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Updating the Plant "Red List" of Palestine (West Bank and Gaza Strip): Conservation Assessment and Recommendations

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Abstract

Palestine (West Bank and Gaza) has been considered as an important center of plant diversity and speciation in the Mediterranean region. However, several species are threatened by numerous factors including human activities, e.g., conversion of traditional to intensive agriculture, accompanied by deep ploughing and the application of pesticides, overgrazing, and urban development and construction; and global climatic change. In this study, the "red-number" procedure was applied, with a few modifications, to Palestinian plants and a red list with International Union for Conservation of Nature (IUCN) categories conservation priorities was constructed, as quantified by the red numbers. The same procedure was applied to extinct plants. One hundred and two species that received red numbers of 3 or above were entered in the updated "red list" of the endangered plants. This study also shows a high extinction risk to the Palestinian threatened wild flora, with 76.4% of the threatened species were critically endangered 39.2%, and endangered 3.72% only 19.6% were vulnerable. The Palestinian flora is thus of conservation concern. The study provides an updated national IUCN Red List for a large group of Palestinian plants, and thus offers an overview of the threatened Palestinian flora. This Red List is an important prerequisite towards the recognition of the danger to Palestinian biodiversity hotspots, conservation of threatened species and the raising of public awareness at national and international levels.

Keywords: Biodiversity conservation; Biodiversity hotspot; Extinction risk; Red number; IUCN categories; Red listing; Palestinian wild flora; Threatened flora

Introduction

Palestine, as part of the Mediterranean region, is one of the important reservoirs of plant diversity hotspots and speciation on a global scale [1-3]. Its flora comprises about 1938 species belonging to 733 genera and 111 families, this richness is due to the geographical position of Palestine, with its varied topography, geology, eco-regions and climate, and also by it being a pathway for flora spreading between Europe, Asia, and Africa [4].

The main responsibilities in conservation programs are to identify the species and the ecosystems that are a high priority for conservation and to outline the importance of certain taxon for the investment of conservation efforts in a limited resources situation [5].

Conservation efforts for plants have been based mainly on estimations of vulnerability, which may be varying among countries and conservation organizations. The World Conservation Union (IUCN) has developed five quantitative criteria of vulnerability for evaluating the extinction probability of species [6,7]: Extinct (EX) (when there is no reasonable doubt that the last individual of the species has died), Critically Endangered (CR>75% reduction) (in grave danger of extinction, considered as a species facing an especially high risk of extinction in nature), Endangered (EN=50-75% reduction) (in danger of extinction, considered as a species facing a very high risk of extinction in nature), Vulnerable (VU=>30-50% reduction) (considered as a species facing a high risk of extinction in nature), and Near Threatened (NT) (expected to be endangered in the near future).

These categories have been widely accepted throughout the world and form the basis for the IUCN Red List of Threatened Plants [8]. The IUCN criteria consist of a set of decision rules, based mainly on quantitative thresholds of population size, distribution range, the rate of declining and extinction probability [6,7]. These criteria are considered the first step in conservation, expressing the estimation of extinction probability. The next step should be setting priorities of the species for conservation. A priority setting process was suggested by Coates and Atkins [9]. Such process was based on the risk of extinction at population, taxon and ecological community levels, genetic structure and population ecology. The method requires extensive surveys to generate the necessary data needed. For most countries where such data are scarce or unavailable, setting an urgent conservation policy is a necessity.

The Red List of threatened species has been used to guide conservation responses, influence conservation policies and legislation, plan protected area networks and prioritize sites to be safeguarded [10,11].

Red listing update of the Palestinian flora could be an essential initiative in the elevation of the danger of loss to the Palestinian flora. Little has been done to recognize the importance of the biodiversity of the Palestinian hotspots or to map the distribution of the threatened species [12]. Moreover, not much is being done in terms of habitat protection, conservation assessments and the raising of public awareness to this threatened flora.

The "red-number" (RN) method, as complementary to IUCN criteria, was proposed to determine priorities for conservation on a regional and/or national scale [5]. The method is thought to be compatible with any region of the world with minor adjustments,

making it applicable for regional or national conservation policies. Calculating the RN demands minimum data gathering. RN can be calculated even if only preliminary data were available. The RN, which is an additive index, was calculated by summing up the values of 6 parameters:

- Rarity
- Habitat vulnerability
- Attractiveness
- Distribution type (endemism)
- Disjunctiveness
- Peripherality [5]

A parameter that does not contribute any value to the checked species is scored as zero. The advantage of the linear summary is the practical use and the possibility to compare red lists between different regions. Entry threshold of a species to the calculation is the rarity parameter and then the other parameters are added. The highest possible score for a species can be up to 10 when all the parameters get the highest score, i.e., representing the highest value.

In the present study, we focus on updating the 2002 "Red List of threatened plants of the West Bank and Gaza" [12] by red listing of the Palestinian flora according to International Union for Conservation of Nature (IUCN) criteria and categories, using a modification of the "Red Number" method [5,13,14]. We target the rare plants at the species level with the purpose of calculating and producing a relative estimate of the likelihood of extinction of the taxa in the near future. The aim of red listing the wild Palestinian flora is to provide information and analyses on the status of the species, their trends and threats to species and populations in order to inform and catalyze actions for biodiversity conservation. By red listing the wild Palestinian flora, we also aim to establish a baseline to monitor the changes in the status of all species, to establish conservation priorities at the Palestinian level, and to set up representative selection of species as biodiversity indicators that cover all the major ecosystems of Palestine (West Bank and Gaza strip).

Material and Methods

To carry out the red listing and conservation assessments of the Palestinian flora, the following methodology was adopted.

