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Chorological and conservation status of the endemic cypress, *Cupressus atlantica* Gaussen, in the High Atlas (Morocco)

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Abstract: We present a study of the distribution, ecology and conservation status of *Cupressus atlantica*, an endemic tree of the High Atlas (Morocco). The main populations of this species grow in a reduced area along the N'Fiss valley in the Central High Atlas and are gradually receding. Particular populations are increasingly fragmented and the total area covered by the cypress woodland has decreased to less than a third of the surface occupied in the 1930s. Overgrazing reduces the woodlands' regenerative capacity, and the exploitation of the wood, linked to traditional uses by the rural society of the N'Fiss valley, directly reduces the number of trees. Great efforts being made to protect the species by the Haut Commissariat aux Eaux et Forêts are having some effect in recent years.

Additional key words: Cupressaceae, degraded forest ecosystems, ecology, Moroccan Cypress, Moroccan flora, North Africa, plant conservation, plant geography.

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Introduction

Cupressus atlantica Gaussen, commonly known as the Moroccan Cypress, Cyprès de l'Atlas or Azel, is a tree up to about 18–20 m high and to 1.6, sometimes even to 2 m DBH (Farjon 2005). The scientific literature has recorded the presence of *C. atlantica* in the Central High Atlas since Jahandiez and Maire (1931) and Emberger (1938), both after data by Brives (1909), but years passed before it was described by Gaussen (1950). Emberger (1938) and Emberger and Maire (1941) had already indicated the exceptional, relictic nature of *C. atlantica*, a testimony of past ages under different climatic conditions. Following Gaussen's (1950) description, the bibliography of this taxon has been scant. It is only recently that it

has become an object of interest, with contributions from Bellefontaine (1979), Silba (1998), Alifriqui et al. (1996), El Alaoui et al. (2001), Bechir et al. (2001) and lately it reappears in synthetic works by Farjon (2005, 2010), Debreczy and Racz (2011) and Quézel and Médail (2003).

From the nomenclatural point of view, the position of *C. atlantica* is not free of controversy (Debreczy and Racz 2011). It was combined by Silba (1981) at the varietal level *C. sempervirens* L. var. *atlantica* (Gaussen) Silba, Phytologia 49(4), p. 398 (1981). Then the rank was changed by the same author (Silba 1998) to a variety of *C. dupreziana* A. Camus, in "a home made 'journal' of unknown distribution" (but distributed to NYBG and RBG Kew) as photocopied texts from his earlier writings pasted together, see above: *C. dupreziana* var. *atlantica* (Gaussen) Silba, *comb. nova*, 29", according to Farjon (2005). Later, this same author proposed the combination at subspecific level. On the whole, the specific rank seems to be the most adequate, though this should not be to the detriment of the conclusions of future studies, as proposed recently (Rushforth et al. 2003; Earle 2008).

Cupressus atlantica Gaussen in Le Monde des Plantes,14: 55 (1950).

Syn.: *Cupressus sempervirens* L. var. *atlantica* (Gaussen) Silba in Phytologia 49: 398 (1981); *Cupressus dupreziana* A.Camus var. *atlantica* (Gaussen) Silba in J. Int. Conifer Preserv. Soc., 5(2): 29 (1998); *Cupressus dupreziana* A.Camus subsp. *atlantica* (Gaussen) Silba in J. Int. Conifer Preserv. Soc. 12(2): 64. 2005 [Jul 2005]

Cupressus atlantica is a species endemic to the Moroccan High Atlas, where its largest populations are known from the N'Fiss valley, growing at altitudes between 1200 and 1800 m (Charco 2001), extended recently to the altitudinal range 1000-2000 m (Oldfield et al. 1998), or even 900 to 2220 m (El Wahidi 2004; Farjon 2005). The area, covered with cypress plant communities or juniper woodlands with admixture of *C. atlantica* was estimated at about 5500 ha by Gaussen (1950), but lately as only 1480 ha by Ech-Chamikh (1983), 1460 ha by Achhal (1986) and 8898 ha by El Wahidi (2004). The rest of the nearby stands and open woodlands of *C. atlantica,* frequently with *Juniperus phoenicea* L., at the lower part of the altitudinal range, also with *Tetraclinis articulata* (Vahl) Mast., and at the upper, *Quercus ilex* L. (Charco 2001), were reported mostly on the slopes of the N'Fiss Valley and some lateral valleys. *C. atlantica* is able to survive in the continental climatic conditions, with high oscillations of temperature and a low precipitation (Alifriqui et al. 1995; Quézel and Médail 2003). Soils covered with *C. atlantica* communities are generally poorly developed, rocky and strongly eroded.

Cupressus atlantica plays an important social role in Morocco. The wood of the species is used by the local population for construction and for home uses, also as a fuel for cooking and heating, and, during the last decades, for the production of souvenirs for tourists. The young twigs with leaves are fed to sheep and goats. The permanent exploitation of *C. atlantica* wood and the overgrazing of the terrains are recognized causes for the decrease in the number of individuals and lack of successful regeneration (F.A.O. 1976; Griffith 1998; El Wahidi 2004; Farjon 2005; Ouahmane et al. 2006).

Considerable attempts are being made by the Moroccan Forest Service (Haut Commissariat aux Eaux et Forêts) to replant *C. atlantica* in its area of distribution in the Oued N'Fiss Valley, but the rate of success is low (Oldfield et al. 1998; Ouahmane et al. 2006). It has been found lately that the use of 'plant nurses' such as *Thymus saturejoides* Cosson or *Lavandula* spp. can be of great value to restore a vegetation cover with participation of the Atlantic cypress (Ouahmane et al. 2006; Duponnois et al. 2011). These plant species operate not only as a mechanical protection of young seedlings, but also as a source of fungi which form arbuscular mycorrhiza, characteristic for *C. atlantica* (Ouahmane et al. 2007). In any case, knowledge of this tree is fragmentary and incomplete. Among other aspects, the detailed distribution, ecology, population dynamics and state of conservation are still insufficiently known.

The aims of this study were to: 1) estimate the area covered with the groves and woodlands of or containing specimens of *C. atlantica* in their main area of distribution in the N'Fiss valley, 2) determine the environmental conditions favouring its occurrence, 3) summarize the phytosociological character of communities which it forms or enters, as a background to conservation activities needed to preserve this endemic and endangered species with the IUCN category EN (A1bc, B1+2b) (IUCN 2006).

Methods

Study area

The study area covers the main part of the natural geographical range of *C. atlantica* in the N'Fiss valley, in the Moroccan High Atlas (Fig. 1). The Oued N'Fiss, due to its general orientation from NE to SW and huge dimensions, presents the characteristics of inland valleys situated within a mountainous region. It exhibits a specific climate, where the low rainfall is combined with a continental regime and with a high daily temperature oscillation. The N'Fiss valley remains clearly screened from any type of Atlantic climate influence, being surrounded by high mountains, with peaks and mountain passes reaching al-

