Article

Fl. Medit. 32: 327-338
https://doi.org/10.7320/FlMedit32.327
Version of Record published online on 28 December 2022

Hicham El Zein & Rhéa Kahale

First comprehensive IUCN Red List assessment of 100 endemic species of the flora of Lebanon

Abstract

El Zein, H. & Rhéa Kahale, R.: First comprehensive IUCN Red List assessment of 100 endemic species of the flora of Lebanon. — Fl. Medit. 32: 327-338. 2022. — ISSN: 1120-4052 printed, 2240-4538 online.

This review presents the first IUCN Red List of 100 vascular plant species endemic to Lebanon. The taxa were assessed using the IUCN guidelines and criteria to evaluate their conservation status. Assessed taxa are either endemic to the coast of Lebanon, the Beqaa, the mountain ranges of Mount Lebanon, Anti-Lebanon and Mount Hermon. Most of the species assessed were in the Endangered category (54), followed by the Vulnerable (20), Critically Endangered (16), Least Concern (7), Near Threatened (2) and Data deficient (1). The rarity of these endemic taxa was illustrated by the fact that 29% had an AOO inferior or equal to 20 km². Unregulated urbanisation, road construction, quarries, forest fires and overgrazing constituted the main causes for the decrease of many endemic species. Most of the threatened taxa occurred in rocky habitats, woodlands and shrublands of the supra (20), montane (36), oro-Mediterranean (28) belts. Around 81% and 70% of the taxa respectively listed as CR and EN were located in the montane and oro-Mediterranean belts. Only 2 taxa occurred in coastal habitats and only 8 were related to wetlands. Thirty-five of the threatened taxa were included in at least one protected area, while 17 were present in two protected areas. Mount Hermon hosted 17 threatened taxa, followed by Horsh Ehden (9), Jabal Moussa (8), Chouf Biosphere (7), Tannourine (6), Ehmej el-Dichar (3), Ras Chaqaa (1) and Yammoune (1). The distribution of the threatened taxa within protected areas highlighted the fact that some habitats are underrepresented in the network of natural reserves in Lebanon. High plateaus of the oro-Mediterranean belt over 2000 m were the less protected habitats. The regions of Mounts Makmel, Mneitre, Sannine and Kneisse particularly lacked protection, as well Anti-Lebanon range. These areas should be targeted in priority for conservation actions such as the creation of protected areas. Due to the limited size of the country and its high density in human population, most of the threats are widespread but vary depending on the altitudinal belt.

Key words: Levant, Mediterranean Basin, flora, threats, conservation, species.

Introduction

There is currently a global crisis on biodiversity with the sixth mass extinction threatening an important number of species due to the direct or indirect impacts of human activities (Ceballos & al. 2015; Torres-Romero & al. 2020). Red Lists have become an essential

reference prior to the establishment of conservation strategies (Brummit & al. 2008; Betts & al. 2020) and the role of the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species has become fundamental as it brought the scientific community to use comparable standardised system to estimate the vulnerability of species and to quantify their risks of extinction (Possingham & al. 2002). It also encourages the compilation of important amount of data about each species (Rodrigues & al. 2006).

The Mediterranean Basin, a region that simultaneously shelters exceptional concentrations of endemic species and experiences a high rate of loss of habitat, was considered as one of the global hotspots (Myers & al. 2000; Cuttelod & al. 2008). Located in the eastern Mediterranean, Lebanon consists of a local hotspot for biodiversity (Médail & Quézel 1997; Verlaque & al. 1997). The flora of Lebanon consists of 2612 specific and subspecific taxa. Lebanese exclusive taxa (strictly endemics) are 154 (Tohmé & Tohmé 2014). The efforts to catalogue the floral diversity of Lebanon to identify the areas of high floristic diversity and endemism where the conservation effort should concentrate (Bou Dagher-Kharrat & al. 2018; El Zein & al. 2018), the construction of a Red List of threatened plant species for the country constitute another essential tool for practitioners. This paper focuses on the conservation status of the vascular endemic species of Lebanon.

Materials and Methods

Data

In addition to the knowledge of the authors and local experts involved in conservation, data about the endemic species was collected actively between 2012 and 2020: The herbarium samples collected during the 19th and 20th centuries gathered in bibliographic references (Mouterde 1966, 1970, 1984) gave precious indications about the occurrences of endemic species in the country. The historical localities reported from the samples were visited in priority to verify if the populations were still extant. The field observations allowed the update of most of the historical information. When the plants were not observed during exploration, the most recent reference for species occurrences in Lebanon was used (Tohmé & Tohmé 2014). Taxonomy was updated in accordance with the International Plant Names Index (INPI 2022) and the Euro+Med Plantbase (2022). The maps were prepared with QGIS software (QGIS Development Team 2022) using layers available on the DIVA-GIS website (2022).

