EVALUATION OF THE INFLUENCE OF DENDROMETRIC AND ECOLOGICAL FACTORS ON THE NATURAL REGENERATION OF "*CEDRUS ATLANTICA* MANNETTI." IN AIN ANTAR FOREST, ALGERIA

Mourad Bared[1] and Mohamed Berrichi[2]
[1]Laboratory of Conservatory Management of Water, Soil and Forests.
[2]Department of Forest Resources, Faculty of Nature and Life and Earth Sciences and the Universe, University of Tlemcen, Algeria.
Corresponding Author: Mohamed Berrichi
berrichi_mohamed@yahoo.fr

(Received 17 July 2017 – Accepted 11 January 2018)

ABSTRACT

Bared, Mourad and Mohamed Berrichi. 2018. Evaluation of the influence of dendrometric and ecological factors on the natural regeneration of "C*edrus atlantica* mannetti" In Ain Antar forest, Algeria. Lebanese Science Journal, 19(1): 85-94.

This study aims to evaluate the effect of dendrometric and ecological factors on the natural regeneration of the Atlas cedar "Cedrus atlantica Mannetti" in Ain Antar forest, Algeria. This study was carried out in 14 circular plots of 500 m^2 area. In order to quantify the seedling classes, six sub-plots of 1 m^2 were installed in each plot. The results of the dendrometric data showed the presence of a "Gaussian distribution" with a dominance of fruiting diameters (37.5 and 57.5 cm). The results of ecological parameters revealed that in high altitudes, above 1300 m, natural regeneration seemed to be relatively difficult (30% compared to low and medium altitudes). On slopes greater than 30%, seedlings of less than one year old were less present (20 % compared to the seven first plots). The role of the vegetation cover (40– 0%), the litter cover (30–40%) and of the soil depth (shallow and deep) appeared to favor the survival of seedlings, especially when they were still young. The correlation analysis indicated that the different seedling classes became less numerous when altitude, slope and basal area increased.

Keywords: Natural regeneration, seedling classes, Atlas cedar, Ain Antar forest.

INTRODUCTION

The *cedrus* genus is located in three distinct regions in North Africa and Asia, and composed of four species: *Cedrus atlantica* Manetti, *Cedrus libani* A. Rich, *Cedrus brevifolia* Henry and *Cedrus Deodara* G. Don (M'hirit, 1994; Toth, 2005). The Atlas cedar is a forest species endemic to the North African mountains. In Morocco, cedar forests are exposed to moisture-laden west winds and cover 132,000 ha. Algerian cedar forests cover 32,000 ha, occupying two different climatic zones: the Saharan Atlas zone, which is characterized by the most severe climatic conditions and is subject to Saharan influences and the zone of Atlas tellien, with a particularly favorable climate, located near the sea (Derridj, 1990; M'hirit, 1994; Quezel, 1998).

Compared to its longevity and early fruiting that appears from 15-20 years, natural regeneration or seedling cycle of the Atlas cedar is subject to strict environmental constraints; determined by the requirements of the species vis-a-vis water, soil and cold (Toth, 1980; Illoul et *al*., 2004; krouchi et *al*., 2004). Hinesley et *al*. (1994) and Jull and Blazich (2000) reported the inability of Atlas cedar to compete on dry sites. Drought is an important factor in seedling

http://dx.doi.org/10.22453/LSJ-019.1.085-094

mortality. Three or four wet years not interspersed with dry years are necessary for an adequate regeneration (Dalling et *al*., 1998; Ezzahiri & Belgazi, 2000; Delissio & Primack, 2003). The influence of the soil is important when the climate is dry. Lepoutre (1963) and Gross (1990) and Ezzahiri and Belgazi (2000) noted that deep soil and below the litter, is moist. The germination of the cedar seed is more important if it is placed at a temperature of 4 °C and kept moist (Malki, 1992). Navarro-Cerrillo et *al*. (2013) noted that in the Middle Atlas cedar in Morocco, the forest structure and regeneration dynamics are related to the level of stand perturbation, such as management practices, pasture, fire and climate change.

By the uncontrolled effect of man, combined with the dieback and the action of some diseases and pests, this spectacular specimen tree is exposed to a continuous degradation, which could compromise its existence in some sites of its natural range (Khemici, 2001; krouchi et *al*., 2004; Bentouati & Bariteau, 2006; Talbi & Bouhraoua, 2015). For the above-mentioned reasons, in 2013 the International Union of Nature Conservation has considered changing the status of Atlas cedar as a species of "minor concern" to "endangered".