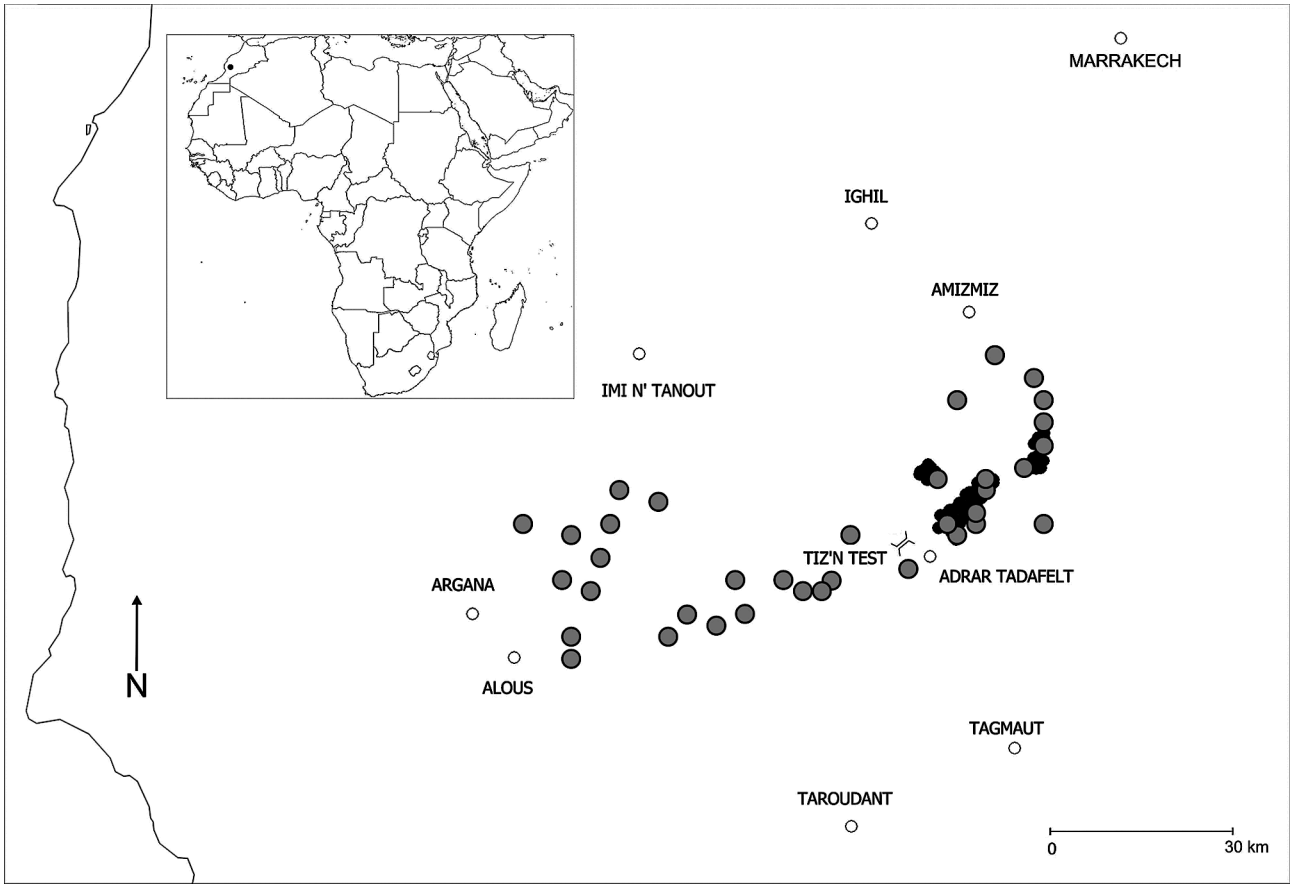

Fig. 1. Distribution of *Cupressus atlantica* in the High Atlas after Alifriqui (1996) and El Wahidi (2004): grey circles and own data: black circles (*MapInfo* v. 9.5)

titudes over 3600 and 2400 m, respectively. Even to the S, the peaks reach beyond 2700 m. The only two lower reaches are the Tizi-n-Test pass (2092 m) to the South-West and the river N'Fiss gorge, which is downstream, in the lower part of the valley (980 m) to the North (Alifriqui et al. 1995).

The exceptional dry and continental nature of the valley is attested to by the presence of species like *Warionia saharae* Cosson, *Kleinia anteuphorbium* (L.) Haw. and *Cymbopogon schoenanthus* (L.) Spreng. The summers in the valley are very hot and the winters cold, in both cases with strong oscillations of daily and even extreme average monthly temperatures (Ta-

Table 1. Average month temperature with monthly average minimum and maximum at Tizi-n Test (after El Wahidi 2004)

Temperature [°C]	Month												Yearly
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Average	6.0	7.0	8.4	11.4	13.8	18.2	24.0	23.8	19.0	12.7	8.6	5.4	13.2
Minimum	2.4	2.7	4.1	6.9	8.6	12.0	18.2	18.1	13.5	5.1	5.1	–1.4	8.5
Maximum	9.7	11.4	12.7	15.8	19.0	24.4	30.8	29.6	24.3	17.3	12.1	8.9	17.9

Table 2. Average precipitation within the N'Fiss valley (after El Wahidi 2004)

Climate station	Altitude	Month												Total	Period
	[m]	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		
Ijoukak	1185	51.7	41.4	38.1	30.0	12.2	4.4	3.4	7.6	29.7	31.8	57.3	38.6	346.2	1942–1972
Tlat n-Ya'qoub	1233	35.6	22.9	28.1	16.8	9.1	4.8	1.1	5.9	14.1	36.8	40.5	24.8	240.5	1930–1971
Idni	1700	105.9	88.7	39.5	29.0	9.4	5.1	4.7	6.6	14.6	95.0	154.3	81.8	634.6	1953–1972
Tizi-n Test	2080	54.0	58.0	74.0	80.0	57.0	14.0	4.0	4.0	25.0	48.0	58.0	68.0	544.0	1933–1963
Aghbar	2700	105.8	85.6	65.6	30.1	11.3	5.5	2.1	11.7	24.7	91.1	137.3	130.5	701.5	1938–1972

ble 1). In the lower parts of the N'Fiss valley, the annual precipitation is below 400 mm and in higher parts about 500–600 mm (Table 2). In this area, the rainiest season is winter, followed by autumn, spring and summer (WASpSu), after Alifriqui et al (1995) and El Wahidi (2004). The N'Fiss valley area is situated on the border of two different pluviometric regimes, because it is not far from the zone where the rainiest season is spring, followed by winter, autumn and summer (SpWASu) (Alifriqui et al. 1995).

Field measurements

The data on the distribution of *C. atlantica* was gathered from literature and herbaria. Field studies were then conducted during the first days of September 2005 and July 2008. The distribution of populations, groups of trees and single individuals has been mapped in the N'Fiss valley using topographic maps 1:100,000 of Amezmiz (1974. Ministère de l'Agriculture et de la Reforme Agraire, Division de la Carte, Rabat) and Tizi'n Test (1974. loc. cit). The toponyms were also adopted from these maps. The area of particular tree conglomerations and parts of the stands were estimated directly in the field and verified on the map. The area of each unit was approximated to about 0.04–0.05 ha. The single trees and groups of trees covering terrain smaller than about 20 × 20 m were not included into the estimated area. The data obtained were compared to those known from the literature, and the tendency of the population to increase/decrease its area was estimated.

The type of rock, main relief form, exposure and inclination have been determined for localities of the species in the field (Boratyński 1985). We have distinguished three main categories of the ground where *C. atlantica* grows (1) limestone rock fissures and gravels, (2) schist rocks and gravels and (3) sandstone fissures and gravels, which are consistent with the High Atlas Geology (Hollard et al. 1985).

The main relief forms included slope, frequently with terraces (ZB), concave forms, such as slope troughs, stream valleys, gorges, etc. (WKL), and convex forms, such as slope protuberances, ridges, great rocks, etc. (WYP). The exposure of localities was determined according to the 4 main and 4 intermediate geographic directions, N, NE, E, etc. Inclination included categories (1) to 10°, (2) 11–20°, (3) 21–30°, (4) 31–45° and (5) more than 45°. The exposure and inclination was measured in the field using compass (Sylva) and clinometers (Suunto), respectively.

