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Constructing Red Numbers for setting conservation priorities of endangered plant species: Israeli flora as a test case

Yuval Sapir[1]*, Avi Shmida[1] & Ori Fragman[1,2]

[1] Rotem – Israel Plant Information Center, Dept. of Evolution, Systematics and Ecology, The Hebrew University, Jerusalem, 91904, Israel; e-mail: sapir@vms.huji.ac.il
[2] Present address: Botanical Garden, The Hebrew University, Givat Ram, Jerusalem 91904, Israel

Abstract

A common problem in conservation policy is to define the priority of a certain species to invest conservation efforts when resources are limited. We suggest a method of constructing red numbers for plant species, in order to set priorities in conservation policy. The red number is an additive index, summarising values of four parameters: 1. Rarity – The number of sites (1 km^2) where the species is present. A rare species is defined when present in 0.5% of the area or less. 2. Declining rate and habitat vulnerability – Evaluate the decreasing rate in the number of sites and/or the destruction probability of the habitat. 3. Attractivity – the flower size and the probability of cutting or exploitation of the plant. 4. Distribution type – scoring endemic species and peripheral populations.

The plant species of Israel were scored for the parameters of the red number. Three hundred and seventy (370) species, 16.15% of the Israeli flora entered into the "Red List" received red numbers above 6. "Post Mortem" analysis for the 34 extinct species of Israel revealed an average red number of 8.7, significantly higher than the average of the current red list. Only 15 species were known only from one site before extinction, indicating that rarity is not the only factor of extinction in Israeli flora.

The red number suggested here is a pragmatic method and can be easily modified for conservation needs of any region. The red number method can supply a powerful quantitative weapon in the struggle for conservation.

Key words: Biodiversity, conservation policy, extinct species, habitat destruction, rare plants.

Introduction

The extinction rate of species is increasing and threatens the biodiversity of nature (Pimm & Raven 2000). Species extinction is but the tip of an iceberg because it does not reflect the loss of individual populations or of genetic diversity as separate declines in populations (Ehrlich & Daily 1993). That human activity is responsible for mass extinction at present is now beyond argument. The impact of human activity is prevalent in the Mediterranean Basin, which is an important hotspot of diversity on a global scale (Myers et al. 2000). While considerable effort has been invested in conservation programs around the world, the conflict of how to distribute limited resources is still not completely solved. The main challenge is to identify the species and the ecosystems that are high priority for conservation. The main problem is to define the importance of a certain species for investment of conservation efforts in a situation of limited resources.

In the past, conservation efforts for plants were based mainly on estimations of vulnerability, which may be inconsistent among countries and conservation organisations. The World Conservation Union (IUCN) has developed quantitative criteria for evaluating the extinction probability of species (IUCN 1994), contain-

*corresponding author

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ing five criteria of vulnerability: Extinct, Critical endangered, Endangered, Vulnerable and Near Threatened. These categories have been widely accepted throughout the world and form the basis for the IUCN Red List of Threatened Plants (Walter & Gillet 1998). The IUCN criteria consist of a set of decision rules, based on quantitative thresholds of population size, distribution range, rate of declining and extinction probability (IUCN 1994, 2001). Modifications to the IUCN criteria of 1994 took place due to critiques concerning scale problems, regional requirement and the need to fit the criteria to the whole spectrum of organisms (Gardenfors et al. 2001; IUCN 2001; Keith 1998; Keith et al. 2000; Mace 1995). The overall structure of the rule set, however, was not altered (IUCN 1994, 2001).

The IUCN criteria are the first step in conservation, expressing the estimation of extinction probability. The next step should be setting priorities of the species for conservation. Coates and Atkins (2001) suggested a priority setting process based on the risk of extinction at population, taxon and ecological community levels, genetic structure and population ecology (Coates & Atkins 2001). For such a prioritisation method, an extensive survey is needed. For most countries that require an urgent conservation policy setting, such data are scarce or unavailable.

Legislation for nature conservation in Israel is based on the 1964 law of "Protected Natural Values". An appendix to the law included a species list, since protected by law (Paz 1981). The list includes 268 wild plant species that are protected throughout Israel. The list was constructed mainly for attractive flowers, and contains no quantitative assessment. All species are equal in their status. There is no contesting the fact that this law saved some attractive plants (e.g. *Oncocyclus* irises, Peony and Candid lily) from extinction or at least from a drastic decline in population, but on the other hand, none of the 34 extinct plant species of Israel were included in the list prior to their extinction (Shmida et al. 2002).

We suggest a pragmatic method to determine priorities for conservation on a regional and/or national scale. This method is compatible to any region of the world with minor adjustments, making it applicable for regional or national conservation policies. The "red number" method suggested here is not an alternative to IUCN criteria, but complementary in the regional scale for setting conservation priorities.