The objective of this study is to analyze the effect of ecological parameters (altitude, slope, soil depth, litter cover and vegetation cover) on the natural regeneration of the Atlas cedar, considering their dendrometric parameters: tree height, diameter and basal area. For this purpose, the Atlas cedar forest of Ain Antar located in the Ouarsenis Mountains of Algeria was selected for this study.

MATERIALS AND METHODS

Study area

The study area "Atlas cedar forest" is located in Ain Antar municipality at 6 km northwest of Bordj Bounaama. This cedar forest is situated in the northern slope of the Ouarsenis mountain in the Atlas tellien. It covers 502.5 ha. Its geographical coordinates are 35º 53' 26" in latitude North and 01º 40' 14'' in longitude East.

The climate characteristics of the Ain Antar cedar are: semi-arid bioclimatic stage with fresh variant, maximum and minimum average temperatures recorded between 2000 and 2015 are respectively 31.42 ° C in July and 1.06 ° C in January, annual rainfall average of 586 mm, and 10 weeks snow cover between November and March, with an average of 22.1 days/year.

Plant diversity of the cedar forest of Ain Antar consists of the following species: *Pinus halpensis* Mill. *; Quercus ilex* L.*; Cupressus sempervirens* L.*; Juniperus oxycèdrus L.; Genista tricuspidata* Desf.*; Calycotome spinose* L. *; Ampelodesma mauritanica* Poir. *; Crataegus monogyna* Jacq.

Ain Antar's cedar forest does not show symptoms caused by insects and/or fungal diseases. Pasture is practiced there at low and medium altitudes. This forest is also characterized by the absence of silvicultural activities and illicit harvesting of wood.

Design and data collection

Seedlings installation is evaluated by counting seedlings of less than one year and those more over one year old. In the case of seedlings older than one year, there are two classes: the class of seedlings with a height less than 50 cm and the class of installed seedlings with a height between 50 and 150 cm.

We have installed 14 plots of 500 m^2 according to the different altitude levels (1000-1600 m). The centers of each plot were spaced by 50 m. In order to inventory the seedling classes, six subplots of 1m^2 were installed in each plot (Figure 1). Figure 2 illustrates the categories of seedlings that were inventoried in the subplots.

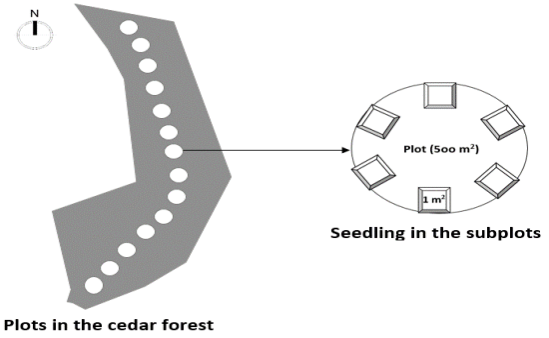

Figure 1. Schematic representation of experimental design used to inventory seedlings classes.

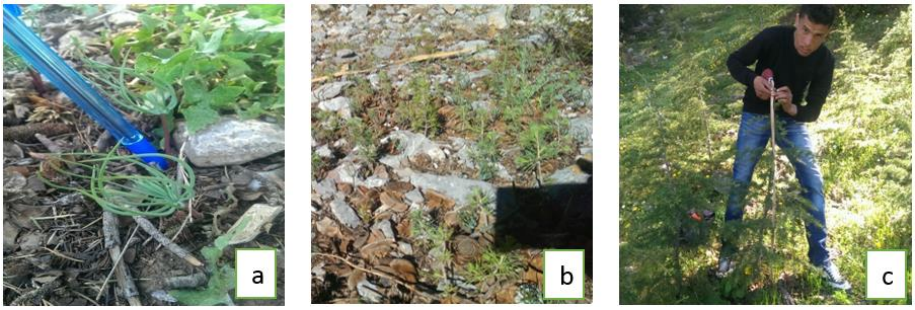

Figure 2. Categories of Atlas cedar seedlings in the subplots.
A= seedlings < 1 year, **b=** seedlings > 1 year (< 50 cm), **c=** seedlings > 1 year (50-150 cm).

RESULTS

Ecological parameters

Table 1 and Figure 3 illustrate the synthesis of the ecological parameters of the 14 plots of the Atlas cedar.

Table 1. Ecological Parameters of Atlas cedar (AIN ANTAR forest - Algeria) in different 14 plots.