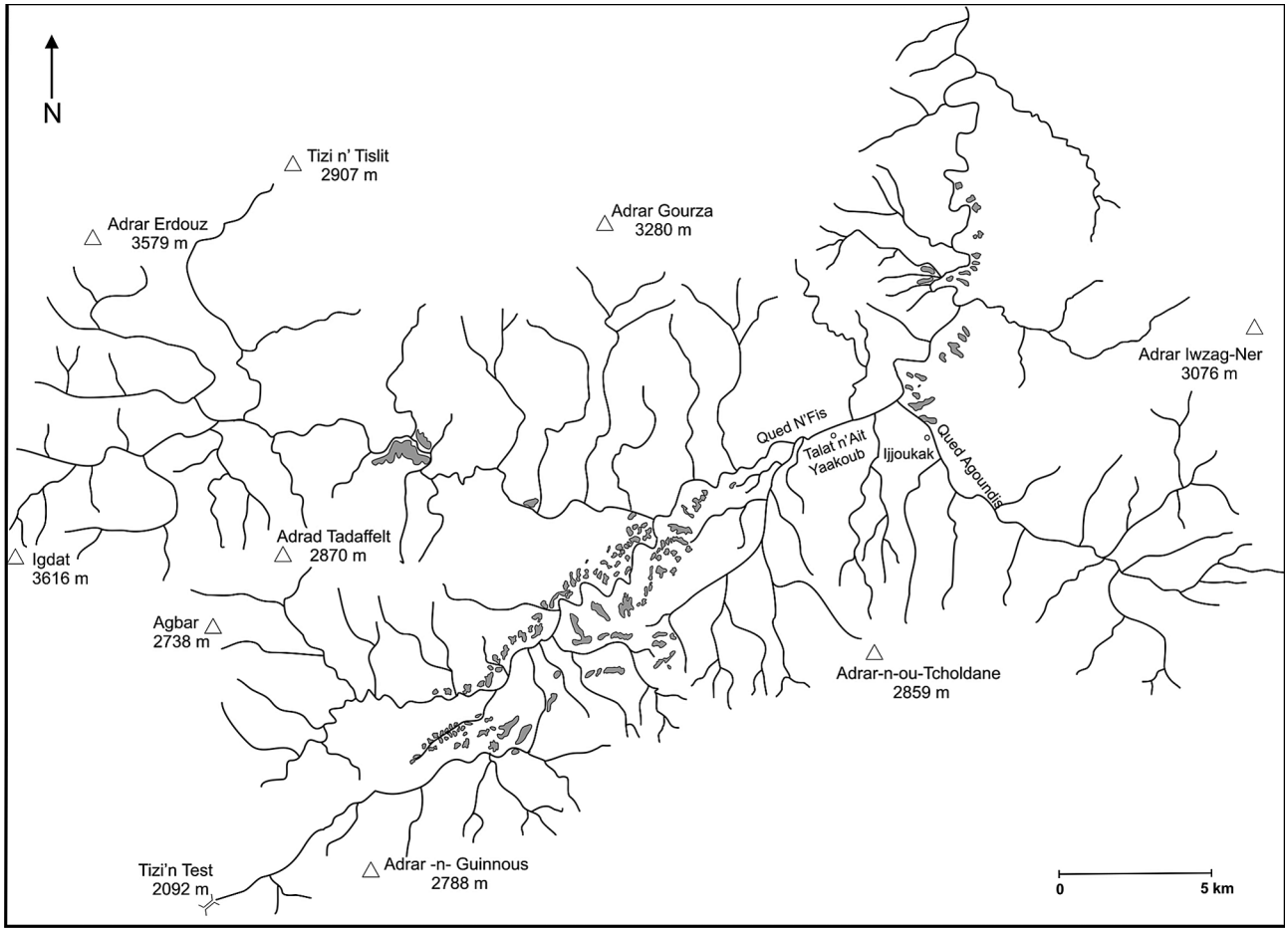

Fig. 2. Localities of *Cupressus atlantica* in the Oued N'Fiss valley based on field observations

The most representative localities were documented phytosociologically according to the Braun-Blanquet (1979) method. We have made inventories in order to recognize the vegetation communities, to analyze the species accompanying the cypress and to document presence/absence of seedlings and saplings of *C. atlantica.* We compared our phytosociological relévés with data concerning similar plant communities, accessible in the literature, to verify the possible specific plant composition of this *Cupressus* woodland. The nomenclature of taxa follows Fennane et al (1999; 2007).

Results

Area of distribution

Although the main centre of *C. atlantica* occurrence covers slopes of the valley of the Oued N'Fiss, there are several small populations of the species dispersed in other valleys, harbouring as a rule not as many individuals (Fig. 1). The Atlantic cypress has been reported also from isolated localities, such as to the SW of Tizi'n Test close to Adebni village, situated on northern slopes of a lateral valley at 1450 m. Several other localities have been found on the southern and western slopes of Adrar Aoulime, towards Imoulas and the Assif n'Aït Tament, Assif Togouga, Assif Medlawa and Assif n'Aït Cha'ib (western localities of Fig. 1). Another one is situated on the northern slopes of Adrar Tadafelt, close to the village of the same name (Fig. 2). Other smaller and reduced populations are found at Southern Amizmiz, Imi n'Tanout, North-East and East Argana (Appendix 1).

We detected three nuclei of *C. atlantica* in the Oued N'Fiss. The first exists between Imidel and Ijoukak, the second, better nourished, between Talat-n-Ya'qoub and Tizi-n-Test and the third between Iguer and Taourirt in the lateral valley of Taslit, which descends from Tizi-n Taslit (Fig. 1). The first nucleus is calculated to occupy about 423 hectares, the second about 959 and the third around 298. The species-loose groves cover about 70% of that area, so its woodland area was about 2180 hectares during field studies in 2005 and 2008, with an average tree layer coverage of about 30% (Appendix 2).

We have observed individuals of *C. atlantica* in the N'Fiss Valley at altitudes between 1060 and 1690 m, with the best conserved woodlands between Mzouzit and Idni (Fig. 2), at altitudes of 1400–1700 m. The patches of the forest have been observed at that elevation, while below and above that belt the species forms, as a rule, open groves across rather restricted areas, or grows in the form of dispersed, single trees. Besides this, a small group of *C. atlantica* trees has also been observed on the south facing slopes of Tizi'n Test, at an altitude of 1700 m. Judging by the distribution and demographic structure, in this case we are most likely talking about planted trees.

Occurrence conditions

Lithology

The occurrence of *C. atlantica* appears to be uninfluenced by substrate type, and the species can be found equally on slightly acid soils made up of sandstones and schist, as on carbonated soils, originating from dolomites. It always occurs on shallow, undeveloped, stony and strongly eroded soils, where the stones measure more than 30 cm in diameter and cover more than 50% of the area. In many cases, it is found on slopes with rock slabs of over one metre in diameter.

Relief forms

In the localities studied, slopes dominate, concave sites are rare, and convex sites are absent. The species has been observed mostly on the lower and middle slopes, but completely absent on their upper parts. In the middle parts of high slopes, it occurs above all at the foot of rocks and small rocky terraces or in concave relief forms, such as the dry beds of small streams, slope hollows, small gullies, etc. *C. atlantica* is more frequent on the lower flanks of the valleys but does not enter riparian communities. It constitutes a transition between the hygrophilous riverine vegetation and the communities dominated by *J. phoenicea*, which colonize the drier environments with shallower soils typical of the upper parts of the slopes.

Most of the localities of the cypress were observed on slopes inclined between 20 and 45°, although in exceptional cases also on more abrupt ones (Fig. 3A). The species stands on the most precipitous slopes occur in valleys moulded by fluvial activity and, consequently, strongly eroded.

Aspect

The patches of communities with *C. atlantica* are found above all on the slopes exposed to N and NW, and become scarcer on S and SW facing slopes (Appendix 1, 2, Fig 3B). The association of the species or communities with their co-dominance was documented from the N, NW and W aspects (Appendix 2), but localities were found quite frequently also on the slopes exposed to S and SE (Fig. 3B).

Phytosociological characteristic

Floristic composition

We documented 33 relevés of *C. atlantica* woodland in different parts of the N'Fiss and Taslit valleys (Appendix 2). All of them represent the plant community from the *Ephedro nebrodensis-Juniperion*