The targeted species are endemic to Mount Lebanon and/or Anti-Lebanon and/or Mount Hermon and/or the Beqaa or to the coastal Mediterranean strip. Altitudinal belts were used to differentiate the zonation of the vegetation in Lebanon. They were defined based on the work of Abi-Saleh (1982): coastal-Mediterranean is the belt influenced by the Mediterranean Sea, thermo-Mediterranean is located between the coast and 500 m, meso-Mediterranean between 500 to 1000, supra-Mediterranean between 1000 to 1600 m, montane-Mediterranean between 1600 and 2000 and oro-Mediterranean above 2000 m. The protected areas include the nature reserves and the nature sites under the protection of the Ministry of Environment of Lebanon (MoE-UNEP-GEF 2016).

Red Listing

The International Union for Conservation of Nature (IUCN) Red List categories and guidelines (2022) were the reference used to evaluate the conservation status of the endemic species. Seven categories were used to define the species: Extinct (EX), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC) and Data Deficient (DD). Among the five criteria, B (geographic range) and D (very small or restricted population) were used as they were based on data related to geographic distribution, which was available for most of the taxa. The number of subpopulations, number of locations, the extent of occurrence (EOO) and the area of occupancy (AOO) were calculated for each taxon. The calculation of the EOO and AOO, two key parameters for the evaluation of the geographic range of the species, was carried out using the GeoCAT software (Bachman & al. 2011). The EOO is estimated by using the minimum convex polygon method which is the area that encompasses all the occurrences of a taxon in the shortest boundary. The AOO is calculated by summing the number of cells occupied by individuals in a grid of 1 × 1 km. The use of criteria A and C was not possible because data about temporal trends of the species' populations was not available.

In addition to the collection of occurrences of the taxa, the different threats affecting them and their habitats were identified. During several explorations in the same sites, the impacts on the vegetation were observed. For instance, some species had disappeared after the repeated passages of the herds. Depending on the intensity of the grazing and the palatability of the plants, some species would be eaten before having been able to flower or make seeds and others would have been extirpated from the site by the degradation of their habitats due to heavy trampling and soil destruction. Another example is the total eradication of the natural habitats which was observed frequently in many localities due to the construction of buildings, the creation of quarries or the levelling works for the establishment of agricultural terraces. The threats result in the continuing decline of area extent, quality of habitats and number of individuals. Some species are more fragile than others and don't recover properly after being disturbed. Others have a limited capacity of dissemination with reduced seed production. This information was noted attentively to determine the severity of the impacts of the threats on each species as defined by the guidelines of IUCN. Based on the mapping of the species to understand their distribution and the ability of their pollen to be disseminated, the fragmentation of the population was estimated. The data collected about the threats also allowed the calculation of the number of locations for each species. These data are necessary to fulfil the conditions a, b and c of criterion B and to determine the IUCN status.

Threats by altitudinal belts

The presence of the threats affecting the endemic plants was represented by altitudinal belt. For each taxon, the threats were ordered by severity (Electronic Supplementary File 1: Table S1). For example, some species are primarily affected by urbanisation and secondarily by overgrazing. The three first threats were considered for each species. Using the altitudinal belt on which each species occur, the extend of the threats per altitudinal belt was represent in a histogram. The complete references to these assessments published online are included in the ESF1.

Results

Over the 100 endemic taxa assessed, 90 were listed under a threatened category, namely 20 as VU, 54 as EN and 16 as CR. Two species were listed as NT, seven as LC and one as DD. The most used criteria to assess their conservation status were B1 and B2 as the most reliable information available about the taxa was their distribution. The fieldwork yielded a total of 961 observations that could be directly used to map the distribution of the taxa and calculate their AOO and EOO. Twenty-nine species had an AOO inferior or equal to 20 km² and therefore considered as narrow endemic. Thirty-nine taxa had an EOO inferior to 200 km².

Odontarrhena libanotica (Nyár.) Španiel, Al-Shehbaz, D.A.German & Marhold was the only species that was listed as DD as it could not be observed during fieldwork and was not even reported from recent bibliographic references (ESF 1: Table S1). The recent fieldwork allowed the rediscovery of one plant species that was considered possibly extinct, *Hieracium kneissaeum* Mouterde listed as CR. The population was estimated of 436 individuals in Mount Kneisse where it is threatened by the intensification of grazing.

Most of the threatened endemic taxa (83) occurred over 1200 m asl in rocky habitats, woodlands and shrublands of the supra (20)/montane (36)/oro-Mediterranean (27) belts, while two species, *Matthiola crassifolia* Boiss. & Gaill.and *Gagea dayana* Chodat & Beauv. were found in coastal habitats. Only 8 species were related to wet habitats, such as *Alchemilla diademata* Rothm., *Eleocharis macrantha* Boeckeler and *Stachys hydrophila* Boiss.

Threats

The most common threats were urbanisation, overgrazing, quarrying and agriculture as they destroy the species and their habitats, affecting respectively 48%, 40%, 40% and 26% of the taxa. Logging, forest fire and dam construction constituted threats that directly impacted particular taxa or/and their habitats. Collection of plants and reforestation are threats that target particular species. The importance of the threats varies depending on where species occur across the altitudinal belt (Fig. 1). For instance, lower altitude habitats are intensely impacted by urbanisation which includes the construction of houses, commercial buildings and roads, while high plateaus located above 2000 m of altitude are heavily impacted by overgrazing.