Calculating red numbers demands minimum data gathering. It can be calculated even if only preliminary data are available. For example, if only herbarium records exist for a certain country, red numbers will be calculated based on existing data, and then a successive approximation will be conducted during or after the field survey.

The red number is an additive index, calculated by summarising the values of four parameters: (1) rarity, (2) declining rate, (3) attractivity, and (4) distribution type. 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 17, when all the parameters get the highest score.

In the following sections of the paper we will describe the method for constructing red numbers for plants. We applied the red number method to Israeli plants and built a red list with conservation priorities, as quantified by the red numbers. Hereafter we analyse the biological traits of the plants in the red list. The same procedure was applied for extinct plants, as will be described later. The data on the plants were gathered from the Rotem (Israel Plants Information Center) database since 1981, based on volunteer and expert observations from all around Israel. The second source of information was experts' comments on the preliminary red list.

Parameters for the Red Number

Rarity

A definition of rarity is a subject to confusion and arbitrary decisions (Gaston 1997). Generally, rarity is unequal neither to endemism nor to threatened status (Gaston 1997). Rarity definitions are by geographic range, abundance, niche width, or a combination of these factors (Rabinowitz 1981). We suggest using the extent of occurrence as a measure of rarity. The number of sites where the species is present is suggested as the measurement unit, where a site is defined as 1 km^2. One square kilometer suggests a comfortable working frame and an applicable unit (Gaston 1994). In the Rotem database, observations of plants are usually recorded in a resolution of 100 m. Nonetheless, a number of species' sites are not significantly affected by the exact superimposition of the map grid lines (Nathan and Shmida, unpublished data).

Rarity is scored according to the species' occurrence as a percentage of the area in question. Israel's area is approximately 22,000 km^2 (eventually being 22,000 potential sites for each species). Here we determined rarity as a relative attribute, proportional to the country area. Rare species are those that are present in less than 0.5% of Israeli area, which are 110 sites. Species present in 110 sites or less score a rarity value of 1. For the following values of rarity, the area of occurrence decreases in values that create "focal points" of relative abundance, i.e. 0.5% to 0.1% of the area, 0.1% to 0.05% of the area, etc. (Table 1). The highest value is 6, applies to a species that is present in only one site. We suggest using this value for a single site, regardless of its percentage of the region in question, to emphasise the vulnerability of a single site to human disturbance. Areas of occurrence in the scale are suitable to Israel's area, but can be applied to any geographical or political region by considering the percentage of the region as a scale.

Declining rate and habitat vulnerability

Declining rate is a measure based on the number of sites known at present, compared to the number of sites recorded in the past. Usually the number of known sites for a certain species increases with the development of knowledge. Distribution of a rare species that decreases with time (and knowledge assemblage) may indicate a threat for that species. The rate of decline of plant species in Israel is calculated as the ratio between the number of sites recorded after 1965 and the number of sites before 1965, as judged by herbarium records. This ratio, expressed as percentages, is the declining rate. Although the declining rate recommended by the IUCN categories is over ten years (IUCN 2001), the year of 1965 was chosen for Israel because of the role of the "Law of National Parks and Nature Reserves" as a turning point in the conservation policy of Israel (Paz 1981). In a case of no significant turning point date in national conservation policy, the parameter of the recent ten years may be used, as recommended in the IUCN criteria (1994, 2001). A declining rate of sites is correlated to habitat vulnerability, and expressed by the rate of habitat destruction (Fragman et al. 1999a). The values of the declining parameter (Table 1) consider not only the past declines, but also the probability of future declines by considering habitat vulnerability, estimated by extrapolating the destruction rate till present. Habitat vulnerability is a categorical feature, to be used whenever no quantitative data for the declining rate are available.

Table 1. Values for the Red Number parameters.

Criterion	Value
Rarity	
0.5%–0.1% of the area (110-22 sites in Israel)	1
0.1%–0.05% of the area (21-11 sites in Israel)	2
0.05%–0.01% of the area (10-4 sites in Israel)	3
0.01% of the area (3 sites in Israel)	4
0.005% of the area (2 sites in Israel)	5
Single site	6
Declining rate and habitat vulnerability	
Declining rate of 1%–30% or small probability of habitat destruction	1
Declining rate of 31%–50% or medium probability of habitat destruction	2
Declining rate of 51%–80% or high probability of habitat destruction	3
Declining rate of > 81% or very high probability of habitat destruction	4
Attractivity	
Flower size of 1–2 cm or succulent	1
Flower size of 2–3 cm or commercial / medicinal herb	2
Flower size of >3 cm or colourful inflorescence or trees with straight trunk	3
Distribution type	
Endemic Sub-species or peripheral populations	1
Regional endemic species	2
Sub-endemic species	3
Narrow endemic species	4

Attractivity

The value of the red number parameter of attractivity is expressed by the levels of threat by human exploitation, alongside the potential "public relations" of the flower. Attractivity may be the probability of cutting the flower due to its size or colour, but can be also the threat of logging, collecting of medicinal herbs for commercial use, and collection of succulents (Table 1). In the case of two possibilities for scoring attractivity (e.g. succulent and colourful inflorescence), the higher score is chosen. Flower attractivity is not only the threat of picking for the plant, but also may aid in "marketing" it to the public as an important species for conservation.