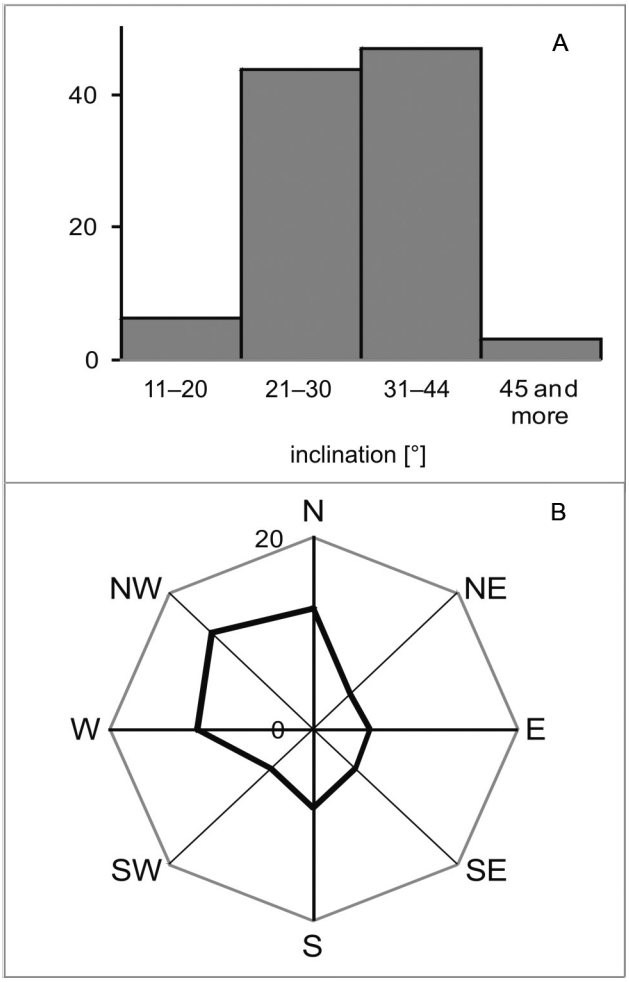

Fig. 3. Occurrence of *Cupressus atlantica* depending on: A – inclination of the slopes; B – exposure; based on the phytosociological data and authors' field observations

turbinatae Quézel & Barbero (1981) 1986 alliance, but in respect to the floristic composition they pertain to none of the associations already described (Table 3). For that reason, we decided to describe them as a new plant association: *Micromerio hochreuteneri-Cupressetum atlanticae*; the relevé number 25 in Appendix 2 is chosen as type. It is close to the *Junipero turbinatae-Cupressetum atlanticae* Quézel & Barbero 2007 in Asensi, Díaz-Garretas & Quézel and should be included in the *Ephedro nebrodensis-Juniperion turbinatae* alliance, order *Ephedro-Juniperetalia* Quézel & Barbero 1981 ex Quézel, Barbero, Benabid, Loisel & Rivas-Mart. (1988) (Table 3).

The number of species in particular inventories of *Micromerio hochreuteneri-Cupressetum atlanticae* oscillated between 9 and 26 per 100 m^2. The High Atlas endemics, apart from the cypress, are *Polygala balansae* Coss., *Coronilla ramosissima* Ball and *Lavandula pedunculata* (Mill.) Cav. subsp. *atlantica* (Braun-Blanq.) Romo. The plant species typical for the open areas include most frequently: *Avenula bromoides* (Gouan) H.Scholz, *Cymbopogon schoenanthus* Spreng., *Globularia alypum* L., *Lavandula dentata* L. and *Thymus saturejoides* Coss. & Balansa. Also, there are some ruderal plants that occur less frequently, such as *Poa bulbosa* L., *Dittrichia viscosa* (L.) Greuter and *Piptatherum miliaceum* E.Fourn. (Appendix 2).

Canopy structure

In the woodland communities with *C. atlantica*, the tree canopy rarely reaches a coverage of more than 40%, and the tree height oscillates between 4 and 10m. We cannot speak of a dense forest formation but rather of trees, in this case *C. atlantica, Juniperus phoenicea* and *J. oxycedrus* L., below which a dense shrub canopy is developed, where the herbaceous plants play a minor role. The trees do not modify excessively the amount of light that penetrates to the ground below the canopy. In fact, we are referring to a plant community dominated by trees in which the term 'woodland' can only be applied in a wide sense.

One of the main goals of the phytosociological inventories was to detect the seedlings of *C. atlantica* in nature. Unfortunately, we found not one seedling during the whole field study period, not only in our phytosociological relevés.

Discussion

Area of woodlands

The localities of *C. atlantica* are dispersed within the northern macro-slope of the High Atlas. The species occurs in the valleys with populations separated from each other by distance and high mountain ridges. The most numerous and best known conglomeration covers the N'Fiss valley, where Atlantic cypress occurs between Imidel and Ijoukak and then between Talat-n'Ya'qoub and Tizi-n'Test. The lateral valley of Taslit, close to the N'Fiss valley, between Iguer and Taourirt, harbours quite large populations, which cover about 300ha (Fig. 2). The species-open groves cover about 70% of these three regions and the total area of woodland with *C. atlantica* was estimated at about 2200 ha in the first decades of the 20th Century (Watier 1921; Jahandiez and Maire 1931; Emberger 1938; Gaussen 1950). The first great area of occurrence of *C. atlantica*, easily accessible from the road from Marrakesh to Tizi-n-Test, covers at present about 420-430 ha and is not the most abundant population of the species, despite the view of Farjon (2005), although that may have been years ago. Several large trees have been found there with the circumference of 4–5 m at 1.3 m above ground level. The largest cypress trees are near the Ijoukak Forest Station. Some of them were drawn by Farjon (2005). Most of the trees show signs of cutting for wood and lopping for animals.

Table 3. Associations of the *Ephedro majoris-Juniperion phoeniceae* Quézel et Barbero (1981) 1986 alliance: A: *Coronillo ramosissimae-Juniperetum phoeniceae* Quézel et Barbero (1981); B: *Warionio saharae-Antirrhinetum ramosissimae* Quézel et Barbero (1981); C: *Retamo dasycarpae-Juniperetum phoeniceae* Quézel et Barbero (1981); D: *Junipero turbinati-Cupressetum atlanticae* Quézel et Barbero 2007 in Asensi, Díaz-Garretas et Quézel and E: *Micromerio hochreuteneri-Cupressetum atlanticae, ass. nova*

Species	A	B	C	D	E
Cupressus atlantica				V	V
Ephedra nebrodensis	V	V	V	V	V
Polygala balansae	II		V	V	V
Thymus saturejoides			I	IV	V
Lavandula dentata	III			III	IV
Phagnalon saxatile	I		II		III
Ballota hirsuta	I				II
Globularia alypum	III	III	II		II
Lavandula pedunculata subsp. *atlantica*	I		I		II
Asparagus albus	V			I	I
Cistus creticus					I
Ephedra fragilis	I	V	II		I
Cladanthus scariosa			V		I
Pistacia atlantica	IV		III		I
Polycnemum fontanesii	I		III		I
Quercus rotundifolia			II	I	I
Rhus tripartita	IV	III			I
Salvia taraxicifolia	II		III		I
Stipa lagascae			III		I
Stipa nitens	I		IV		I
Ziziphus lotus	I			I	I
Acanthorrhinum ramosissimum		V			
Asparagus stipularis					
Bupleurum dumosum	III				
Capparis spinosa	IV				
Ceratonia siliqua	I				
Chamaerops humilis			IV		
Coronilla ramosissima	V		II	III	II
Cytisus balansae			I		
Fraxinus dimorpha			I		
Hedysarum membranaceum		III			
Juniperus oxycedrus			IV	III	III
Juniperus phoenicea	V		V	V	V
Lavandula multifida	I				
Olea europaea subsp. *oleaster*	I				I
Periploca angustifolia				IV	
Retama dasycarpa		V			
Micromeria hochreutineri					II
Stipa tenacissima			IV		
Tetraclinis articulata	I				
Warionia saharae	II	V		III	

The most extended area of the woodland communities with *C. atlantica* covers about 960 ha above Talat-n-Ya'qoub, through Mzouzit, Moulddikht and Idni, toward the pass of Tizi-n-Test, up to an altitude of about 1700 m. The largest trees we have observed there were also more than 23–24 m high and about 4 m circumference. The high number of trees is probably a reason for the fact that the injuries are not so visible as in the lower part of the valley. Nevertheless, there are also small goods made from the cypress wood, available for purchase in villages along the road.

The extensive area covered with woodland of *J. phoenicea* and *Q. ilex* in the Atlas suggests the much wider occurrence of *C. atlantica* in the past (Charco 1999). The existing remnants of forest of *C. atlantica* are rare and can be met with in inaccessible, high parts of the valleys or in the vicinity of villages. Predominantly, these forests have a marked open structure and can be thought of as cypress or cypress-ju-

niper woodlands or woodland steppe. The low layer of that community contains several woody and perennial species of open areas, including some endemic plant species of the High Atlas (Charco 1999).