The two significant past threats that have affected several locations at high altitude were the construction of ski resorts in Mount Lebanon (Bcharre, Laqlouq, Faraya, Zaarour) and Mount Hermon (on the Israeli-occupied slopes) and their associated touristic housing, as well as the construction of dams (Janne on Nahr Ibrahim river, Bqaatouta on Nahr el-Kalb river, Hamat and Chatin on Nahr el-Joz river). However, these threats could occur again in the future. Climate change is a general threat impacting all taxa at all altitudinal belts. It was considered as a future threat to the taxa occurring below 1600 m of altitude. The taxa occurring over 1600 m of altitude and those occurring in wetlands were considered more vulnerable to warming and drought events. Although primarily affected by quarrying, urbanisation and agriculture, wetland plants like *Alchemilla diademata* might disappear with the intensification of drought events as they totally depend on water.

Presence in protected areas

Only 35 of the threatened taxa were present in at least one protected area, which included one species listed as CR, 21 as EN and 13 as VU. Seventeen taxa were present in 2 pro-

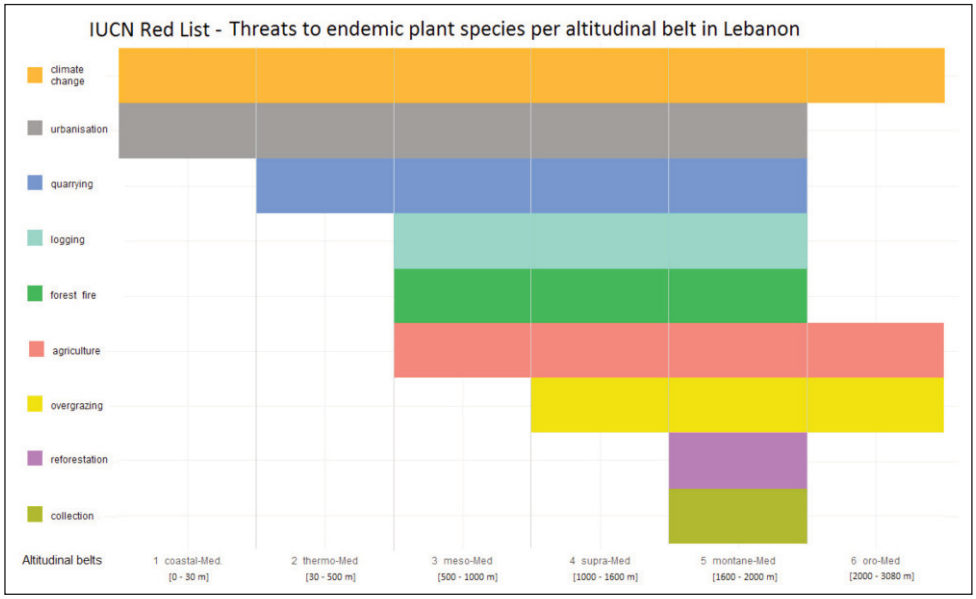

Fig. 1. Threats affecting the 100 assessed endemic taxa in Lebanon according to the altitudinal belt.

tected areas, including 3 species that have their entire distribution included in protected areas, namely *Allium feinbergii* Oppenh., *Cephalaria cedrorum* Mouterde and *Salvia peyronii* Boiss. *Allium feinbergii* was assessed as LC and occurs at the oro-Mediterranean in the nature reserves of Shouf Biosphere and Mount Hermon. Climate change constitutes the most important threat in this context. *Cephalaria cedrorum* was assessed as VU and occurs uniquely at the montane-Mediterranean in Shouf Biosphere. *Salvia peyronii* was assessed as CR and occurs in the nature site of Jabal Moussa at the supra-Mediterranean where it is threatened by over-grazing and forest fires (Fig. 2). Mount Hermon is the protected area that hosted the highest number of threatened taxa with 10 taxa listed as EN and 7 as VU. This is due to the fact that it is the only protected area located in the oro-Mediterranean belt. The other protected areas sheltering threatened taxa in descending order are Horsh Ehden with 9 threatened taxa, followed by Jabal Moussa (8), Shouf Biosphere (7), Tannourine (6), Ehmej el-Dichar (3), Ras Chaqaa (1) and Yammoune (1). Many regions lacking protection are located on the coast, in the east of the country in Anti-Lebanon, and in the north of Mount Lebanon, such as Makmel, Mneitre, Sannine and Kneisse (Fig. 3). Other examples of unprotected taxa are *Astragalus kurnet-es-saudae* Eig, *Matthiola crassifolia* Boiss. & Gaill and *Senecio bertramii* Post. *Astragalus kurnet-es-saudae* occurs at the oro-Mediterranean in North Lebanon and is CR. *Matthiola crassifolia* is a coastal species assessed as EN and threatened by intense urbanisation. *Senecio bertramii* was assessed as CR and occurs at the montane-Mediterranean in North Lebanon.