A preliminary list of species was defined. The wild plant species of Palestine (Appendix 1: Checklist of the Palestine flora) were targeted based on existing scientific literature [12-40], databases including Biodiversity and Environmental Research Center (BERC) Plants Info, Database since 1982 based on expert observations from all around Palestine (WB and Gaza), and herbarium records at BERC Herbarium since 2000.

The 2002 "Red List of threatened plants of the West Bank and Gaza" was based on preliminary surveys (conducted in the period 1982-2000) [12]. This latter list includes some obscurities including plant species that are highly abundant. Since the taxa were not entered in the list on the basis of mainly quantitative data, it is inadequate for the current conservation needs of Palestine. An updated list is thus needed.

In 2001, with the establishment of the Biodiversity and Biotechnology Research Unit-at BERC, a wave of surveys, research, and documentation of Palestinian flora including rare plants was launched. Between 2011 and 2017, a survey of rare species was conducted in cooperation with the Palestine Bio-Exploration Unit at BERC.

Criterion Rarity	Value
Area % (Number of sites in Palestine: West Bank and Gaza)	
0.50-0.1% (62-13)	0.5
0.10-0.05% (12-7)	1
0.05-0.01% (6-4)	1.5
0.01-0.005% (3)	42
0.005% (2)	2.5
Single site	3
Habitat vulnerability (declining rate)	
Stable-not declining	0
Small probability of habitat destruction (0-25%)	0.5
Medium probability (25-50%)	1
High probability (50-75%)	1.5
Very high probability (75-100%)	42
Attractiveness-Flower size in cm (important characteristics)	
Not attractive in any way and does not have a colorful flower	0
Flower size of <1 cm (non-succulent)	0.5
Flower size of 1-2 cm (or succulent)	1
Flower size of 2-3 cm (or colorful inflorescence)	1.5
Flower size of >3 cm (or commercial medicinal or nutritional plant /trees with straight trunk)	2
Distribution type (Endemism)	
Not endemic	0
Endemic sub-sp. or peripheral population	0.5
Regional endemic sp.	1
Sub-endemic sp.	1.5
Narrow endemic sp.	2.04
Peripherality*	
Peripheral	0.5
Non-Peripheral	0
Disjunctiveness**	
Plants located within a single geographical fragment	0.5
Plants located within more than one geographical fragment	0

Table 1: Values for the suggested Palestinian Red Number parameters. *Denotes plants whose populations in the PA are at the edge of their worldwide distribution. This criterion is assigned values of 0.5 or 0 for peripheral and non-peripheral respectively. **Denotes the closeness of the plants to each other in one geographical fragment. This criterion is

a given a value of 0.5 or 0 for plants located in a single geographical value and located in more than one geographical fragment, respectively.

The survey was conducted at 250 preferred sites and habitats and was also based on herbarium sheets from the BERC Herbarium, and on existing studies and plant guides. Many of the herbarium sheets date back to the years before 2000; this provided an indication of the rate of extinction of the species (the criterion of vulnerability). About 60 Natural, random cross-sections of the land area were also sampled, in order to cover unfamiliar sites. In order to set priorities in conservation policy, the red numbers for plant species were constructed by adopting the "Red-Number" method [5]. The red number was calculated by summing up the values of six parameters (Table 1), as described above.

The "Red Number" (RN)

Following the study of 1938 wild plant species (the natural plant species of Palestine) and in the process of preparing the "red list", approximately 500 species that are likely to be included in the list of endangered species were identified. The "red number" method [5] with some modifications was used to calculate the red numbers for the plants in order to identify the threshold for the endangered status of a plant species and rank the degree of risk.

Briefly, the modified "red-number" method uses six quantitative criteria (a rarity, habitat vulnerability, attractiveness, distribution type (endemism), Disjunctiveness and peripherality) (Table 1) which is combined into a single quantitative index known as the "red number". Each criterion has its own scale, which reflects its relative weight in determining the extent to which a certain plant species are endangered.

Rarity: This criterion designates the number of sites in which a species is found. This criterion is assigned a value ranging from 0.5 to 3, where the value 3 represents a plant that is found in only one site. The criterion of rarity has the highest weight in the "red number", almost one third (3/10) of its value. The extent of occurrence is used as a measure of a rarity. The measurement unit is the number of sites where the species is present. A site defined as 0.5 km2 (is a comfortable working frame and an applicable unit). Rarity is measured as the extent of occurrence of a plant species in the region surveyed. The total area of the West Bank and Gaza Strip is approximately 6220 km2, and this area was subdivided in a grid of 0.5 km2 (12,440 sites). Each plant species was assigned a score from 0.5 to 3 according to the proportion of sites it occupied, as indicated in Table 1. The rarest species scored 3 (only one site), while the most common species scored 0.5 (62-13 sites).

Habitat vulnerability: This standard denotes designates the percentage of extinction of the habitat. The standard is measured by comparing the number of sites before 1982 to their number in 2017. It is based on a scale ranging from 0-42, where the value where the value 42 (representing "very high vulnerability") is designated to plants that have become extinct in more than 75% of all sites since 1982 (Table 1). The value 0 is given to plants that have become extinct in less than 1% of all sites since 1982 considering the possible impact of human activities on the plant, a value of 1 is assigned to species for which there is no information concerning vulnerability.

Attractiveness This criterion designates the cases in which humans have a motive to exploit or harm the plant-e.g., a large, colorful flower or a tree with a straight trunk. The larger and more colorful the flower, the greater the risk that it will be picked and the higher value that will be assigned to it. Medicinal and culinary herbs that are picked for commercial purposes are assigned the maximum value of 42, which designates "exploitation" (Table 1). Attractivity may also be the probability of collecting succulents. The value 0 is assigned to a plant that is not attractive in any way and does not have a colorful flower greater than 1 cm in size.