Ecological Parameters	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Altitude (m)	1178	1182	1188	1191	1199	1207	1225	1303	1350	1412	1428	1481	1512	1555
Exposure	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Slope (%)	20	18	20	21	30	39	59	61	60	60	61	62	62	64
Soil depth	D	D	D	S	D	D	D	**S**	S	S	Sp	Sp	Sp	Sp
Litter cover (%)	> 40	> 40	> 40	> 40	>30	> 30	> 30	≤ 30	≤ 30	≤ 20	≤ 20	20-40	≤ 20	≤ 20
Vegetative cover (%)	25	25	35	35	50	65	70	75	70	50	35	25	25	30
Sanitary state	H	H	H	H	H	H	H	H	H	H	H	H	H	H
Pasture	+	+	+	+	+	+	+	+	+	-	-	-	-	-

N= North**, D=** Deep, **S=** Shallow, **Sp=** Superficial, **H=** healthy, **+=** absence, **- =** presence.

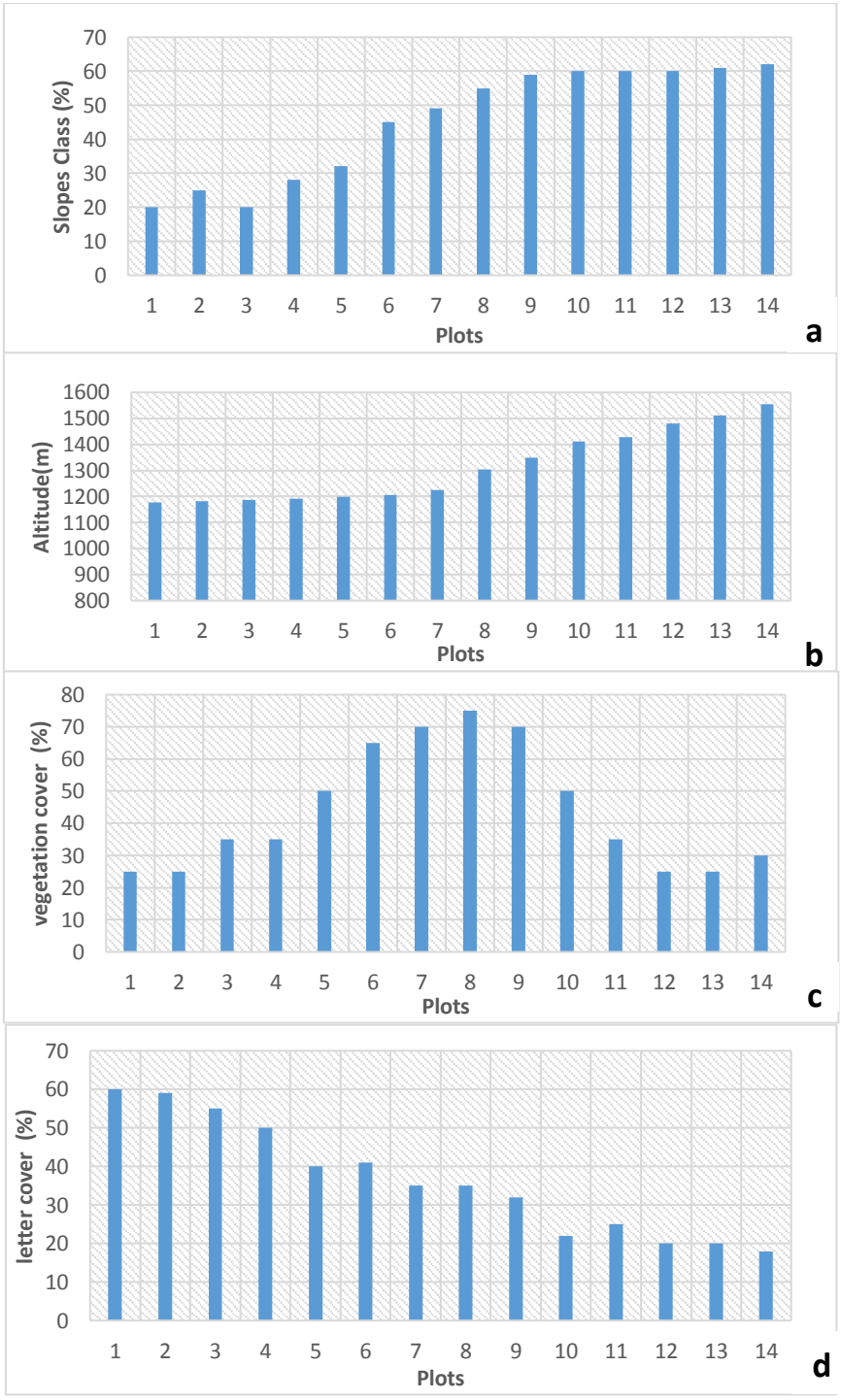

Figure 3. State of the ecological factors of the Atlas cedar (Ain Antar forest, Algeria)
a= slopes (%)**, b=** altitude (m)**, c=** vegetation cover (%)**, d=** letter cover (%).