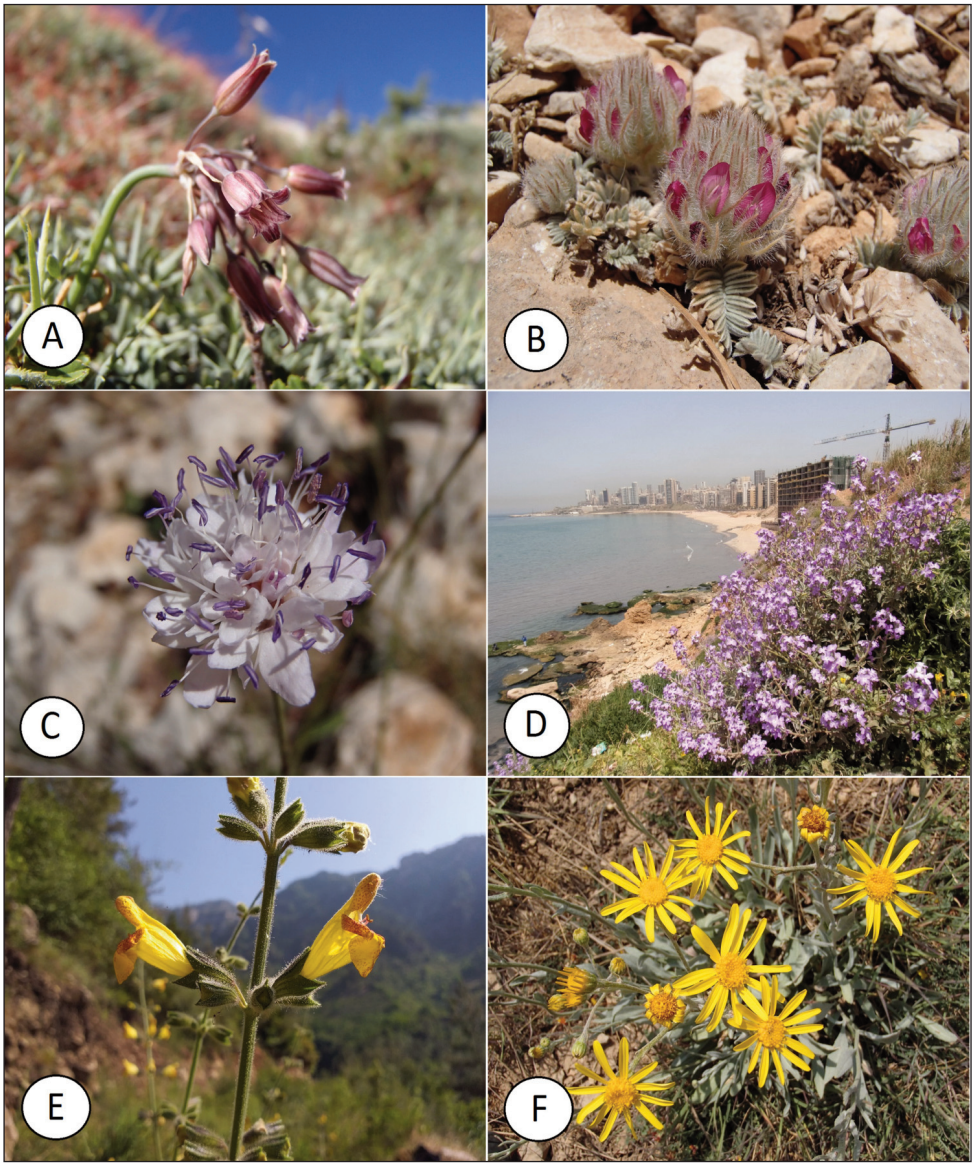

Fig. 2. Illustration of protected and unprotected Lebanese endemic plant species. A : *Allium feinbergii* Oppenh. is Least cornerned (LC) and occurs at the oro-Mediterranean in the nature reserves of Shouf Biosphere and Mount Hermon; B: *Astragalus kurnet-es-saudae* Eig is Critically Endangered (CR), occurs at the oro-Mediterranean in North Lebanon and is currently unprotected; C: *Cephalaria cedrorum* Mouterde Vulnerable (VU) occurs at the montane-Mediterranean in Shouf Biosphere; D: *Matthiola crassifolia* Boiss. & Gaill is Endangered (EN), occurs at the coast and is unprotected; E: *Salvia peyronii* Boiss. is CR and occurs in the nature site of Jabal Moussa at the supra-Mediterranean; F: *Senecio bertramii* Post is CR, occurs at the montane-Mediterranean in North Lebanon and is unprotected. Photos by H. El Zein.