Distribution type-Endemism: criterion entitled the geographical distribution of the plant, it is given a value between 0 and 42 (Table 1). Plants whose only area is in Palestine are assigned the highest value of 42, which designates "endemic". Plants that are common in other areas are assigned lower values, in descending order: an endemic subspecies (i.e., a population of individuals of the same species which, due to geographic or other isolation, develop a substantial difference in form or a DNA sequence relative to individuals in other populations of the same species) is assigned the value of 1.5; a sub-endemic plant that grows in Palestine and deviates only slightly beyond Palestine's borders is assigned the value of 1 (e.g., the deviation can be on the border with Jordan in the Jordan Valley and Dead Sea areas), and Green-line Israel; a plant that is endemic to the Levant (i.e., it is spread throughout Palestine, Israel, Jordan, and Sinai) is assigned the value of 0.5. The value 0 is assigned to a plant which is not endemic at all.

Peripherality: This criterion designates plants whose populations in Palestine are at the edge of their worldwide distribution. This criterion is assigned a value of 1 0.5 or 0 for "peripheral" and "non-peripheral", respectively (Table 1). For peripheral plants, the boundary of their distribution in Palestine (south, north, east, west) is also specified. For example, a plant whose worldwide distribution is primarily north of Palestine is classified as peripheral-north.

Disjunctiveness: Designates the closeness of the plants to each other in one geographical fragment. This criterion is given a value of 10.5 or 0 for plants located within a single geographical fragment and located within more than one geographical fragment, respectively (Table 1).

Calculation and conversion of the red number into extinction risk categories

The RN values, as relative estimates of the likelihood of extinction of the taxa in the near future, were calculated according to six criteria that are summed up by one quantitative index: the red number. Each criterion receives a range of values according to its "contribution" to the degree of danger of extinction, as follows:

RN=Rar. + Vul. + Att. + END + Per. + Des.

Where: Rar. Rarity=0.5-3; Vul. Vulnerability=0.0-2; Att. Attractivity=0.0-2; END. Endemism=0.0-2; Per. Peripherality=0.0-.0.5; Des. Desjunctiveness=0.0-0.5.

In cases where the number of sites is reduced to only 0.5, the risk of extinction is the highest. Therefore, the rarity criterion for this situation was given a value of 3. This is the only criterion that species can be "red" because it is only very rare (but not vulnerable, endemic, attractive, etc.). The scale of the rarity criterion was constructed so that only in the case of a plant that grows only on a single site in Palestine (rarity value=3) is a single criterion sufficient to include it as a red species. This is also the main reason that the threshold for the definition of an endangered species included in the Red List is 3. In other words, even plants that are most vulnerable (value of vulnerability 2) or endemic to Palestine only (endemic value 2) will not be included in the list if they do not have additional numbers from

another red criterion. Attractive species with large colored flowers or colorful inflorescences receives in the Israeli model a low red number that does not exceed 2, which is not enough to pass the threshold value for acceptance as a red species; if these species do not have incremental numbers by the vulnerability criterion, they will not be included in the red list.

The species of "red" plant is defined as such on the basis of the six criteria and not only on the basis of a single criterion, and only consideration of all of them together with their quantitative summation brings a plant to the threshold of inclusion in one of following IUCN risk levels (threatened categories): critically endangered (CR), endangered (EN), and vulnerable (VU) (Table 2). The "red number" is either assigned a value ranging from 0 to 20 which equals the sum of the criteria, or it is assigned the value "extinct".

IUCN risk level	"Red number" range	No. of Species	% in the region (n=1938)
Critically Endangered (CR)	05-Oct	40 (39.2)	2.1
Endangered (EN)	04-May	38 (37.2)	2
Vulnerable (VU)	03-Apr	24 (19.6)	1.2

Table 2: Conversion of the "red number" into the IUCN risk levels. Distribution of IUCN risk levels (threatened categories) in the Palestinian Red List of endangered species.

Results and Discussion

Of the 1938 wild plant species in Palestine (West Bank and Gaza strip), 102 (5.3%) which received red numbers of 3 or above were classified as endangered species and make up the "red list" (Table 3). These species belong to 83 genera and 39 plant families. 39 plant families 5.3%, 102/1938) compared to, for example, 16.15% (370/2290) in historic Palestine [5]; larger compared to, for example, 2.6% in the United States [41]. In addition, the percentage of endangered species/ related genera 2%, 102/83) is smaller than that of the total number of species in Palestine/number of related genera (2.7%, 1938/733). This can be seen as an important indicator of the magnitude of the problem and the need to take appropriate measures to protect threatened plants.