Table 1 and figure 3 show that the last seven plots have a slope greater than 50 % and are at altitudes greater than 1225 m. The rate of vegetation cover varied from 25% to 60%, and was higher at medium altitude (1200-1400 m). Litter cover gradually decreased with altitude.

Dendrometric parameters

Table 2 presents the dendrometric measurements data of the 14 plots of the Atlas cedar.

Table 2. Dendrometric Parameters of Atlas cedar (Ain Antar forest, Algeria) 14 plots.

Parameters	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Height (m)	12.6	12	11.6	12,7	12,2	11,4	12,9	12,89	12,7	12,5	12,7	13,1	12,2	12,43
Diameter(cm)	45.7	42.5	39.5	44.95	43	37.90	46.90	46.08	46.17	47	45.62	48.38	45.57	47.56
Basal area "g" (m^2)	0.166	0.145	0.127	0.162	0.150	0.147	0.131	0.172	0.173	0.179	0.175	0.220	0.170	0.187
Basal area "G" (m^2/ha)	16.6	14.5	12.7	19.4	21.0	14.7	13.1	20.64	24.22	25.06	28.0	36.0	23.8	29.92

Table 2 indicates that Ain Antar Atlas cedar is characterized by an average density of 260 to 360 trees/ha, (68% of calculated densities), a height average between 12.5 m and 13 m and an average basal area of 23.1 (m^2/ha). Compared to the dendrometric results of partially depleted cedar forest in the national park of Thniet El Had (Taleb et *al*., 2016) and according to Cordonnier *et al*. (2007), the dendrometric results indicated that the cedar forest of Ain Antar was between little dense and dense and constituted by young trees. According to Navarro-Cerrillo *et al*. (2013), in the different management gradients of the cedar national park (Ifrane, Morocco), the height, diameter and basal area were superior to those of Ain Antar cedar.

Bouchon (1979) and McElhinny et *al.* (2005) noted that the distribution of trees according to diameter classes defines the structure of a forest. In the Atlas cedar of Ain Antar forest, the general appearance of this distribution had a bell shape, forming a "Gaussian distribution", as shown in Figure 4. This structure characterizes a forest where all trees have similar age with similar diameters and where all stages of evolution are present. The classes of diameters most presented were between 37.5 cm and 57.5cm.

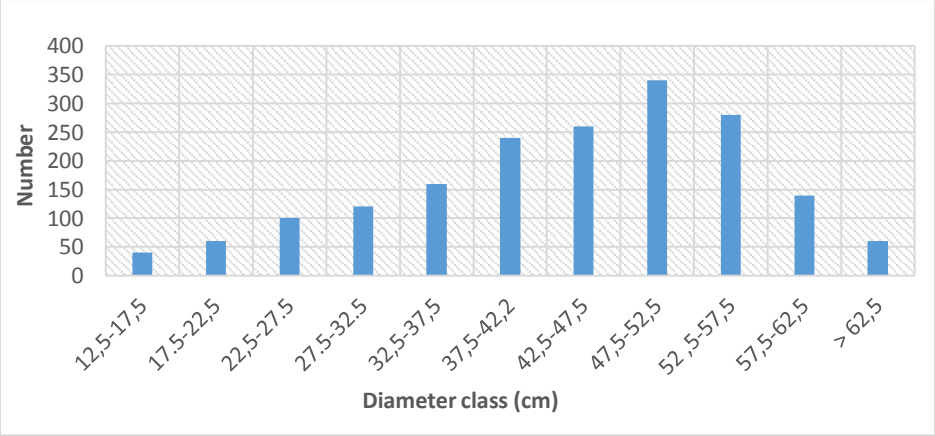

Figure 4. Forest structure of Atlas cedar (Ain Antar forest, Algeria).

Parameters of natural regeneration

The preliminary diagnosis of the natural regeneration of the Atlas cedar gave the results presented in Table3.

Table 3. State of seedlings in 14 plots of Atlas cedar (Ain Antar forest, Algeria).

Seedling's categories		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	Seedling < 1 year	540	780	500	1000	900	580	400	160	360	120	140	160	100	80
	Seedlings > 1 year **S < 0,5m**	500	340	300	540	600	340	300	80	200	100	80	100	120	120
	0,5 < S < 1.5	240	260	280	440	360	300	160	120	240	120	200	100	60	200
Total Seedlings /ha		1280	1380	1080	1980	1860	1220	860	360	800	340	420	360	280	400

Table 3 shows that all seeding categories were more abundant in the first seven plots in the lower and middle altitudes. At high altitude, seedlings were slightly present.