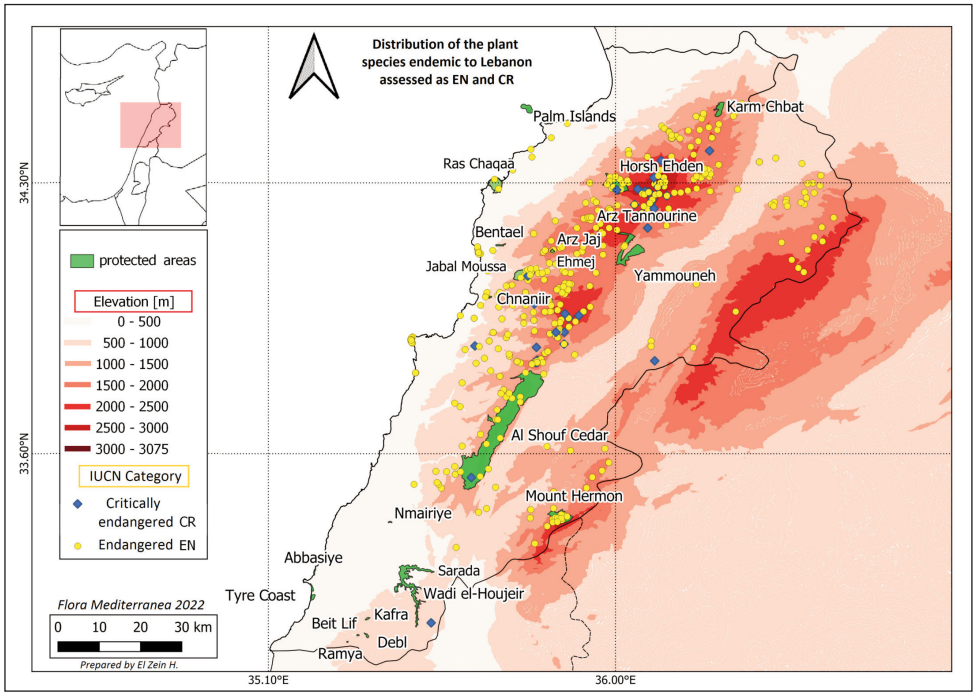

Fig. 3. Map showing the distribution of the taxa assessed as Endangered and Critically Endangered in Lebanon as well as the protected areas.

Discussion

Threats are often specific to specific altitudinal belts and habitat and do not affect the taxa equally. For example, urbanisation has massively been affecting natural habitats from the coastal to the supra-Mediterranean belts. The construction of roads and buildings and the creation of quarries irreversibly destroy the vegetation and constitute the most important threat at the national level. Lebanon was classified as the ninth most populated country in the world (World Population Review 2022) explaining the intensity of the anthropic activities and their impacts even in remote areas. Meanwhile, the lack of national coordinated spatial planning for urbanisation is considered as another parameter responsible for the loss of biodiversity (Masri 1997). The destruction of ecosystems by quarries is widespread in the country (Darwish & al. 2011) and durably threatens numerous species such as *Atocion reuterianum* Boiss. & Blanche and *Rhododendron ponticum* var. *brachycarpum* Boiss.

Overgrazing is a widespread threat that has slow but significant impacts over time. Due to the increase of urbanisation, the rangelands have been reduced and restricted to the remaining non-urbanised areas. In summer, this activity is essentially concentrated in the montane and oro-Mediterranean belts and the size of the flocks are larger, resulting in an intensification of pressure on the natural vegetation to feed the goats. The vegetation is heavily affected and the reproduction cycles, such as the production of flowers and seeds,

are directly impacted. Seedlings and young trees are systematically eaten, preventing the regeneration of the forests. Meanwhile the soils are trampled by repeated passages, leaving the soil bare of vegetation and increasing the erosion phenomenon due to rainfall runoffs.

Logging directly impacts the two endemic oak tree species *Quercus kotschyana* O. Schwarz and *Q. look* Kotschy. Forest species are inescapably the victims of fire, such as *Cyclamen libanoticum* Hildebr. that has been severely threatened by the fires that occurred in 2017 in the area of Jabal Moussa. Collection of plants mainly targets bulbous species with ornamental value, especially irises, such as *Iris cedreti* Dinsm. ex Chaudhary and *I. sofarana* Foster. Reforestation affects species for which other threats were minimised thanks to their presence in protected areas. *Cephalaria cedrorum* is an interesting case as it grows at the cedar altitudinal level in open areas and is threatened by the thick shade resulting from tree plantation.

Climate change manifesting through drought events was here considered as a future threat that will affect all the species. However, many changes have already occurred over the past 40 years and impacted the Mediterranean terrestrial biodiversity and ecosystems faster than other areas of the world (Hassoun & al. 2020; Guiot & al. 2021). Around 48% of the Mediterranean wetlands were lost between 1970 and 2013 which also impacted on the animals living in these habitats threatening 36% of them with extinction. Moreover, terrestrial biodiversity, forest productivity, freshwater ecosystems and agrosystems will be negatively impacted by decreased precipitations, changes in biological communities as a result of harsher environmental conditions, and a decrease of biological processes such as nutrient uptake, primary production, or decomposition. Another response to climate change will be the extension of drylands (Hassoun & al. 2020; Guiot & al. 2021). The ecosystems of the southern Mediterranean are particularly at risk of fragmentation or disappearance due to anthropic activities such as urbanisation, agriculture, overexploitation of firewood and overgrazing. For the taxa occurring above 2000 m of altitude, the drought and warming events were considered as current threats as there already have been changes in the average temperature and amount of precipitation. Mediterranean mountains are fragile ecosystems that are currently facing climate change more intensely than other non-Mediterranean ranges (Bravo & al. 2008), especially the vegetation of the oro-Mediterranean belt that is more vulnerable (Rosbakh & al. 2017). It is happening through reduction of snow cover, soil fertility and water availability. The changes are fast and the species located at the highest level of the mountains cannot migrate to a higher altitudes. Even coastal species and habitats will be impacted by the imminent sea-level rise (Snoussi & al. 2008; Castillo & al. 2022).