Altitudinal limits

The numerous populations in the N'Fiss valley of the High Central Atlas are located between 1300 and 1585 m, but we have observed single and/or groups of individuals between 1060 and 1690 m. Open associations and small copses can be found approaching both the upper and the lower altitudinal limits. If we contrast these data with those of the bibliography, we can see that the limits indicated by Emberger (1938) between 1100 and 1800 m, by Charco (2001) between 1200 and 1800 m, or by Benabid and Fennane (1994) between 1000 and 1800 m, are in closer conformity with our findings than the data presented by Benabid (2000) between 900 and 1400 m, 1100 and 2200 m by Alifriqui (1995) or by Farjon (2005) between 900 and 2220 m.

Occurrence conditions

We did not find a direct influence of the substrate on the occurrence of *C. atlantica*, although we have never found it on the basalts, as reported by Earle (2008). The species has been observed on the slightly acid, undeveloped soils overlying sandstones, more basic soils on schists, and the carbonated soils on the dolomites (Hollard et al. 1985). The soils are as a rule poorly developed or undeveloped, very stony and covered with stones and rocks (Appendix 2). The same types of substrate were reported earlier for communities of *C. atlantica* (Quézel and Barbero 1981; Ech-Chamikh 1983; Achhal 1986; Quézel et al. 1994; Alifriqui 1995; El Wahidi 2004).

The close connection of the remnants of the *C. atlantica* groves with the strongly inclined slopes, observed in the field, may reflect the smaller accessibility of such a site and its uselessness for human agricultural activity. It concerns mostly the vicinities of villages and settlements, where some less steep slopes have been converted into small patches of vegetable plots, especially in the basal parts of the hills. The old trees, existing among settlements or not far from them, have been preserved for their shade. Some of them are of impressive dimensions, as near the Ijoukak Forest House (Maison Forestière, Ijoukak).

The northern or close to northern exposures (Fig. 3B) and slightly concave forms of the terrain at most of the localities can indicate the higher degree of survival of *C. atlantica* in the N'Fiss valley on the sites retaining humidity for a longer time span, when compared to the drier conditions present on the southern slopes and raised relief forms. The predominantly winter precipitation and very restricted rain during spring and summer over the studied area (Alifriqui 1995; Alifriqui et al. 1995) are probably a limitation for the cypress, which is replaced on the drier sites by junipers.

Phytosociology

The specific species composition of woodland with *C. atlantica* (Table 3, Appendix 2) led Asensi et al. (2007) to propose a new syntaxon *Junipereto turbinatae-Cupressetum atlanticae* Quézel et Barbero in Asensi et al. 2007. The first eight inventories published by Quézel and Barbero (1981) as *Coronillo ramosissimae-Juniperetum phoeniceae* subass. *cupressetosum atlanticae* Quézel et Barbero 1981, *nom. inval.*, ought also to be referred to this syntaxon. The *Junipereto turbinatae-Cupressetum atlanticae* belongs, together with *Coronillo ramosissimae-Juniperetum phoeniceae* Quézel et Barbero (1981), *Warionio saharae-Antirrhinetum ramosissimae* Quézel et Barbero (1981), *Retamo dasycarpae-Juniperetum phoeniceae* Quézel et Barbero (1981) and *Micromerio hochreuteneri-Cupressetum atlanticae* to the alliance *Ephedro nebrodensis-Juniperion* Quézel et Barbero (1981) 1986, order *Ephedro-Juniperetalia* Quézel et Barbero 1981 ex Quézel, Barbero, Benabid, Loisel et Rivas-Mart. (1988).

The *Junipero turbinatae-Cupressetum atlanticae* is characterized by the high frequency of *C. atlantica, Polygala balansae, Asparagus albus* L., *Thymus saturejoides* and *Ephedra nebrodensis* Guss. The high number of Atlas endemic plants which are observed in this association is Noteworthy. Apart from the cypress, *Polygala balansae, and Coronilla ramosissima* are frequently present. They are found in steeper slopes and more eroded soils.

The *Micromerio hochreuteneri-Cupressetum atlanticae* colonizes more gentle slopes and less eroded soils. It presents a high degree of biodiversity and a high number of Atlas endemic plants. The following are characteristic taxa, not present in the *Junipero turbinatae-Cupressetum atlanticae: Capparis spinosa* L., *Ephedra fragilis* Desf., *Lavandula pedunculata* subsp. *atlantica, Olea europaea* L. subsp. *oleaster* (Hoffmanns et Link) Greuter et Burdet, *Pistacia atlantica* Desf., *Rhus tripartita* (Ucria) Grande and *Micromeria hochreutineri* (Briq.) Maire. It makes the association an important element of the ecosystem, which developed independently on the substratum, mostly on the lower parts of the slopes, at altitudes of 1000–2000 m in the closed valleys of the High Atlas. The open structure of the tree component of these woodland communities allows for the existence of high numbers of species in the open areas (Table 3). The dispersed nature of the tree's occurrence in the woodlands and the presence of the characteristic plants above was

interpreted as a "pré-steppique" character of these plant communities (Quézel and Barbero 1981). The presence of ruderal plants indicates the long-lasting anthropogenic influence, among them interim cultivation and above of all a pastoralism of the areas covered with associations included within the *Ephedro nebrodensis-Juniperion turbinatae* Quézel & Barbero in Asensi et al. (2007) alliance.

Woodland structure

From the physionomic viewpoint, the woodland formations with *C. atlantica* have received the name of pre-steppe juniper communities (Quézel and Barbero, 1981). These formations, though dominated by trees, nevertheless have a very low percentage coverage, which oscillates between 20% and 60% (Appendix 2). The crowns (which fail to form a canopy) modify only to a small degree the light that reaches the inferior woodland layers, and so these strata are composed of heliophilous shrubs and plants woody at the base. Despite the pre-steppe epithet, the herbaceous layer is dominated by small chamaephytes rather than by grasses. This name designates the physionomic aspect of these formations rather than the strict floristic one usually associated with the steppe concept, and so we are speaking of steppe landscape in its wider sense. For these types of formation, perhaps it would be more appropriate to refer to them as open woodland in continental arid environments.

Conservation

According to IUCN (2006), *C. atlantica* belongs to the EN (A1bc, B1+2b) category. This means that it is considered ENDANGERED, but due to a reduction of the population size, based on direct observation. Such a reduction in the area of the taxon requires that its status be modified (A1ac). It occupies an area of less than 100 km^2 and is under a continuous process of diminishment (B1b) in conformity with the IUCN (2006). The continuous reduction of the area can be influenced by natural and anthropogenic factors. The natural one is the progressive aridisation of the environment. In this context, gradual climate warming combined with an expected reduction in the precipitation will be a very serious threat for this species. It occurs now where site conditions provide better access to the water on the N and W-facing slopes and the concave relief forms.

The anthropogenic influence is connected with the direct exploitation of timber and increasing pastoral activity and small-scale agriculture near human settlements. Grazing reduces the woodlands' regenerative capacity, and the exploitation of the wood is linked to traditional uses by the rural society of this valley. A continual dwindling of the area occupied by the tree has been observed in the last few decades, and the present stands are far from the potential area of occupation, and from the 10,000 ha calculated in 1938 by Emberger. Anthropogenic pressure is a fundamental aspect of the landscapes of *C. atlantica* woodland. In most of the localities regeneration of the species is absent, and its existence is under threat (Alifriqui et al. 1995; Oldfield et al. 1998; Ouahmane et al. 2006). There is an urgent need to take measures to reconcile traditional grazing methods alongside the conservation of the present populations of this endemic cypress (Administration 1992). The cypress woodland from the N'Fiss has been classified as a priority ecological and biological conservation site (F.A.O. 1976; Administration 1992) and an Important Plant Area (Fennane 2004). It should be followed by specific rules for its protection and conservation. At least the plight of *C. atlantica* is not as dramatic as that of *C. dupreziana*, which occurs in Tassili n'Ajjer in the Algerian Central Sahara (Abdoun and Bediaff 2002) and is categorized as critically endangered in the IUCN Red List (2006).

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(Appendices are at the end of volume.)