DISCUSSION

Influence of altitude on seedlings of the Atlas cedar

Figure 5 indicates that seedlings having younger than one year are present in large numbers in low and medium altitude, 705 and 548 seedlings/ha, respectively. At high altitude, the density of this class was only 120 seedlings/ha.

At low altitude, seedlings less than 50 cm high and older than one year were present at a rate of 420 per hectare. At medium and high altitude, the rates were 372 and 120 seedlings per hectare, respectively. Regeneration appeared to be relatively better at low and medium altitude.

The cold weather of high altitude delayed the mechanism of regeneration up to 2-3 months. This time lag led to the death of seedlings during the summer months, seedlings cannot develop deep roots to escape the water stress in shallow profiles (Lepoutre, 1963; Pujos, 1966; Krouchi et *al.*, 2004).

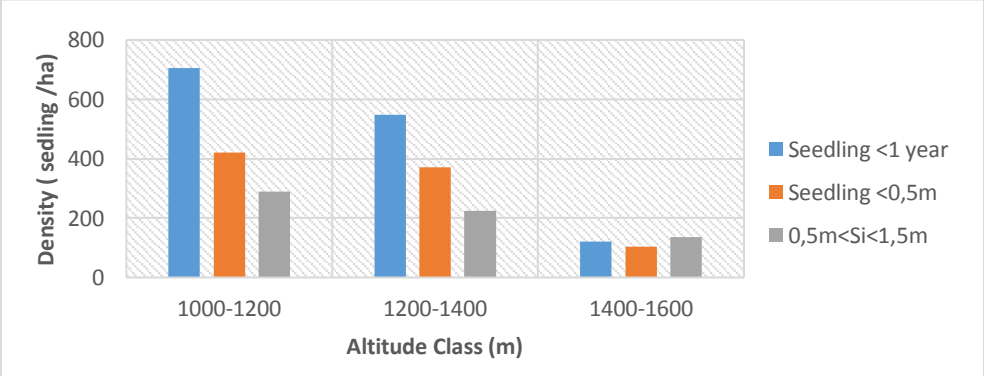

Figure 5. Influence of altitude on seedlings of the Atlas cedar (Ain Antar forest, Algeria).

Influence of slopes on seedlings of the Atlas cedar

Figure 6 shows dominance of < 1 year seedlings (786 plants/ha) on slopes below 20%. On the medium slopes of 21 to 30%, their number was also dominant (680 plants/ha). On steep slopes between 31 and 60%, almost all seedling classes were present in the same order of importance.

A rugged terrain was less favorable to the natural regeneration of the cedar. Nsibi et *al*. (2006) have noted the same result in oaks. On rough terrain subjected to strong water erosion, seeds are less numerous and seedlings cannot develop a sufficient root system that can withstand drought (Zobel et *al*., 1993; Demarteau et *al*., 2007).

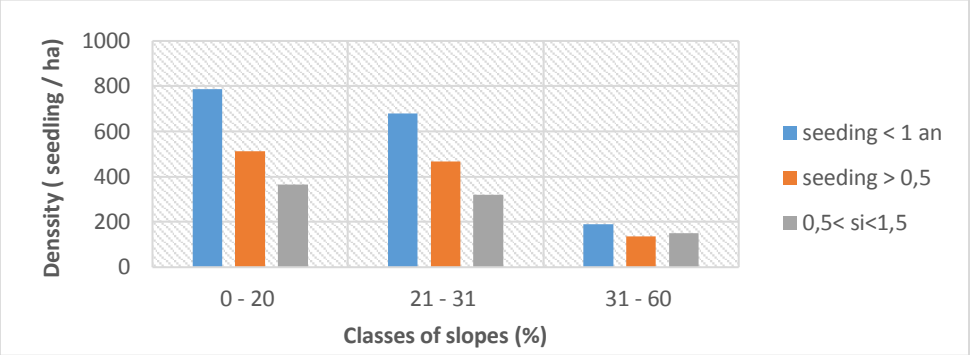

Figure 6. Influence of slopes on seedlings of the Atlas cedar (Ain Antar forest, Algeria).

Influence of rate of vegetation cover on seedlings of the Atlas cedar

Through its action on luminous intensity, air temperature and humidity and vegetation cover play an important role in regeneration (Marchi, 2010). At low altitudes, green oak has a positive role in protecting young seedlings of Atlas cedar. However, at high altitudes, the role of vegetation cover can be dangerous. Indeed, shading delays seed germination (M'Hirit, 1987; Grieu & Aussenac, 1988; Ezzahiri & Belghazi, 2000). In the case of Atlas cedar, rates of vegetation cover up to 50% were usually favorable to regeneration as opposed to extreme recoveries (Ezzahiri and Belghazi, 2000).