The threats to plant diversity in Lebanon are similar to those dominating globally, which are habitat loss, overexploitation and climate change (Corlett 2016). Habitat loss includes conversion of natural or semi-natural habitats into agriculture, pastures, quarries or urbanised areas. Invasive plant and animal species, causing competitive exclusion of native species or destroying native vegetation, are widespread threats at the global scale that seem relatively of minor importance in Lebanon.

These assessments constitute the first step towards the evaluation of the conservation status of the Lebanese flora. The list of 100 taxa reflects the national scientific efforts carried out for years to explore the country and identify the threats and their impact on the flora. Emphasis was made on endemic species as they represent relevant natural patrimony

and the most fragile taxa due to their restricted distribution (Callmander & al. 2005). As presented by other studies of Ethiopia, Eritrea, Cape Verde and Italy (Vivero & al. 2006; Romeiras & al. 2016; Orsenigo & al. 2018; Fois & al. 2022), the focus on the endemic flora gives an interesting perspective for conservation. Although this red list is quite representative of the trend of the anthropogenic disturbances on the endemic taxa, not all the species were yet assessed and other Levantine endemic taxa are currently being evaluated. Many other species, although not endemic, are rare at the national scale or have ecological significance. Their status need to be assessed to better evaluate the threats affecting them. A national red list is of high importance to understand the patterns of threats and their regional variations (Venter 2006). The next assessments will include more endemic and non-endemic taxa and will allow a more accurate definition of the priority areas for conservation in the country. The red listing process needs to be constantly updated considering the current pace of the anthropic disturbances and the climatic changes. Protected areas in Lebanon should include the most threatened taxa and their related habitats to reverse the erosion of biodiversity. In the future and following long term conservation actions, we might hopefully be able to use the IUCN Green List of species, a new tool that measures species recovery and conservation success across their indigenous range (IUCN 2021).

Acknowledgement

The Red List of the endemic flora of Lebanon was one of the components of the project "Determining Important Plant Areas in Lebanon and Creation of Micro-reserves", implemented by Saint Joseph University (USJ) between 2013 and 2016 and funded by the Critical Ecosystem Partnership Fund. Magda Bou Dagher-Kharrat is the instigator of this project and she organised workshops on how to red list plant species to involve the local experts in the process. This work was possible thanks to the contribution of Jean Stephan, Bouchra Douaihy, Lamis Chalak, Mireille Sayah, Safaa Baydoun, Myrna Semaan, Moustapha Itani, Mohammed Al-Zein, Nisrine Michaka Houri, Nada Sinnu, Nelly Arnold, Carla Khater, Perla Ferhat, Rana El Zein, Ramy Sakr, Rana Jardak, Sarah Jeitani, Tanos Hage, Joelle Breidi, Tony Chahine. Eighty-eight taxa were assessed during this project. The others were assessed during two different projects: Red List assessment of the endemic and near-endemic monocotyledon taxa of the Mediterranean Basin, and the aromatic species assessment in Lebanon. We are particularly grateful to the team of the Royal Botanical Garden of Edinburgh for hosting and training us: Alan Forrest, Tom Christian, Tony Miller, Sabina Knees, Pete Hollingsworth; to the IUCN team who helped us through the whole process, from the review, to the improvement and the publication of the assessments: David Allen, Caroline Pollock, Ana Isabel Martinez Richart; to Dana Leaman, member of the Species Survival Commission Medicinal Plant Specialist Group for her contribution in the assessments of some medicinal species endemic to Lebanon; to Errol Véla for reviewing the assessments.

References

Abi-Saleh, B. 1982: Altitudinal zonation of vegetation in Lebanon. – Ecol. Medit. **8:** 355-364. https://doi.org/10.3406/ecmed.1982.1960

Bachman, S., Moat, J., Hill, A. W., De La Torre, J., & Scott, B. 2011: Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. – ZooKeys **150:** 117. https://doi.org/10.3897%2Fzookeys.150.2109

Betts, J., Young, R. P., Hilton-Taylor, C., Hoffmann, M., Rodríguez, J. P., Stuart, S. N., & Milner-Gulland, E. J. 2020: A framework for evaluating the impact of the IUCN Red List of threatened species. – Conserv. Biol. **34(3):** 632-643. https://doi.org/10.1111/cobi.13454