Appendix 1. Locality of populations. groups of trees and single individuals of *C. atlantica* in N'Fiss Valley (A. Romo. Y. Didukh and A. Boratyński 2005. field observations)

Field observations	Lat_N	Long_W	Altitude [m]
NE of Talat-n-Ya'qoub			
Between Outakhri and Ijoukak, N of Foresty, WKL	30.997	8.147	1360
Ijoukak, above Forestry, NW, ZB	30.998	8.152	1360
Between Outakhri and Ijoukak, N of Foresty, slopes of the gorge, N, ZB	30.998	8.148	1340
Between Outakhri and Ijoukak, N of Foresty, slope saboe the small gorge, N, ZB	30.998	8.139	1430
Between Outakhri and Ijoukak, N of Foresty, slopes above the road, NW, ZB	31.004	8.151	1320
Between Outakhri and Ijoukak, N of Foresty, WKL, W, ZB	31.008	8.134	1270
Outakhri, ZB	31.009	8.147	1400
Outakhri, ZB	31.01	8.148	1350
Outakhri, ZB	31.011	8.15	1280
Outakhri, ZB	31.012	8.151	1250
Between Alla-n-Mzeghni and Outhakri, WKL, ZB	31.013	8.144	1300
Between Alla-n-Mzeghni and Outhakri, WKL, ZB	31.014	8.145	1340
Between Alla-n-Mzeghni and Outhakri, WKL, ZB	31.016	8.143	1250
Alla-n-Mzeghni, small gorge S of village, N, ZB	31.018	8.139	1250
Alla-n-Mzeghni, small gorge S of village, NW and N, ZB	31.024	8.136	1200
Targa-n-Ait-Irafene, small gorge above village, N, WKL	31.034	8.148	1200
Between Iguer Kouris and Targa-n-Ait Iratene, SW, ZB	31.035	8.139	1150
Between Iguer Kouris and Targa-n-Ait Iratene, N, ZB	31.039	8.136	1150
Between Iguer Kouris and Targa-n-Ait Iratene, NW, ZB	31.04	8.133	1150
Between Iguer Kouris and Targa-n-Ait Iratene, W, WKL	31.041	8.133	1120
Targa-n-Ait-Irafene, small gorge N of village, NE, WKL	31.042	8.143	1180
Between Iguer Kouris and Targa-n-Ait Iratene, SW, ZB	31.042	8.133	1150
Above Iguer Kouris, W, ZB	31.049	8.133	1150
Iguer Kouris, W, WKL	31.05	8.133	1160
Between Tigouramine and Tough al Kheyr	31.06	8.138	1100
Tigouramine, NE, ZB	31.069	8.136	1060
Tough al Kheyr, SW slopes of Jbel Talfanart, ZB	31.07	8.135	1060
N of Iguer Kouris, SW, ZB	31.56	8.134	1130
SW of Talat-n-Ya'qoub			
Around Muldirt, NW, WKL	30.892	8.285	1610
Tanzzat, N of village, N, WKL, ZB	30.902	8.293	1700
Ifezd ad ene, S slopes N of village, WKL, ZB	30.909	8.316	1800
Around Muldirt, NE, WKL	30.909	8.288	1580
Around Muldirt, NE, WKL	30.911	8.288	1530
Idni, W of village, N, ZB	30.912	8.304	1650
Idni, near Forestry, NE, ZB	30.912	8.294	1600
Idni, near Forestry, NE, ZB	30.913	8.291	1550
Idni, near auberge, ZB	30.913	8.288	1610
Idni, 2 km W of village, slopes above the road, E, WKL	30.914	8.306	1800
Idni, W of village, slopes above the road, NW, ZB	30.914	8.303	1590

Field observations	Lat_N	Long_W	Altitude [m]
Around Muldirt, E, ZB	30.915	8.29	1550
Idni, W of village, slopes above the road, NE, WKL	30.916	8.301	1530
Idni, W of village, slopes above the road, NW, WKL	30.916	8.299	1560
Idni, W of village, slopes above the road, N, WKL	30.916	8.295	1600
Idni, W of village, slopes above the road, NE, WKL	30.916	8.294	1590
Around Muldirt, NE, WKL	30.916	8.285	1480
Mouldirt, S of village, N, ZB	30.916	8.278	1505
Around Muldirt, SE, WKL	30.919	8.289	1500
Around Muldirt, NW, WKL	30.92	8.28	1460
Moulddirt, N of village, NW, WKL	30.92	8.276	1520
Isoul, W of village, SE, WKL, ZB	30.927	8.297	1500
Between Isoul and Talatane, SE, WKL, ZB	30.927	8.14	1520
Between Isoul and Talatane, SE, WKL, ZB	30.927	8.12	1600
Agadir-n-Tagountaft, slopes and gorges around the village, NW, WKL	30.928	8.266	1540
Agadir-n-Tagountaft, slopes and gorges around the village, N, WKL	30.93	8.272	1460
Isoul, NW of village, E, WKL, ZB	30.932	8.23	1500
Between Tagmout and Issoul, E, WKL, ZB	30.933	8.29	1430
Agadir-n-Tagountaft, slopes and gorges around the village, NW, WKL, ZB	30.933	8.263	1490
Tagmout, N of village, SE, WKL, ZB	30.934	8.29	1500
Idni, W of village, slopes above the road, NW, ZB	30.935	8.296	1480
Agadir-n-Tagountaft, slopes and gorges around the village, NW, WKL, ZB	30.935	8.257	1530
Agadir-n-Tagountaft, slopes and gorges around the village, NW, WKL, ZB	30.935	8.251	1590
Between Tagmout and Issoul, E, WKL, ZB	30.936	8.29	1510
Agadir-n-Tagountaft, slopes and gorges around the village, S, WKL	30.936	8.264	1450
Agadir-n-Tagountaft, slopes and gorges around the village, W, ZB	30.938	8.248	1605
Agadir-n-Tagountaft, slopes and gorges around the village, S, WKL	30.939	8.259	1600
Ighil, SE of village, N, WKL, ZB	30.942	8.252	1720
Between Ighil and Taous, above the main road, N, WKL, ZB	30.943	8.255	1600
Tagmout, N of village, NE, WKL, ZB	30.944	8.278	1450
Ighil, SE of village, N, WKL	30.945	8.252	1650
Between Taous and Tagmout, E, WKL, ZB	30.946	8.28	1500
Taous, E slopes W of village, ZB	30.946	8.278	1430
Between Ighil and Taous, above the main road, N, WKL, ZB	30.947	8.258	1500
Ighil, SE of village, N, WKL, ZB	30.948	8.252	1550
Ighil, SE of village, N, WKL, ZB	30.948	8.249	1520
Between Ighil and Taous, above the main road, N, WKL, ZB	30.949	8.254	1400
Between Tasouakt and Ighil, N, WKL, ZB	30.951	8.246	1500
Between Tasouakt and Ighil, NW, WKL, ZB	30.953	8.241	1560
Ighil, N of village, SE, WKL, ZB	30.955	8.26	1420
Ighil, N of village, SE, ZB	30.956	8.26	1510
Ighil, NW of village, E, WKL, ZB	30.957	8.267	1520
Ighil, NW of village, E, WKL, ZB	30.958	8.268	1620