Influence of litter cover on seedlings of the Atlas cedar

Figure 7 summarized the relationship between the rate of soil cover by litter and seedlings density. The main conclusions from this relationship are: (i) the presence of seedlings is low when litter is poorly present and vice versa, (ii) the proportion of installed seedings is more prevalent with increasing litter, (iii) the role of the litter appears to be in favor of the survival of seedlings, especially when they are still young. Several workers (Ezzahiri and Belghazi, 2000; Boeken and Orenstein, 2001; Loydi *et al*., 2013) showed that a thick layer of litter prevents root contact with the soil, limiting their chances of survival.

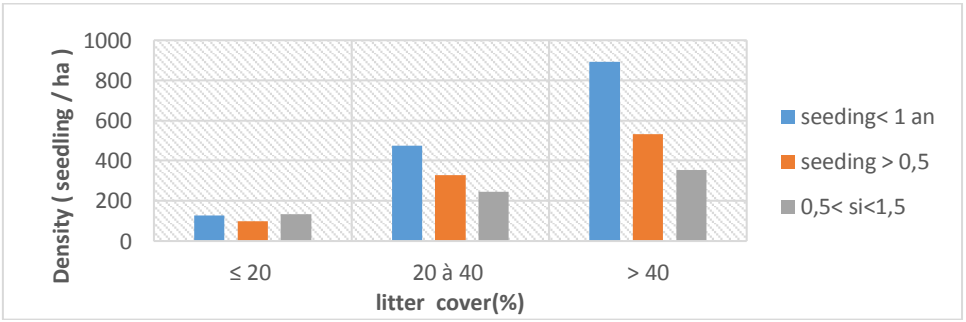

Figure 7. Influence of litter cover on seedlings of the Atlas cedar (Ain Antar forest, Algeria).

Influence of soil depth on seedlings of the Atlas cedar

Figure 8 shows the distribution of Atlas cedar seedlings at different levels of soil depth. The density of all seedling categories exceeds 1200 seedling / ha on deep soils. On shallow soil, the density is 885 seedlings / ha and on surface soil, the number of seedlings does not exceed 400 seedlings / ha. On shallow soil. The proportion of the different seedling classes of cedar increases proportionally with the thickness of the soil. The depth of the soil and its moisture

promote the seed germination and especially the development of the root system of seedlings (Ezzahiri et *al*., 1994; Danjon & Fourcaud, 2009).

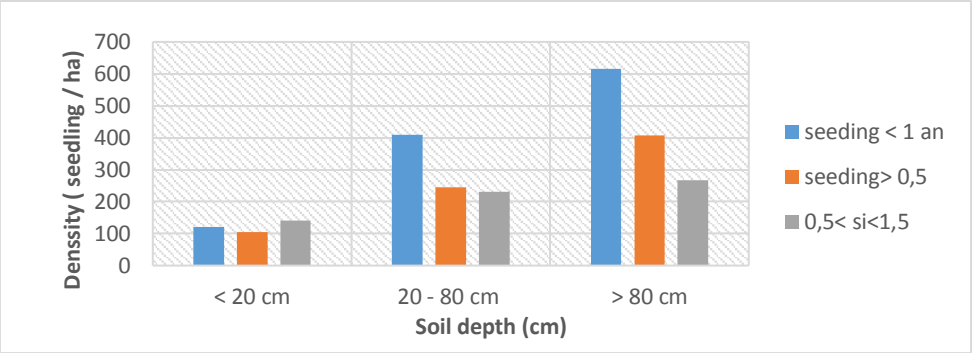

Figure 8. *Influence* of soil depth on seedlings of the Atlas cedar (AIN ANTAR forest - Algeria).

Correlation coefficients

Table 4 summarizes the correlation coefficient of the various parameters.

Table 4. Correlation coefficient between parameters affecting the natural regeneration of Atlas cedar (AIN ANTAR forest - Algeria).