Bou Dagher-Kharrat, M., El Zein, H. & Rouhan, G. 2018: Setting conservation priorities for Lebanese flora—Identification of important plant areas. – J. Nat. Conserv. **43:** 85-94. https://doi.org/10.1016/j.jnc.2017.11.004

Bravo, D. N., Araújo, M. B., Lasanta, T., & Moreno, J. I. L. 2008: Climate change in Mediterranean mountains during the 21st century. – AMBIO J. Human Environ. **37(4):** 280-285. https://doi.org/10.1579/0044-7447(2008)37[280:CCIMMD]2.0.CO;2

Brummitt, N., Bachman, S. P., & Moat, J. 2008: Applications of the IUCN Red List: towards a global barometer for plant diversity. – Endang. Spec. Res. **6(2):** 127-135. https://doi.org/10.3354/esr00135

Callmander, M. W., Schatz, G. E. & Lowry, P. P. 2005: IUCN Red List assessment and the Global Strategy for Plant Conservation: taxonomists must act now. – Taxon **54(4):** 1047-1050. https://doi.org/10.2307/25065491

Castillo, J. M., Curado, G., Muñoz-Rodríguez, A. F. & Infante-Izquierdo, M. D. 2022: Salt tolerance during germination identifies native intertidal plant species at risk under increasing salinity with sea level rise. – Marine Ecol. Progr. Ser. **684:** 57-68. https://doi.org/10.3354/meps13961

Ceballos, G., Ehrlich, P. R., Barnosky, A. D., García, A., Pringle, R. M., & Palmer, T. M. 2015: Accelerated modern human-induced species losses: Entering the sixth mass extinction. – Sci. Advances **1(5):** e1400253. https://doi.org/10.1126/sciadv.1400253

Corlett, R. T. 2016: Plant diversity in a changing world: status, trends, and conservation needs. – Pl. Div. **38(1):** 10-16. https://doi.org/10.1016/j.pld.2016.01.001

Cuttelod, A., García, N., Malak, D. A., Temple, H. J. & Katariya, V. 2008: The Mediterranean: a biodiversity hotspot under threat – Pp. 89-105 in: Vié, J. C., Hilton-Taylor, C., Stuart, S. N. (eds), Wildlife in a changing world: an analysis of the 2008 IUCN Red List of threatened species. – Gland.

Darwish, T., Khater, C., Jomaa, I., Stehouwer, R., Shaban, A. & Hamzé, M. 2011: Environmental impact of quarries on natural resources in Lebanon – Land Degrad. Develop. **22(3):** 345-358. https://doi.org/10.1002/ldr.1011

DIVA-GIS 2022: Free spatial data by country. – http://www.diva-gis. org/gdata [Last accessed 20/9/2022]

El Zein, H., Itani, M. & Talhouk, S. 2018: Key Biodiversity Areas in Lebanon. Pp. 78-84 in: Valderrábano, M., Gil, T., Heywood, V. & de Montmollin, B. (eds), Conserving wild plants in the south and east Mediterranean region. – Gland and Málaga.

Euro+Med (2022) Euro+Med PlantBase—the information resource for Euro-Mediterranean plant diversity. – https://europlusmed.org [Last accessed 8/4/2022]

Fois, M., Farris, E., Calvia, G., Campus, G., Fenu, G., Porceddu, M. & Bacchetta, G. 2022: The endemic vascular flora of Sardinia: a dynamic checklist with an overview of biogeography and conservation status. – Plants **11(5)**: 601. https://doi.org/10.3390/plants11050601

Guiot, J., Cramer, W. & Marini, K. 2021: Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future – First Mediterranean Assessment Report, **1.** – Marseille.

Hassoun, A. E. R., Guiot, J., Marini, K. & Cramer, W. 2020: The changing Mediterranean Basin through the lens of Mediterranean experts. – Int. J. Euro-Medit. Stud. **13(2):** 117-137.

International Plant Names Index (INPI) and World Checklist of Selected Plant (WCSP) Families (2022) – http://www.ipni.org. [Last accessed 8/4/2022]

IUCN 2021: IUCN Green Status of Species: A global standard for measuring species recovery and assessing conservation impact. Version 2.0. – Gland, Switzerland. https://doi.org/10.2305/IUCN.CH.2021.02.en

— 2022: Guidelines for Using the IUCN Red List Categories and Criteria: Version 15. IUCN, Gland, Switzerland and Cambridge, UK.

Masri, R. 1997: Environmental Challenges in Lebanon. – Pp. 73-91 in: Jabbra, J. G. & Jabbra, N. W. (eds), Challenging Environmental Issues: Middle Eastern Perspective. – Brill, Leiden.

Médail, F. & Quézel, P. 1997: Hot-spots analysis for conservation of plant biodiversity in the Mediterranean Basin. – Ann. Missouri Bot. Gard. **84:** 112-127. https://doi.org/10.2307/2399957

MoE-UNEP-GEF. 2016. Lebanon's National Biodiversity Strategy and Action Plan (NBSAP) – Beirut.