Species name	GF	Chorotype	Poll	Climatic region	Total no. of sites	Rar	Vul	Att	END	Per	Des	RN	IUCN category
Abutilon indicum (L.) Sweet	C	T	Z	SD	6	1.5	1	0.5	0	0.5	0	3.5	VU
Adonis aestivalis L.	A	ES-M-IT	Z	Med, TZ, SD	3	2	1	1	0	0	0.5	4.5	EN
Aeluropus lagopoides (L.) Thwaites	H	IT-M-SA	W	TZ, SD	5	1.5	2	0	0	0	0.5	4	EN
Aeluropus littoralis (Gouan) Parl.	H	M-IT	W	Med, SD	5	1.5	2	0	0	0	0.5	4	EN
Aethionema carneum (Banks and Sol.) B.Fedtsch.	A	IT	Z	Med	2	2.5	2	0	0	0.5	0.5	5.5	CR
Agrostemma githago L.	A	ES-M-IT	Z	Med	1	3	2	1	0	0.5	0.5	7	CR
Alkanna galilaea Boiss	C, H	M	Z	Med	2	2.5	2	0	1.5	0	0.5	6.5	CR
Allium albotunicatum O.Schwarz	G	M	Z	Med	3	2	1.5	0	0	0.5	0	4	EN
Allium negevense Kollmann	G	IT	Z	SD	1	3	2	0.5	2	0	0	7.5	CR
Allium papillare Boiss.	G	SA	Z	SD	1	3	2	0.5	1	0.5	0	7	CR
Allium schubertii Zucc.	G	M	Z	Med, TZ	3	2	1	1	0	0.5		4.5	EN
Alopecurus arundinaceus Poir.	H	ES-M-IT	W	Med	1	3	2	0	0	0.5	0.5	6	CR
Androsace maxima L.	A	M-IT	Z	TZ, SD	4	1.5	1.5	0	0	0	0.5	3.5	VU
Anthemis hyalina DC.	A	IT	Z	Med	8	1	1	1	0	0.5	0	3.5	VU
Anthemis indurata Delile	A	IT	Z	Med, TZ, SD	6	1.5	1	0	2	0	0	4.5	EN

Anthephora laevis Stapf and C.E. Hubb	H	SUD	W	SD	1	3	0	0	0	0.5	0	3.5	VU
Asphodelus viscidulus Boiss.	G	SA	Z	SD	2	2.5	1	0	0	0.5	0	4	EN
Astragalus brachystachys DC.	H	IT	Z	TZ	2	2.5	1	0	0	0.5	0.5	4.5	EN
Astragalus cretaceus Boiss. and Kotschy	H	IT	Z	TZ	12	1	0.5	1	0	0.5	0	3	VU
Astragalus fruticosus Forssk	H	SA	Z	TZ, SD	3	2	1.5	0	0	0.5	0	4	EN
Avena clauda Durieu	A	M-IT	W	Med, TZ	2	2.5	1.5	0	0	0.5	0	4.5	EN
Bolanthus filicaulis (Boiss.) Barkoudah	H	IT	Z	TZ	2	2.5	0	0	1	0.5	0.5	4.5	EN
Brachiaria eruciformis (Sm.) Griseb.	A	M-IT-T	W	Med	2	2.5	1	0	0	0	0.5	4	EN
Bupleurum brevicaule Schltdl.	A	M	Z	Med, TZ	5	1.5	1.5	0	0	0	0	3	VU
Callipeltis factorovskyi (Eig) Ehrend.	A	M	W	Med	5	1.5	1.5	0	1	0.5	0.5	5	CR
Catabrosa aquatica (L.) P.Beauv.	H	ES-M-IT	W	Med	1	3	1.5	0	0	0.5	0	5	CR
Centaurea ascalonica Bornm.	H	M	Z	TZ	5	1.5	1.5	0	1.5	0	0.5	5	CR
Chlamydophora tridentata Delile Ehrenb. ex Less.	A	M-SA	Z	Med, TZ	10	1	2	0	0	0	0.5	3.5	VU
Chorispora purpurascens (Banks and Sol.) Eig	A	IT	Z	TZ, SD	6	1.5	1	0.5	0	0.5	0	3.5	VU
Cladium mariscus (L.) Pohl	HE	T	W	Med	1	3	2	0	0	0	0	5	CR
Clinopodium graveolens subsp. rotundifolium (Pers.) Govaerts	A	M-IT	Z	TZ	3	2	0.5	0	0	0.5	0.5	3.5	VU
Consolida orientalis (J.Gay) Schrödinger	A	IT	Z	Med	2	2.5	0.5	1	0	0.5	0.5	5	CR
Corchorus trilocularis L.	A	T	Z	Med, TZ	2	2.5	1.5	0	0	0.5	0	4.5	EN
Cordia sinensis Lam.	tree	SUD	Z	SD	2	2.5	1	0.5	0	0.5	0	4.5	EN
Crocus hermoneus Ky.ex Maw	G	M	Z	Med	12	1	2	1	1.5	0.5	0.5	6.5	CR
Crucianella maritime L.	C	M	Z	Med	1	3	2	0	0	0.5	0	5.5	CR
Cuscuta babylonica Ascher ex Choisy	A, P, V	IT	Z	SD	5	1.5	1	0	0	0	0.5	3	VU
Cutandia maritima (L.) Banth.	A	M	W	Med	1	3	2	0	0	0.5	0	5.5	CR
Cyperus corymbosus Rottb.	HE	T	W	Med	1	3	1.5	0.5	0	0.5		5.5	CR
Descurainia sophia (L.) Webb ex Prantl	A	ES-M-IT	Z	TZ	2	2.5	1.5	0	0	0	0.5	4.5	EN

