d = diameter at breast height.

Discussion and conclusion

The study of structure and species composition of young stands in Arasbaran shows that hornbeam and oak are the most common species in this region occupying a vast area. They regenerate mainly through vegetative system and build coppice with standard stands which are poor of standards in the upper layer (or rich of coppice).

Comparison of the results of the recent study with the previous investigations carried out by ALIJANPOUR (1996) shows that the proportion of hornbeam and oak is lower in the young stands than the old. In other words, the proportion of these two species is reduced from 51% and 37% in old stands to 32% and 29% in young stands, respectively. In contrast to hornbeam and oak, the proportion of other species is increased in young stands. Maple shows very strong contribution among the species, where the crown canopy is open. However, the proportion of maple may decrease later in old stands (SAGHEB-TALEBI, 1999). These results indicate that forestry operations caused the demise of noble broadleaves, such as wild cherry and maple, and led to a reduction of their presence in old stands.

Moreover, the proportion of coppice shoots was relatively high in the study forest. Lack of mature and seed-trees does not assure regeneration success from seeds. The natural regeneration of noble broadleaves, with the exception of maple, is therefore endangered. In other words, the stands do not regenerate easily. Only on the north and north-west exposures, where snow melts slowly and provides moisture, is natural regeneration successful. On these exposures, soil and seedbed conditions allow a better germination of seeds than on other exposures. This occurs especially where the slopes have a 41 to 60% gradient.

Summary

The structure and composition of some young stands in the mountainous region of Arasbaran were studied and compared with some old stands. Located in East-Azerbaijan (northwest Iran), Arasbaran is a transitional zone with sub-humid climate between the humid Caspian zone to the north and the sub-humid Zagros zone of western Iran.

The forests in this region are protected and formed mainly of oak (*Quercus macranthera* Fisch & Meyer, *Q. petraea* Matt), hornbeam (*Carpinus betulus* L., *C. orientalis* Mill.), maple (*Acer*

campestre L., *A. monspessulanum* L.), elm (*Ulmus glabra* Huds.), wild cherry (*Prunus avium* L.), ash (*Fraxinus excelsior* L.) and juniper (*Juniperus communis* L., *J. foetidissima* Willd., *J. excelsa* M.B.). The main forest associations are pure oak (*Quercetum*), pure hornbeam (*Carpinetum*), mixed oak-hornbeam (*Quercu-Carpinetum*), mixed broad-leaved and needle-leaved species.

In order to study the structure of the young stands, an experimental forest called Sutanchay with a total area of 2400 ha was selected. 134 sample plots were laid out, each covering an area of 100 m², and all the species with less than 7.5 cm dbh were studied.

The results showed that the most frequent regeneration system was coppice with standards. High stands were also identified in some parts of the study area as well as coppice forests in other parts. Only 28% of regeneration was via seed dispersal. In coppice form, each stump produced six stems on average with a mean height of 3.7 m. The ability to produce coppice sprouts was highest among individual oak and hornbeam trees.

The portion of species within the young stands were: hornbeam (32%), oak (29%), maple (8%), wild cherry (1%) and other species (30%). The structure of the study stands was mainly composed of two layers, with standards in the upper layer and coppice sprouts in the under-story. Juniper stands showed a peculiar structure with trees arranged in clusters; these stands do not regenerate easily.

Zusammenfassung

Untersuchungen zur Struktur von Jungbeständen in den Gebirgswäldern von Arasbaran (Nordwest-Iran)

Das Hochland von Arasbaran (Provinz Ost-Aserbaidschan) liegt in einer humiden Übergangszone, die einerseits durch das Kaspische Meer und andererseits durch das humide Klima des Zagros-Gebirges im Westen beeinflusst wird.

In den unter Naturschutz stehenden Wäldern dieser Region kommen Laubbäume wie Eiche (*Quercus macranthera* und *Q. petraea*), Hainbuche (*Carpinus betulus* und *C. orientalis*), Ahorn (*Acer campestre* und *A. monspessulanum*), Ulme (*Ulmus glabra*), Kirschbaum (*Prunus avium*), Esche (*Fraxinus excelsior*), aber auch Nadelbäume wie Wacholder (*Juniperus communis*, *J. foetidissima*, *J. excelsa*) sowie weitere Arten vor. Die dominierenden Waldgesellschaften von Arasbaran sind Eichen- und Hainbuchenwälder. Daneben sind auch Mischwälder wie Eichen-Hainbuchenwälder oder Laub-Nadel-Mischwälder häufig vertreten.