	Altitude (m)	**Slope (%)**	**Vegetat. cover (%)**	**Height (m)**	**Diam. (cm)**	**Basal area (m^2)**	**Seedlings < 1 year**	**Seedlings < 0.5m**	**Seedlings > 0.5m**	**Seedlings /ha**
Altitude (m)	1.00									
Slope (%)	0.82	1.00								
Vegetative cover (%)	-0.24	0.31	1.00							
Height (%)	0.35	0.50	0.08	1.00						
Diameter (cm)	0.61	0.63	-0.09	0.90	1.00					
basal area (m^2)	0.75	0.56	-0.28	0.58	0.68	1.00				
Seedlings < 1 year	-0.83	-0.85	-0.03	-0.33	-0.53	-0.55	1.00			
Seedlings < 0,5 m	-0.79	-0.83	-0.07	-0.28	-0.43	-0.53	0.93	1.00		
Seedlings > 0,5 m	-0.68	-0.75	-0.01	-0.36	-0.54	-0.46	0.89	0.82	1.00	
Seedlings /ha	-0.82	-0.85	-0.04	-0.33	-0.52	-0.55	0.99	0.96	0.92	1.00

The analysis of the Pearson correlation matrix (Table 4) carried out on the traits studied shows the degree of binding. When the correlation coefficient approaches (+ 1), the other variable tends to increase as well. Otherwise, if the coefficient tends to (-1), the other variable tends to decrease. Evans (1996) suggests a "strong" and "very strong" correlation for the absolute value of "r" respectively of "0.60-.79" and ".80-1.0". The results of the correlation matrix show that the number per hectare of all seeding classes decreases as the altitude, slope and base area become more important. However, the vegetation cover has no direct effect on seedlings (correlation coefficient near to 0).

REFERENCES

Bentouati, A. and Bariteau, M. 2006. Réflexions sur le dépérissement du Cèdre de l'Atlas des Aurès (Algérie). Forêt Méditerranéenne, 27(4): 317-322.

Boeken, B. and Delissiand, O. D. 2001.The effect of plant litter on ecosystem properties in a Mediterranean semiarid shrubland. Journal of Vegetation Science, 12(6): 825–832.

Bouchon, J. 1979. Structure des peuplements forestiers. Ann. Sci. Fores, 36: 175-209.

Cordonnier, T., Tran-Ha, M., Piat, J. and François, D. 2007. La surface terrière: méthodes de mesure et intérêts. ONF, Rendez-Vous Techniques, 18: 9-16.

Dalling, J. W., Hubbell, S. P. and Silvera, K. 1998. Seed dispersal, seedling emergence and gap partitioning among tropical pioneer trees. Journal of Ecology, 86: 674–689.

Danjon, F., Fourcaud, T. and Bert, D. 2009. Root architecture and wind firmness of mature *Pinus pinaster* (Ait.). New Phytologist, 168(2): 387-400.

Delissio, L.J. and Primack,R.B. 2003. The impact of drought on the population dynamics of canopy tree seedlings in a seasonal Malaysian rain forest. Journal of Tropical Ecology, 19: 489-500.

Demarteau, M., Francois, L., Cheddadi, R. and Roche, E. 2007. Réponses de Cedrus atlantica aux changements climatiques passés et futurs. Geo-Eco-Trop, 31: 105-146.

Derridj, A. 1990**.** Etude des populations de *Cedrus atlantica*. Manetti en Algérie. Thèse Doct. Université de Toulouse. 282 pp.

Evans, J. D.1996. Straightforward statistics for the behavioral sciences. Pacific Grove, CA: Brooks/Cole Publishing. Total number of pages??

Ezzahiri, M., Belghazi, B. and Behmad, M. 1994. Bilan régénération naturelle de la cédraie dans les parcelles clôturées du Moyen Atlas, Maroc. Ann. Rech. For Maroc, 27 (Spécial), 36: 259 -267.

Ezzahiri, M. and Belghazi, B. 2000. Synthèse de quelques résultats sur la régénération naturelle du cèdre de l'Atlas au Moyen Atlas (Maroc). Sécheresse ,11(2): 79-84.

Grieu, P. and Aussenac, G.1988. Croissance et développement du système racinaire de semis de trois espèces de conifères. *Pseudotsuga menziesii*, *Pseudotsuga macrocarpa* et *Cedrus atlantica*. *Ann. Sci. For*., 45(2): 117-124.

Gross, K. L. 1990. A comparison of methods for estimating seed numbers in the soil. *The Journal of Ecology*, 78(4): 1079–1093.

Hinesley, L. E., Blazich, F. A. and Snelling, L. K. 1994. Propagation of Atlantic white-cedar by stem cuttings. HortScience, 29: 217–219.

Illoul, M., Derridj, A. and Moualek, O. 2004. Production grainière et germination des graines de différentes provenances algérienne de cèdre (*Cedrus atlantica*). Naturlia Maroccana, 2(1-2): 269-277.

Jull, L. G. and Blazich, F. A. 2000. Seed germination of selected provenances of Atlantic white-cedar as influenced by stratification, temperature, and light. Hortscience, 35:132-135.