Doellia bovei (DC.) Anderb.	C	SA-SUD	Z	SD	4	1.5	1.5	0	0	0.5	0	3.5	VU
Elymus elongatus (Host) Runemark	H	M-ES	W	Med	1	3	1.5	0	0	0.5	0.5	5.5	CR
Enneapogon desvauxii P.Beauv.	H	IT-SA	W	SD	1	3	1.5	0	0	0.5	0	5	CR
Epipactis veratrifolia Boiss. and Hohen.	G	M-IT	Z	Med. SD	4	1.5	1.5	0.5	0	0	0.5	4	EN
Euphorbia peplus L.	A	ES-M-IT	Z	Med	1	3	1.5	0	0	0	0.5	5	CR
Euphorbia phymatosperma Boiss.	A	IT	Z	SD	3	2	0.5	0	0	0.5	0.5	3.5	VU
Ferula biverticillata J. Thieb.	H	M	Z	TZ	1	3	2	0	1	0.5	0.5	7	CR
Gagea villosa (M.Bieb.) Sweet	G	M-ES	Z	Med	3	2	1	0.5	0	0.5	0.5	4.5	EN
Galium philistaeum Boiss.	A	M	Z	Med	2	2.5	1.5	0	2	0	0.5	6.5	CR
Grewia villosa Willd.	PhS	SUD	Z	SD	1	3	2	0	0	0.5	0.5	6	CR
Heteranthemis viscidehirta Schott	A	M	Z	Med	1	3	2	0.5	0	0.5	0.5	6.5	CR
Hueblia calycina (Banks and Sol.) Speta	A	IT	Z	SD	1	3	0.5	0	0	0	0	3.5	VU
Iberis odorata L.	A	M	Z	TZ	4	1.5	0.5	0	0	0.5	0.5	3	VU
Iris atrofusca Baker	G	IT	Z	TZ, SD	18	0.5	0	1.5	1.5	0.5	0.5	4.5	EN
Iris haynei Baker	G	M	Z	Med, TZ	16	0.5	0	1.5	1.5	0	0.5	4	EN
Iris lortetii Barbey ex Boiss.	G	M	Z	Med, TZ	10	1	0	1.5	2	0	0.5	5	CR
Iris vartanii Foster	G	M	Z	Med, TZ	17	0.5	0	1.5	2	0	0.5	4.5	EN
Lachnophyllum noeanum Boiss.	H	IT	Z	Med, TZ	5	1.5	1.5	0	0	0.5	0.5	4	EN
Lallemantia iberica (M.Bieb.) Fisch. and C.A.Mey.	A	IT	Z	TZ	13	0.5	1.5	0	0	0.5	0.5	3	VU
Legousia hybrida (L.) Delarbre	A	M-ES	Z	Med	2	2.5	1	0.5	0	0.5	0.5	5	CR
Lepidium latifolium L.	H	ES-M-IT	Z	SD	1	3	2	0	0	0.5	0	5.5	CR
Maerua crassifolia Forssk.	T	SUD	Z	SD	1	3	2	0.5	0	0.5	0	6	CR
Medicago murex Willd.	A	M	Z	Med	1	3	2	0	0	0.5	0.5	6	CR
Medicago monantha (C.A.Mey.) Trautv.	A	IT	Z	SD	2	2.5	0	0	0	0.5	0.5	3.5	VU

Mickauxia campanuloides L'Her.	H	M	Z	Med	1	3	1.5	1.5	0	0.5	0	6.5	CR
Moringa peregrina (Forssk.) Fiori	T	SUD	Z	SD	8	0.5	1	1	0	0.5	0	3	VU
Myrtus communis L.	PhS	M	Z	Med	1	3	1.5	2	0	0.5	0.5	7.5	CR
Onopordum macrocephalum Eig	H	IT	Z	TZ, SD	1	3	0	0	1	0.5	0.5	5	CR
Onosma gigantea Lam.	H	M	Z	Med, TZ	15	0.5	1.5	1	0	0.5	0	3.5	VU
Orchis punctulata Stev. ex Lindl.	G	M-IT	Z	Med	2	2.5	0.5	1	0	0.5	0	4.5	EN
Ornithogalum fuscescens Boiss. and Gaill.	G	M	Z	Med	9	1	1.5	0	0.5	0.5	0	3.5	VU
Oroibanche palaestina Reut.	P	M	Z	Med	2	2.5	1	0.5	1	0.5	0	5.5	CR
Orobanche schultzii Mutel	P	M	Z	Med	1	3	0	0	0	0.5	0	3.5	VU
Petrorhagia zoharyana A.Liston	A	M	Z	Med, TZ, SD	5	1.5	0	0	1.5	0.5	0.5	4	EN
Phlomis herba-venti subsp. pungens (Willd.) Maire ex DeFilipps	H	M - IT	Z	Med, TZ	2	2.5	1.5	1	0	0.5	0	5.5	CR
Phyllitis sagittata Guinea and Heywood		M	Z	Med, SD	1	3	1.5	1	0	0.5	0	6	CR
Pimpinella corymbosa Boiss.	H	IT	Z	Med, TZ	3	2	1	0.5	0.5	0.5		4.5	EN
Platanus orientalis L.	T	M-IT	W	Med	1	3	2	0.5	0	0.5	0.5	6.5	CR
Polygonum maritimum L.	H	M-ES	Z	Med	1	3	2	0	0	0.5	0.5	6	CR
Prunus arabica (Olivier) Meikle.	PhS, T	IT	Z	TZ	3	2	0.5	1	0	0.5	0	4	EN
Reseda globulosa Fisch. and Mey.	A	IT	Z	TZ, SD	2	2.5	0.5	0	0	0.5	0.5	4	EN
Romulea columnae Sebastiani and Mauri	G	M	Z	Med	3	2	1	0	0	0.5	0	3.5	VU
Ruppia maritima L.	Q	COSM	H	Med, SD	1	3	1.5	0	0	0	0	4.5	EN
Salvia ceratophylla L.	H	IT	Z	SD	1	3	0	1	0	0	0	4	EN
Salvia sclarea L.	H	M - IT	Z	Med	1	3	0	1	0	0.5		4.5	EN
Sarcocornia perennis (Mill.) A.J.Scott	C	M	W	Med, TZ	4	1.5	2	0	0	0	0	3.5	VU
Satureja thymbrifolia Hedge and Feinbrun	C	IT - SA	Z	SD	3	2	2	0	1.5	0	0	5.5	CR
Scandix palaestina (Boiss.) Boiss.	A	M	Z	Med	2	2.5	1.5	0	1	0	0	5	CR
Sedum palaestinum Boiss.	A	M	Z	Med, TZ	9	1	1	0	1	0	0	3	VU