Mouterde, P. 1966: Nouvelle flore du Liban & de la Syrie, **1.** – Beirut.

—1970: Nouvelle flore du Liban & de la Syrie, **2.** – Beirut.

— 1984: Nouvelle flore du Liban & de la Syrie, **3.** – Beirut.

Myers, N, Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B. & Kent, J. 2000: Biodiversity hotspots for conservation priorities. – Nature **403:** 853-858. https://doi.org/10.1038/35002501

Orsenigo, S., Montagnani, C., Fenu, G., Gargano, D., Peruzzi, L., Abeli, T Alessandrini, A., Bacchetta, G., Bartolucci, F., Bovio, M., Brullo, C., Brullo, S., Carta, A., Castello, M., Cogoni, D., Conti, F., Domina, G., Foggi, B., Gennai, M., Gigante, D., Iberite, M., Lasen, C., Magrini, S., Perrino, E. V., Prosser, F., Santangelo, A., Selvaggi, A., Stinca, A., Vagge, I., Villani, M., Wagensommer, R. P., Wilhalm, T., Tartaglini, N., Duprè, E., Blasi, C. & Rossi, G. 2018: Red Listing plants under full national responsibility: Extinction risk and threats in the vascular flora endemic to Italy. – Biol. Conserv. **224:** 213-222. https://doi.org/10.1016/j.biocon.2018.05.030

Possingham, H. P., Andelman, S. J., Burgman, M. A., Medellín, R. A., Master, L. L. & Keith, D. A. 2002: Limits to the use of threatened species lists. – Trends Ecol. Evol. **17(11):** 503-507. https://doi.org/10.1016/S0169-5347(02)02614-9

QGIS Development Team (2022) QGIS Geographic Information System. – http://qgis.osgeo.org [Last accessed 8/6/2022]

Rodrigues, A. S., Pilgrim, J. D., Lamoreux, J. F., Hoffmann, M., & Brooks, T. M. 2006: The value of the IUCN Red List for conservation. – Trends Ecol. Evol. **21(2):** 71-76. https://doi.org/10.1016/j.tree.2005.10.010

Romeiras, M. M., Catarino, S., Gomes, I., Fernandes, C., Costa, J. C., Caujapé-Castells, J. & Duarte, M. C. 2016: IUCN Red List assessment of the Cape Verde endemic flora: towards a global strategy for plant conservation in Macaronesia. – Bot. J. Linn. Soc. **180(3):** 413-425. https://doi.org/10.1111/boj.12370

Rosbakh, S., Leingärtner, A., Hoiss, B., Krauss, J., Steffan-Dewenter, I. & Poschlod, P. 2017: Contrasting effects of extreme drought and snowmelt patterns on mountain plants along an elevation gradient. – Frontiers Pl. Sci. **8:** 1478. https://doi.org/10.3389/fpls.2017.01478

Snoussi, M., Ouchani, T. & Niazi, S. 2008: Vulnerability assessment of the impact of sea-level rise and flooding on the Moroccan coast: The case of the Mediterranean eastern zone – Estuarine Coastal Shelf Sci. **77(2)**: 206-213. https://doi.org/10.1016/j.ecss.2007.09.024

Tohmé, G. J. & Tohmé, H. S. 2014: Illustrated flora of Lebanon. – Beirut.

Torres-Romero, E. J., Giordano, A. J., Ceballos, G. & López-Bao, J. V. 2020: Reducing the sixth mass extinction: Understanding the value of human-altered landscapes to the conservation of the world's largest terrestrial mammals. – Biol. Conserv. **249:** 108706. https://doi.org/10.1016/j.biocon.2020:108706

Venter, O., Brodeur, N. N., Nemiroff, L., Belland, B., Dolinsek, I. J. & Grant, J. W. 2006: Threats to endangered species in Canada. – Bioscience **56(11):** 903-910. https://doi.org/10.1641/0006-3568(2006)56[903:TTESIC]2.0.CO;2

Verlaque, R., Médail, F., Quézel, P. & Babinot, J. F. 1997: Endémisme végétal & paléogéographie dans le bassin méditerranéen. – Geobios **30:** 159-166. https://doi.org/10.1016/S0016-6995(97)80083-6

Vivero, J. L., Kelbessa, E. & Demissew, S. 2006: Progress on the red list of plants of Ethiopia and Eritrea: Conservation and biogeography of endemic flowering taxa. – Pp. 761-778 in: Ghazanfar, S. A. & Beentje, H. J. (eds), Taxonomy and ecology of African plants, their conservation and sustainable use. – Kew.

World Population Review. Countries by Population Density 2022: – https://worldpopulationreview.com/country-rankings/countries-by-density [Last accessed 29/3/2022]

Addresses of the authors:
Hicham El Zein[1] & Rhéa Kahale[2],
[1]Independent Researcher – Beirut, Lebanon. E-mail: hichamelzzein@gmail.com
[2]Saint Joseph University, Faculty of Science, Laboratoire Biodiversité et Génomique Fonctionnelle, Campus Sciences et Technologies, Mar Roukos, Mkalles, Lebanon.