Field observations	Lat_N	Long_W	Altitude [m]
Ighil, NW of village, E, ZB	30.958	8.267	1570
Tasouakt, E of village, NW, WKL, ZB	30.96	8.244	1450
Ighil, NW of village, E, ZB	30.961	8.262	1710
Tasouakt, W of village, E, WKL, ZB	30.961	8.25	1460
Tasouakt, E of village, NW, WKL, ZB	30.961	8.243	1550
Between Mzouzit and Tasouakt, NE, WKL, ZB	30.961	8.239	1590
Tasouakt, W of village, E, WKL, ZB	30.962	8.256	1520
Between Mzouzit and Tasouakt, N, WKL, ZB	30.962	8.241	1450
Mzouzit, W of village, SE, ZB	30.966	8.246	1330
Mzouzit, W of village, E, ZB	30.967	8.247	1450
Mzouzit, E of village, W, WKL, ZB	30.968	8.234	1520
Mzouzit, E of village, W, WKL, ZB	30.968	8.232	1550
Mzouzit, W of village, NE, ZB	30.97	8.244	1280
Mzouzit, E of village, W, WKL, ZB	30.971	8.237	1450
Mzouzit, N of village, NW, WKL, ZB	30.972	8.236	1420
Mzouzit, W of village, N, ZB	30.976	8.248	1340
Tinmal, N slopes above the road, toward Mzouzit, ZB	30.976	8.221	1420
Tinmal, NW slopes above the road, WKL, ZB	30.978	8.223	1450
Tinmal, N, ZB	30.98	8.221	1400
TADAFELT			
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.98	8.336	2050
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.98	8.333	2000
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.982	8.333	1900
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.983	8.333	1830
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.984	8.33	1860
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.985	8.327	1790
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.985	8.326	1800
Alous N of Tadafelt, slopes of Adrar Tadafelt, NE, WKL	30.986	8.334	1780
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.986	8.332	1720
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.986	8.328	1710
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.986	8.324	1820
Alous N of Tadafelt, slopes of Adrar Tadafelt, E, ZB	30.987	8.339	1930
Alous N of Tadafelt, slopes of Adrar Tadafelt, NE, ZB	30.987	8.338	2000
Alous N of Tadafelt, slopes of Adrar Tadafelt, NE, ZB	30.987	8.335	1830
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.987	8.324	1710
Alous N of Tadafelt, N slopes of Adrar Tadafelt, N, WKL	30.987	8.323	1760
S of Iguer, slopes of Adrar Tadafelt, NW, WKL	30.987	8.321	1760
S of Iguer, N slopes of Adrar Tadafelt, NW, ZB	30.987	8.32	1840
W of Khassaf, N, WKL	30.988	8.348	1920
Alous N of Tadafelt, N slopes of Adrar Tadafelt, NE, WKL	30.988	8.333	1740
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.988	8.328	1650
Alous N of Tadafelt, N slopes of Adrar Tadafelt, N, WKL	30.988	8.326	1670

Field observations	Lat_N	Long_W	Altitude [m]
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.988	8.323	1640
S of Iguer, N slopes of Adrar Tadafelt, NW, ZB	30.988	8.32	1740
W of Khassaf, NW, ZB	30.989	8.342	1750
S of Khassaf, N, WKL	30.989	8.341	1950
Alous N of Tadafelt, Adrara Tadafelt, NE, WKL	30.989	8.33	1650
Between Khassaf and Iguer, S parts of Jbel Imlit, S ZB	30.989	8.327	1660
Alous N of Tadafelt, N slopes of Adrar Tadafelt, NE, WKL	30.99	8.335	1800
W of Khassaf, N, WKL	30.991	8.347	1850
S of Khassaf, NE, WKL	30.991	8.343	1920
S of Khassaf, NE, ZB	30.991	8.342	1840
S of Khassaf,N, ZB	30.991	8.339	1750
W of Khassaf, NW, ZB	30.992	8.347	1800
S of Khassaf, NE, ZB	30.992	8.343	1740
Between Khassaf and Iguer, S parts of Jbel Imlit, W, ZB	30.992	8.33	1670
S of Iguer, slopes of Adrar Tadafelt, SE, WKL	30.992	8.321	1630
S of Khassaf, NE, WKL	30.993	8.344	1800
S of Khassaf, N, WKL	30.993	8.339	1880
E of Khassaf, NE, WKL	30.993	8.336	1820
Between Khassaf and Iguer, S parts of Jbel Imlit, W, WKL	30.993	8.33	1710
E of Khassaf, W, WKL	30.995	8.338	1780
E of Khassaf, NE, ZB	30.995	8.336	1790
Alous N of Tadafelt, Adrar Tadafelt, NE, WKL	30.995	8.335	1860
Alous N of Tadafelt, slopes of Adrar Tadafelt, N, WKL	30.995	8.332	1780
Between Khassaf and Iguer, S parts of Jbel Imlit, NW, WKL	30.995	8.328	1950
E of Khassaf, NE, WKL	30.996	8.337	1800
E of Khassaf, NE, WKL	30.996	8.336	1700
E of Khassaf, NE, WKL	30.996	8.335	1680
Between Khassaf and Iguer, S parts of Jbel Imlit, SW, WKL	30.997	8.333	1670
Between Khassaf and Iguer, S parts of Jbel Imlit, W, WKL	30.997	8.331	1650
Between Khassaf and Iguer, S parts of Jbel Imlit, SW, WKL	30.997	8.33	1780
E of Khassaf, N, ZB	30.998	8.337	1700
Alous N of Tadafelt, Adrar Tadafelt, N, WKL	30.999	8.329	1940
NE of Khassaf, SW, WKL	31.003	8.334	1750

Abbrevations: E – east. eastern; N – north. northern. NE – north-east. north-eastern. NW – north-west. north-western. S – south. southern. SE – soth-east. south-eastern. SW – south-west. south-western. W – west. western. WKL – concave. WYP – convex. ZB – slope

Appendix 2. *Micromerio hochreuteneri-Cupressetum atlanticae, ass. nova*

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	Synt	Q&B
Altitude m	1681	1551	1515	1510	1505	1463	1474	1483	1425	1562	1303	1310	1330	1080	1563	1500	1540	1468	1654	1596	1602	1590	1570	1580	1594	1596	1532	1530	1526	1540	1570	1607	1615		
Aspect	NW	N–NW	N	N	N	W	NW	W	W	W	E	NE	NE	W	NW	N	NE	NW	NW	NW	NW	N	N–NW	NW	N–NW	N	NW	S	S	S-SE	SE	SW	SE		
Slope	40	25	20	40	40	40	40	40	30	25	30	30	40	40	35	40	45	30	30	30	30	30	35	30	30	15	30	40	25	40	40	40	30		
Tree height [m]	8–10	4–10	4–10	>6	>6	>8	>10	>9	>10	8–10	10	>10	>8	>5	6	6	6	6	6	7	6	8	7	8	8	10	10	5–7	6	4–7	>6	8	10–12		
Tree cover [%]	25	20	20	15	20	10	20	30	40	60	30	25	15	20	30	35	25	35	30	30	35	50	40	30	40	10	50	40	25	30	20	40	70		
Shrub height [m]	1–3		2–4	>2	>2	0.5–1.5	0.5–2	0.5–2	0.4–2	0.5–2	0.4–1.5	0.4–1	0.5–1	40	50	50	40	50	50	60	60	50	50	60	80	40	50	60	60	60	50	40	50		
Shrub cover [%]	60	25	30	15	20	45	40	30	30	10	20	30	35	50	20	20	30	40	40	20	30	30	40	40	20	80	35	30	35	40	40	20	15		
Herbs height [cm]	60	50	60	60	60	55	60	65	60	50	60	60	60	50	50	60	60	60	50	50	50	60	50	50	40	40	40	30	40	40	30	30	40		
Herbs cover [%]	40	35	40	40	40	40	45	45	50	50	40	45	40	30	30	35	40	40	35	15	30	40	40	30	30	40	30	40	40	30	35	40	40		
Stone coverture [%]	30	40	40	60	50	50	40	40	35	40	45	40	50	20	10	40	60	30	40	70	40	50	45	50	20	30	60	20	70	50	40	30	80		
Area studied m²*	80	100	120	100	100	100	80	100	100	100	100	100	100	100	100	100	80	100	100	70	80	100	100	100	100	90	90	100	100	80	100	100	100		
Characteristics Ass. Al. & Or.																																			
Cupressus atlantica	2,3	2,3	1,1	2,2	2,2	2,2	2,2	2,2	3,3	4,4	2,3	3,3	1,1	2,3	1,2	2,3	2,2	2,3	2,2	2,3	2,3	3,4	2,3	2,3	3,3	1,2	2,3	3,4	3,4	2,3	1,2	1,2	3,4	33	8
Juniperus oxycedrus	1,1	1,1	1,1	1,1				+	+	.	.	.	.	.	.	.	.	.	2,3	2,2	.	1,1	.	.	+	.	.	.	.	.	.	.	.	10	5
Juniperus phoenicea	2,2	2,2	3,3	2,2	1,1	1,1	1,1	2,2	2,2		2,2	2,2	1,1	2,2	1,1	1,2	1,1	1,1	1,1	.	1,1	1,1	1,2	1,2	1,2	1,1	+	.	.	.	.	.	.	25	8
Quercus rotundifolia	1,1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1,1	1,1	+	.	.	.	.	.	.	.	.	.	.	.	4	1
Asparagus albus	.	.	.	.	.	.	.	.	.	.	1,1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1
Capparis spinosa														.	2,2	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	2	
Ephedra fragilis														1,2	.	.	.	.	.	.	.	.	.	.	1,1	.	.	.	.	.	.	.	.	2	
Ephedra nebrodensis	.	.	.	.	1,1	1,1	.	.	.	.	2,2	1,1	.	.	2,3	.	1,1	.	.	.	.	.	.	.										6	8
Coronilla ramosissima	2,2	.	.	.	.	.	.	.	.	.	+	1,1	.	1,1	.	.	.	.	.	1,1	+	.	1,1	2,3	1,2	1,2	.	.	.	.	.	.	.	10	5
Lavandula dentata	2,2	2,2	2,2	3,3	2,2	3,3	3,4	2,3	2,3	2,2	.	2,2	.	1,1	.	.	1,1	2,2	.	.	2,2	2,2	2,3	.	1,1	.	.	.	.	.	.	1,2	.	19	6
Lavandula pedunculata subsp. atlantica	.	1,1	1,1	.	.	.	.	.	.	.	.	.	.	1,1	.	2,2	2,3	.	1,1	1,2	+	.	.	.	.	.	.	.	.	.	.	.	.	8	
Olea europaea ssp. *oleaster*														+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	2	
Polygala balansae	.	.	.	1,1	1,1	1,1	2,2	1,1	.	1,1	.	+	1,1	+	.	1,2	2,2	3,3	2,3	1,1	1,2	2,2	.	2,2	1,1	1,2	.	.	1,2	1,2	1,1	+	.	23	8
Pistacia atlantica														1,2	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	2	
Rhus tripartita														+	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	.	+	.	2	
Micromeria hochreutineri	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	1,1	.	.	.	.	.	+	.	1,1	1,1	+	1,1	.	1,2	.	+	.	10	
Ziziphus lotus	.	.	.	.	.	.	.	.	.	.	1,1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2
Acompanying taxa																																			
Adenocarpus anagyrifolius														.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	
Alyssum granatense														+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	2	
Anarrhinum fruticosum																									.	.	+	.	.	.	.	.	1,1	2	
Avenula bromoides	.	.	1,1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	+	+	.	.	.	.	.	.	.	5	
Brachypodium distachyon														+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	2	
Carlina involucrata	+	.	.	+	.	+	+	.	+	1,1	1,1	+	+	.	.	+	1,1	+	.	+	.	.	.	.	+	.	+	+	+	+	1,1	1,1	.	20	1