Silene macrodonta Boiss.	A	M	Z	Med, TZ	1	3	1.5	0	0	0	0	4.5	EN
Silene papillosa Boiss.	A	M	Z	Med	1	3	2	0.5	0.5	0.5	0	6.5	CR
Suaeda monoica Forssk. ex J.F.Gmel.	PhS	SUD	W	SD	7	1	1.5	0.5	0	0.5	0.5	4	EN
Suaeda palaestina Eig and Zohary	C	SA - SUD	W	SD	30	0.5	1.5	0	1.5	0	0.5	4	EN
Suaeda vermiculata Forssk. ex J.F.Gmel.	C	SA	W	SD	1	3	1.5	0	0	0	0.5	5	CR
Tetraena alba (L.f.) Beier and Thulin	C	SA	Z	TZ, SD	1	3	2	0	0	0	0.5	5.5	CR
Teucrium spinosum L.	A	M	Z	Med	3	2	1.5	0	0	0	0.5	4	EN
Teucrium parviflorum Schreb.	H	M	Z	TZ	3	2	1	0.5	0	0.5	0.5	4.5	EN
Tripodion vulneraria Boiss.	F	M, ES	Z	Med	2	2.5	1.5	0	0	0.5	0	4.5	EN
Valerianella kotschyi Boiss.	A	IT	Z	Med	3	2	2	0	0	0.5	0	4.5	EN
Viola occulta Lehm.	A	IT	Z	Med, TZ, SD	2	2.5	0	0	0	0.5	0	3	VU
Viola pentadactyla Fenzl	A	M	Z	Med, TZ, SD	1	3	0.5	0	0.5	0.5	0	4.5	EN
Ziziphora tenuior L.	A	IT	Z	TZ, SD	4	1.5	0	2	0	0	0.5	4	EN

Table 3: Updated list of the "Red Plants" of Palestine. Rar=rarity; Vul=Habitat vulnerability and declining rate; Att, Attractivity; END, Endemism=Distribution type. Per=peripherality; Des=desjunctiveness; RN, Red Number (For parameter values see text). GF=Growth Form: A, Annuals; F, Biennials; C, Sub-Shrubs, and Chamaephytes; G, Geophytes; H, Hemicryptophytes; P, Parasites; Q, Aquatic plants; S, Shrubs; PhS, Phanerophyte shrub; T, Trees; V, Vines; HE, Helophyte. Poll=Pollination System: H, Water Pollination; W, Wind Pollination; Z, Animal Pollination; X, Mixed (W+Z) Pollination. Climatic region: Med, Mediterranean; SD, Desert; TZ, Transition. Chorotype: M, Mediterranean; IT, Irano-Turanian; SA, Saharo-Arabian; ES, Euro-Siberian; COSM, Cosmopolitan; SUD-Sudanian; T, Tropical. IUCN category: EX, Extinct; CR, Critically Endangered; EN, Endangered; Vu, Vulnerable.

Most of the threatened plants (78, 76.5%) belong to 12 plant families: Lamiaceae and Poaceae (each 10 spp. 9.8%), Compositae (9, 8.8%), Leguminosae and Iridadaceae 6, 5.9%), Caryophyllaceae (5 spp, 4.9%), Amaranthaceae, Amaryllidaceae, Apiaceae, and Brassicaceae, (each 4 spp, 3.9%), and Boraginaceae, and Rubiaceae each (3 spp, 2.9%) (Table 4).

Biological Characters of the Plants in the Red List

Growth form

Annuals are the highest (46, 45.1%) of threatened plants, followed by the hemicryptophytes (30, 29.4%), geophytes (17, 16.7%), chamaeophytes (sub-shrubs) (12, 11.8%), and trees (5, 4.9%). Growth form distribution in the red plant list was compared to the distribution of growth form in the whole Palestinian flora (Table 5). The frequency of the above-mentioned main growth forms categories in the red plant list is comparable to that of the Palestinian flora. The majority of threatened plants (78, 65%) are either critically endangered or endangered, followed by plants that are vulnerable (24, 1.2%) and therefore likely to become endangered (Table 2).

Pollination system

Eighty-three (81.4%) of the species in the red list are animal-pollinated, while 17 (16.7%) are wind-pollinated. Compared to the distribution of pollinated systems in the Palestinian flora (Table 5) only water-pollinated are over-represented in the red list.

Family	Genera/Family	Species / Family	%of threatened species/Family
Poaceae	9	10	9.8
Compositae	8	9	8.8
Lamiaceae	7	9	8.8
Iridaceae	3	6	5.9
leguminosae	3	6	5.9

Caryophyllaceae	4	5	4.9
Amaranthaceae	2	4	3.9
Amaryllidaceae	1	4	3.9
Apiaceae	4	4	3.9
Brassicaceae	4	4	3.9
Boraginaceae	3	3	2.9
Rubiaceae	3	3	2.9
Total	83	102	

Table 4: Plant families with highest representations of threatened plants.