Khemici, M. 2001. Protection des cédraies en Algérie: inventaire des insectes ravageurs et réseaux d'avertissement et de lutte. Pp. 10-18 *In*: workshop on ″Assessment of the scale insect infestation in cedar forest in Lebanon and the Mediterranean region″. American University of Beirut, Lebanon.

Krouchi, F., Derridj, A. and Lefèvre, F. 2004. Year and tree effect on reproductive organisation of *Cedrus atlantica* in a natural forest. Forest Ecology and Management, 197: 181–189.

Lepoutre, B. 1963. Recherche sur les conditions édaphiques de régénération des cédraies marocaines. T (6). Ann. Rech. For. au Maroc. Rapport 1957-1961, fasc. 2, SRF. Rabat.

Loydi, A., Eckstein, R. L., Otte, A. and Donath, T. W. 2013. Effects of litter on seedling establishment in natural and semi-natural grasslands: a meta-analysis. Journal of Ecology, 101: 454–464.

Malki, H. 1992**.** Contribution à l'étude de l'influence du climat et des facteurs physiques sur la régénération du cèdre de l'Atlas *(Cedrus atlantica* M.) dans les monts de Belezma (Algérie). Thè. Doc. Uni. de Paris -- Sorbonne: 187 pp.

Marchi, A. 2010. Relationship between forest canopy and natural regeneration in the subalpine spruce-larch forest (northeast Italy). Folia Forestalia Polonica, series A, 52 (1): 3–12.

McElhinny, C., Gibbons, P., Brack, C. and Bauhus, J. 2005. Forest and woodland stand structural complexity: Its definition and measurement. *Forest Ecology and Management*, 218(1-3): 1-24.

M'Hirit, O. 1987. État actuel des connaissances sur le cèdre. Éléments pour un programme de recherche. Comité CFA/CEF/CFPO des questions forestières Mediterranéennes. *Silva méditerranea*, pages ??

M'hirit, O. 1994. Le cèdre de l'Atlas (Cedrus atlantica Manetti), présentation générale et état des connaissances à travers le réseau Silva mediterranea "Le cèdre". Ann. Rech. For. Maroc, 27: 3-21.

Navarro-Cerrillo, R. M., Manzanedo, R. D., Bohorque, J., Sanchez, R., Sanchez, J., Miguel, S. D., Solano, D., Qarro, M., Griffith, D. and Palacios, G. 2013. Structure and spatio-temporal dynamics of cedar forests along a management gradient in the Middle Atlas, Morocco. Forest Ecology and Management, 289: 341–353.

Nsibi, R., Souayah, N., Khouja, M., Khaldi, A. and Bouzid, S. 2006. Impacts des facteurs biotiques et abiotiques sur la dégradation de suberaie tunisienne. Biotics and abiotics factors responsible of the Tunisian Cork oak forest deterioration- Geo-Eco-Trop, 30: 25-34.

Pons, T. L. and Schroder H. F. 1986. Significance of temperature fluctuation and oxygen concentration for germination of the rice field weeds Fimbristylis littoralis and Scirpus juncoides. Oecologia, 68: 315–319.

Pujos, A. 1966. Les milieux de la cédraie marocaine. Etude d'une classification des cédraies du Moyen-Atlas et de la régénération actuelle dans les peuplements. Ann. Rech. For., 8: 1-323.

Quezel , P. 1998. Cèdres et cédraies du pourtour méditerranéen : signification bioclimatique et phytogéographique Forêt Méditerranéenne, 19(3): 243-257.

Talbi, Y. and Bouhraoua, R. T. 2015. Complexe xylophage associé au dépérissement du cèdre de l'atlas au Bélezma (Algérie). Lebanese Science Journal, 16: 97-106.

Taleb, M. L., Maatoug, M., Azouzi, B., Zedek., M. and Hellal, B. 2016. Etude eco-dendrométrique du dépérissement du cèdre de l'Atlas dans Le parc national de Theniet El Had, Algérie. European Scientific Journal, 29: 112-123.

Toth, J. 1978. Contribution à l'étude de la fructification et de la régénération du cèdre de l'Atlas *(Cedrus atlantica* M.) dans le Sud de la France. Thè. Doc. Ing. Fac. St. Jérôme, Marseille, France. 136 pp.

Toth, J. 1980. Le cèdre III. La graine des plants en pépinière, reboisement, régénération naturelle. La forêt privée. Rev. For Europe, 132: 41-47.

Toth, J. 2005. Le cèdre de France. Etude approfondie de l'espèce. Paris, Le Harmattan. Biologie, Ecologie, Agronomie. 207 pp.

Zobel, K., Zobel, M. and Peet, R. K. 1993. Change in pattern diversity during secondary succession in Estonian forests. J. Veg. Sci., 4: 489-498.