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	Synt	Q&B
Cistus villosus	3,3													.	.	.	.	.	+	2,2	2,2	.	2,2	.	.	.	.	.	.	.	.	.	5	2
Cladanthus arabicus														1,1	1,1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	
Cuscuta sp.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	
Cymbopogon schoenathus	.	.	.	.	.	.	.	.	.	.	.	+	.	2,2	1,1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1
Cynosurus echinatus	.	.	.	1,1	1,1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	
Dactylis glomerata subsp. *hispanica*	.	.	1,1	1,1	.	.	.	.	1,1	+	.	.	.	.	.	.	.	.	.	+	1,1	+	+	.	.	.	.	+	.	.	.	.	.	2	
Deverra scoparia														.	+	.	.	.	.	.	.	.	.	.	.	.	1,1	+	.	+	+	1,1	.	9	
Dittrichia viscosa	.	.	.	.	.	.	.	.	.	+	.	.	.																						
Echinops strigosus	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	1,1	.	.	.	.	+	+	+	.	.	.	.	.	+	.	6	
Globularia alypum	1,1	.	.	.	1,1	1,1	.	.	.	.	.	.	.	1,1	.	.	.	.	1,1	.	+	+	.	.	.	.	1.1.	1,2	1,2	1,1	1,2	+	1,1	7	2
Helianthemum salicifolium	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14	
Lamarckia aurea														.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	2	
Launea arborescens	.	.	.	.	.	.	.	.	.	.	1,1	+	1,1	1,1	+	.	.	.	.	.	.	.	.	.	.	.	1,1	1,1	+	.	.	.	+	2	1
Linaria reflexa	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9	
Medicago cf. *sativa*														+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	2	
Ononis cf. *atlantica*														.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	2	
Ormenis scariosa														.	.	.	.	.	1,1	.	.	.	.	+	1,1	1,1	.	.	.	.	+	.	.	2	
Paronychia argentea														.	.	+	1,1	.	.	.	+	.	.	.	.	.	+	.	.	+	.	.	.	5	
Petrorhagia illyrica	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	+	.	.	.	+	.	.	.	+	1.1.	1,1	.	.	.	.	+	.	.	5	
Phagnalon saxatile										+				+	.	.	.	+	.	.	+	+	.	.	.	.	+	.	.	.	.	.	1,1	9	
Piptathereum miliaceum	.	.	.	.	.	.	.	.	.	.	1,1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	1
Poa bulbosa	.	.	.	2,2	1,1	1,1	1,1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	
Polycnemum fontanesii	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	+	.	.	.	.	+	.	+	.	.	5	1
Polygala rupestris																									.	.	.	.	.	1,1	.	.	+	6	
Ruta montana														.	+	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	2	
Salvia taraxicifolia																									.	.	.	.	.	.	+	+	.	3	
Santolina rosmarinifolia	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	2	
Satureja hochreutineri	.	.	.	.	.	.	.	.	.	.	.	+	.																						
Senecio flavus														+	1,2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	
Silene sp.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	2	
Stipa lagascae	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1,1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3
Stipa nitens														+	.	.	.	.	1,1	.	.	.	.	.	.	.	.	+	+	+	+	1,1	+	3	
Teucrium polium s.l.														+	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	8	
Thymus saturejoides	.	2,2	2,2	3,3	2,2	2.2.	.	1,1	2,2	.	1,1	.	2,3		1.1	2.2	2.2	2.3	2.3	1.1	3.3	3.3	1.2	3.3	2.2	3.3	3.3	2.2	2.3	3.3	2.2	1.1	.	4	7

Taxa present in a single relevé: *Arenaria leptoclados* (20); *Asphodelus ayardii* (14); *Ballota hirsuta* (14); *Bromus sterilis* (18: 1.1); *Bupleurum spinosum* (31); *Catananche caerulea* (14); *Cheilanthes vellea* (14); *Convolvulus* cf. *althaeoides* (14); *Dittrichia viscosa* (10); *Eryngium* cf. *tricuspidatum* (17); *Feeria angustifolia* (27); *Galium* cf. *verticillatum* (30); *Hyparrhenia hirta* (27); *Linaria* cf. *ventricosa* (18); *Lycium intrincatum* (14); *Micropus erectus* (20); *Nerium oleander* (14); *Opuntia ficus-barbarica* (15); *Pallenis spinosa* (14); *Plantago afra* (33); *Ptilostemon dyricola* (10); *Pulicaria maroccana* (33); *Rhamnus atlantica* (33); *Schismus mollis* (29); *Telephium imperati* (27); *Vulpia* cf. *ciliata* (6: 1.1); *Urginea marítima* (10); *Valerianella microcarpa* (20).

Origin of relevés: 1–9: High Atlas, N fiss Valley, betwen Nyukub and Ilmij. 10–13 Above Yukub, to Tizi-n'Test; 14. N'Fiss Valley, between Ijoukak and Iger-n-Kouris, 31°05'N 8°07'W; 15. Taslit Valley, West of Mzouzit, near Ighil, 30°58' N 8°17'W; 16–18. Taslit Valley, West of Mzouzit, between Ighil and Iguer, 30°58' N 8°16'W; 19–22. N'Fiss Valley, between Tagmout and Assoul, 30°54'N 8°18'W; 23–24. N'Fiss Valley, between Mould-dirt and Tauzzat, 30°54'N 8°17'W; 25–26. N'Fiss Valley, near Tagmout, 30°55'N 8°17'W; 27–31. Taslit Valley, West of Mzouzit, near Iguer, 30°59' N 8°19'W; 32–33. Taslit Valley, West of Mzouzit, near Khassat, 30°59' N 8°19'W

Q & B, resumé of eight relevés published by Quézel & Barbero (1981)

*In some cases, the studied areas are less than 100 m² due to the difficulty of finding greater homogeneous surfaces representative of this type of woodland.