Biological traits	**Palestinian flora (n=1938)**		**Red list (n=102)**	
	Number of species	**%among the total flora**	**Number of species**	**%in the related category**
Growth form				
Annuals (A)	1022	52.7	40	3.9
Chamaephytes (C)	237	12.2	9	3.8
Biennials (F)	2	0.1	0	0
Geophytes (G)	175	9	15	8.6
Hemicryptophytes (H)	383	19.8	26	6.8
Parasites (P)	29	1.5	3	10.3
Aquatic (Q)	1	0.1	1	100
Phanerophyte shrubs (PhS)	60	3.1	4	6.7
Trees (T)	65	3.4	4	6.2
Vines (V)	82	4.2	1	1.2
Helophyte (HE)	28	1.4	2	7.1
Climate zone				
Mediterranean (Med)	1452	74.9	63	4.3
Transition zone (TZ)	886	45.7	38	4.3
Semi and extreme Desert (SD, ED)	1107	57.1	32	2.9
Chorotype				
Cosmopolitan (COSM)	1	0.1	1	100
Tropical (T)	64	3.3	5	7.8
Euro-Siberian (ES)	208	10.7	11	5.3
Mediterranean (M)	1246	64.3	58	4.7
Irano-Turanian (IT)	656	33.8	43	6.6
Saharo-Arabian (SA)	320	16.5	11	3.4
Sudanian (SUD)	86	4.4	8	9.3
Others	106	5.5		0
Pollination system				
Animals (Z)	1497	77.2	83	5.5
Wind (W)	417	21.5	17	4.1
Water (H)	8	0.4	1	12.5

Insect and Wind (X)	7	0.4		
Fern	9	0.5		

Table 5: Distribution of the Palestinian flora and the Red List of endangered species according to growth form, climate zone, chorotype, and pollination system. Species categorized by their main chorotype, include mixed chorotype, e.g. Mediterranean chorotype includes also Mediterranean-Irano-Turanian.

The natural rarity of plants is thought to be accompanied by a breeding system that compensates for the need to seek a mate, e.g., selfing or vegetative reproduction, or making the flower easy to find for the pollinators [42]. Wind pollination was found to be under-represented among rare plants, biologically explained by the inefficiency of wind pollination whenever the mates are sparse [43]. But in the Palestinian red list, there is neither under-representation of wind pollination, nor an over-representation of the insect-pollinated plants. Since the attractivity parameter of the red number favors plants with large, insect-pollinated flowers, a bias of an over-representation of insect-pollination is expected in the list. The absence of such a bias implies that the species chosen for the red list are not necessarily of natural rarity, but threatened by another parameter (e.g., habitat destruction) [5].

Climate region

Out of the red list 63 (61.8%) species are Mediterranean, 38 (37.3%) species occur in the Transition zone, which is a unique area bordering the Mediterranean and the desert regions in Palestine and 32 (31.4%) are desert species [44].

Examining the whole flora, the Mediterranean species on the red list are over-represented, but transition and desert species occur less frequently than expected. This result emphasizes the urgent need for preservation measures for the Mediterranean climate zone in Palestine, which was the most damaged in recent years (Table 5).

Chorotype

Species in the red list are categorized on the basis of their distribution type (chorotype). 56.9 % of the species in the red list are Mediterranean species (Table 5), but this proportion is less than the expected according to the Mediterranean chorotype proportion in the Palestinian flora (64.3%). Sudanian, Tropical species, Irano-Turanin, and Sahara-Arabian which grow mainly in oases along the Dead Sea valley are also over-represented in the list may be due to the presence of water springs along the rift-valley, where those species grow.

Endemic red list plants

The number of threatened endemic plants is 25 plants, about 1.3% (25/1938) of the total number of the Palestinian flora. These species belong to 21 genera belonging to 13 plant families (Table 3). The majority of the plants (18, 72%) belong to six families: Iridaceae (5 species, 20%), Apiaceae, Caryophyllaceae, and Composite each (3 spp, 12%), and Amaryllidaceae, and Rubiaceae every 2 spp (4%).

It should be noted that most of these plants have beautiful flowers and/or bulbs (32%) that tempt individuals to harvest or uproot them (Tables 3 and 6) Most of these plants grow in the transition or Mediterranean zones, 12.7%, and 11.8 %, respectively. The majority of threatened endemic plants are critically endangered or endangered (23, 92%), while the remaining plants are considered vulnerable (2, 8%) and are expected to become endangered in the near future (Table 3).

Some of these plants are endemic in the West Bank and Gaza alone (5, 20%), while other plants are endemic in Palestine and some other neighboring countries (Table 3).

Biological traits	Extinct (n=18)	Endemic (n=25)
	Number of species (%)	Number of species (%, n=102)
Growth form		
Annuals (A)	7 (38.9)	7 (6.9)
Chamaephytes (C)	3 (16.7)	3 (2.9)
Geophytes (G)	2 (11.1)	8 (7.8)
Helophyte (HE)	1 (5.6)	0 (0)
Hemicryptophytes (H)	5 (27.8)	6 (5.9)
Parasite (P)	0 (0)	1 (1.0)
Vines (V)	1(5.6)	0 (0)
Climate zone		
Mediterranean (Med)	10 (55.6)	12 (11.8)
Transition zone (TZ)	3 (16.6)	13 (12.7)
Desert (SD)	7 (38.9)	7 (6.9)
Chorotype		
Euro-Siberian (ES)	1 (5.6)	0 (0)
Irano-Turanian (IT)	8 (44.4)	6 (5.9)
Mediterranean (M)	10 (55.5)	17 (16.7)
Saharo-Arabian (SA)	1 (5.6)	0 (0)
Sudanian (SUD)	1 (5.6)	1 (1.0)
Tropical (T)	2 (11.1)	0 (0)
Pollination system		3 (2.9)
Wind (W)	5 (27.8)	2 (2.0)
Animal (Z)	13 (72.2)	23 (22.5)

Table 6: Distribution of extinct and endemic plants of the red plant list according to growth form, climate zone, chorotype, and pollination system.