Das ausgewählte Untersuchungsgebiet umfasst eine Gesamtfläche von 2400 ha. Es wurden 134 Probeflächen von je 100 m² angelegt und alle Arten mit einem BHD kleiner als 7,5 cm untersucht.

Die Ergebnisse wiesen den Mittelwald als Grundform der Waldbestände aus. Ausserdem gibt es in geringerem Anteil Hoch- und Niederwälder. Nur 28,7% der Sprösslinge haben sich aus Samen entwickelt, der Rest stammt aus Stockausschlägen. Jeder Stock produziert im Durchschnitt sechs Stockausschläge, welche eine Höhe von $3,7 \pm 0,3$ m erreichen können. Unter den ausschlagsfähigen Arten sind Eichen und Hainbuchen am häufigsten.

Die Waldbestände sind zweischichtig, wobei sich die Kernwüchse in der Oberschicht und die Stockausschläge in der Unterschicht befinden. Die Wacholderbestände zeigen in vielen Teilen des Untersuchungsgebietes eine Rottenstruktur und stehen im Kollektiv dicht nebeneinander. Die freien Flächen zwischen den Rotten sind aus edaphischen und anthropogenen Gründen ohne Verjüngung.

Résumé

Étude de la structure de jeunes peuplements dans les forêts de montagne de l' Arasbaran (Nord-Ouest iranien)

La structure et la composition de jeunes peuplements de la région montagneuse de l'Arasbaran ont été étudiées et comparées avec celles de vieux peuplements (DHP > 7,5 cm). L'Arasbaran est situé dans l'Est de l'Azerbaïdjan (Nord-Ouest iranien) et se trouve dans une zone de transition sub-humide influencée d'une part par la mer Caspienne au nord et d'autre part par le climat sub-humide de la chaîne montagneuse du Zagros à l'ouest.

Les forêts de cette région, mises sous protection, sont constituées surtout de chênes (*Quercus macranthera* Fisch & Meyer, *Q. petraea* Matt), de charmes (*Carpinus betulus* L., *C. orientalis* Mill.), d'érables (*Acer campestre* L., *A. monspessulanum* L.), d'ormes (*Ulmus glabra* Huds.), de merisiers (*Prunus avium* L.), de frênes (*Fraxinus excelsior* L.) et de genévriers (*Juniperus communis* L., *J. foetidissima* Willd, *J. excelsa* M.B.). Les associations végétales dominantes sont les chênaies (*Quercetum*) et les charmaies pures (*Carpinetum*), ainsi que les chênaies à charme (*Quercu-Carpinetum*), le reste étant des associations de feuillus et de résineux mixtes.

Une forêt expérimentale appelée Sutanchay et d'une superficie de 2400 ha a été sélectionnée pour mener l'étude. Un relevé de toutes les tiges avec un DHP inférieur à 7,5 cm a été effectué dans 134 surfaces d'essais d'une superficie de 100 m² chacune.

Les résultats montrent que le système de régénération le plus fréquent est celui du taillis sous futaie. Des futaies et des taillis ont aussi été identifiés. Seul 28% de la régénération est issue de semence. En ce qui concerne le taillis, chaque souche produit une moyenne de six rejets qui atteignent une hauteur de 3,7 m en moyenne. Les chênes et les charmes présentent la meilleure capacité à rejeter.

Les jeunes peuplements sont composés de charmes (32%), de chênes (29%), d'érables (8%) et de merisiers (1%) (autres essences: 30%). Deux strates forment les peuplements: la strate inférieure constituée de rejets de souches et la strate supérieure composée de francs-pieds. Les peuplements de genévriers sont formés de collectifs entre lesquels la régénération naturelle a de la peine à s'installer.

Traduction: CHRISTIAN ROSSET

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