Red list-extinct species

Extinction of plant species during the last century is considered to be mainly due to human activity [3,45-48]. Human activity originated the extinction probability of plant species is affected by several factors most of which (e.g., rarity, number of sites, etc.) are included in the red number method used in this research. The number of extinct plant species is 18 plants, about 0.93% (18/1938) of the total number of plants in Palestine (Table 7). These species belong to 17 genera belonging to 15 plant families. The majority of extinct plants were critically endangered or endangered (14/18,78%), before they became extinct, while the remaining plants were considered vulnerable (Table 7).

Species name	GF	Chorotype	PolI	Climatic region	Tot no.of sites	Rar	VU	Att	END	Per	Dis	RN (IUCN category)
Aegilops crassa Boiss.	A	IT	W	TZ, SD	2	5	1	1	1	1	1	5 (CR)
Ambrosia maritima L.	C	M	W	Med	8	2	4	0	0	0	1	3.5(VU)
Ammannia baccifera L.	A	T	Z	Med	3	4	4	0	0	0	1	4.5 (EN)
Bunium ferulaceum Sm.	G	M	Z	Med	2	5	0	0	0	1(N)	0	3 (VU)
Convolvulus pilosellifolius Desr.	G, V	IT	Z	SD	3	4	3	1	1	1(S)	0	5(CR)
Cyperus jeminicus Rottb.	H	SUD	W	SD	1	6	4	0	0	1(S)	1	6 (CR)
Cyperus nutans var. eleusinoides (Kunth) Haines	HE	T	W	SD	1	6	2	0	0	1(S)	1	5 (CR)
Galium humifusum M. Bieb.	H	M-IT	Z	Med, TZ	2	5	0	0	0	0	1	2.5(VU)
Halocnemum strobilaceum (Pall.) M. Bieb.	C	M	Z	SD	1	6	4	0	0	0	0	5(CR)
Hypecoum aegyptiacum (Forssk.) Asch. and Schw.	A	SA	Z	SD	1	6	3	0	0	1	0	5 (CR)
Juncus sphaerocarpus Nees	A	ES-M-IT	W	Med	3	4	4	0	0	0	0	4 (EN)
Linum maritimum L.	H	IT	Z	MED	2	5	4	0	0	1(W)	0	5(CR)
Medicago tornata subsp. helix (Willd.) Ooststr. and Reichg.	A	M	Z	Med	7	2	4	0	0	1(N)	1	4(EN)
Olimarabidopsis pumila (Celak.) Al Shehbaz, O'Kane and R.A.Price	A	IT	Z	TZ, SD	1	6	1	0	0	1(N)	0	4 (EN)
Ononis variegata L	A	M	Z	Med	1	6	4	0	0	1(W)	0	5.5 (CR)
Phlomis chrysophylla Boiss.	C	M	Z	TZ	1	6	0	1	0	1(N)	0	4(EN)
Salvia bracteata Banks and Sol.	H	IT	Z	Med, TZ	2	5	4	2	0	1(N)	0	6 (EX)
Scrophularia macrophylla Boiss.	H	M-IT	Z	Med	8	2	3	0	0	1(N)	0	3(VU)

Table 7: Extinct plant species of Palestine and their conservation status as shown by their "red numbers" before extinction. Abbreviations as in Table 3.

None of these plants were endemic in the West Bank and Gaza alone. Most of them were annuals (about 39%), mainly Mediterranean (about 56%), and mainly pollinated by animals (72.2%) (Table 6).

Plant species extinction has been considered to be mainly due to human activity [3,48]. Rarity, habitat vulnerability, attractivity, endemism, peripherality, and disjunctiveness of the plant are the main factors that affect human-activity-related extinction probability. The rarity of the Palestinian red-listed plants is most likely to be due to habitat destruction and fragmentation which has been regarded as the most threatening cause for rarity and extinction on a global scale [48] and especially in Palestine. Despite its importance as an important factor for predicting extinction, rarity is not an exclusive attribute when dealing with human-activity-related threats. Various types of rarity [49] are not sufficient for determining conservation priorities or human-activity-related extinction probability. The reasons for the rarity of the rare species are not known. However, it can be assumed that heavy urbanization and development in Palestine in the last few decades are the main causes.

Conclusion and Recommendation

The Palestinian flora offers an indication that habitat destruction, and not rarity, is the main cause of extinction Appendix 2 The main factors that threaten the existence of plants (e.g., critically endangered species) in the Palestinian Red List include: transition from traditional to intensive agriculture, accompanied by deep ploughing and the

application of pesticides; small size of the populations; conversion of sandy areas to agricultural use; the plant species is known from only a single site; intensive grazing as well as pressure from the population of adjacent local communities; desiccation and pollution of springs and wetlands where the plant grows; urban development and construction (habitat destruction); the plant grows in one region in Palestine; urban and tourism development (recreational pressure) on the Gaza coast constitute a major threat to the continued existence of some plant species on beaches; increase of water pumping and destruction of the sections on which the species grows on the Gaza coast; massive uprooting for exportation; land reclamation activity and earthworks at the species growth sites; over-pumping of stream waters; and the development of beaches for recreation and bathing (Appendix 2) Management and conservation recommendations have also been presented and discussed in (Appendix 2). In the red list, the plant's biological traits may provide an understanding of the difference between natural rarity and the urgency of preservation. However, no significant relationships were found between any of these biological traits, e.g., life history traits, and rarity. Hence, the red number as the value of a plant species for conservation is not sensitive to the correlations with its biological traits. From the conservation point of view, the quantitative nature of the red number makes it easy to update the values and improve its evaluation whenever new data are gathered. Accordingly, in this study, the BERC 2002 Red list of Palestinian flora of the West Bank and Gaza has decreased in size with the updated list providing a quantitative more realistic and powerful means in the struggle for conservation.

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