Distribution type

Endemism status of a species usually relates to a natural geographical area. Political borders between countries are usually almost invisible to plants and should not be considered (Gardenfors et al. 2001). However, borders can limit the knowledge and conservation cooperation between neighboring countries. We used political borders to indicate distribution types for the sake of prioritisation for conservation. This makes it possible for the red numbers to be computed by each country alone, even without the essential knowledge from neighboring countries. Note that endemism is not necessarily correlated with rarity, since many of the Israeli endemics are in more than 110 sites (A. Shmida, unpublished data). Values for the distribution parameter increase with a decrease of distribution area (Table 1), where a species endemic to the country in question (e.g. Israel) get the highest score. Species also distributed in adjacent regions outside the country's border get the second highest score, and species endemic to the region (e.g. eastern Mediterranean basin or the Levant – Israel, Syria, Lebanon and Jordan – in the case of Israeli species) get the third highest score (Figure 1).

Peripheral populations are more prone to extinction than non-peripheral (core) populations (Nathan et al. 1996; Safriel et al. 1994). Peripheral populations are more variable in genetic, phenotypic and demographic traits (Blows & Hoffmann 1993; Hoffmann & Blows 1994; Nantel & Gagnon 1999; Safriel et al. 1994; Volis et al. 1998). Populations in the margins of the distribution differ in the abundance (Brown 1984) and are a potential refuge for declining species (Channell & Lomolino 2000; Safriel et al. 1994). Considering the relative importance of peripheral populations for conservation, a value of 1 is given if the species has a marginal distribution. The same value of distribution type can be applied both to endemic subspecies and peripheral populations due to their analogy as stages in the speciation process (Grant 1981; Levin 2000).

Constructing the Red List

The threshold value of red number for inclusion in the red list is 6, which except for rarity, at least two parameters should contribute for the red number to score above the threshold. A plant species that acquired a red number of 6 must be restricted to one site only, or very rare (rarity parameter of 5) *plus* a score of at least 1 in another parameter. Only the rarity parameter is able to cause a species to be entered to the list, whenever only one site of a species is known. One site is at a high level of threat, because one single disturbance event can destroy the whole species' distribution.

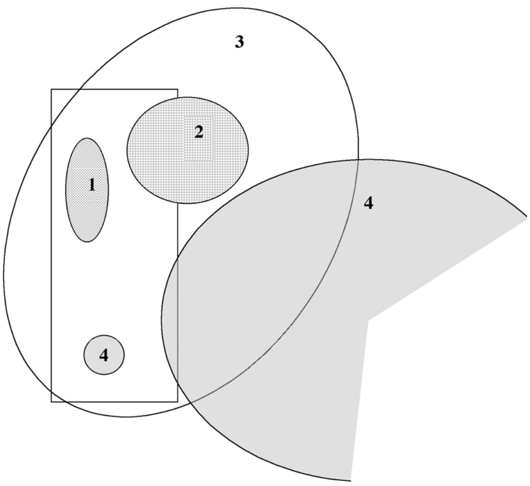

Figure 1. Distribution types for calculating Red Number. The region in question is in the rectangle and the areas of species occupancy are in circles. Numbers of distribution types indicate their priority for conservation (see text). 1. Narrow endemic species. 2. Subendemic species. 3. Regional endemic species. 4. Peripheral populations/endemic subspecies.

No red numbers can be applied to extinct species because the parameters of rarity cannot be applied for not-existing plants. However, the situation changes immediately if this species is re-found or reintroduced. The red number method enables the application of a "Post-Mortem" number that can indicate the reasons for the extinction. The number of sites recorded in the past before extinction contributes to the rarity parameter for extinct species.

Applying the Red Numbers to Israeli flora

For demonstrating the red number method, we will walk through the scoring of *Iris atropurpurea* as an example of applying the method (see appendices for authority of all species mentioned hereafter). *I. atropurpurea* grows in 37 sites along the coastal plain of Israel, giving it a rarity value of 1 (Table 1). Its habitat – sandy hills in the most populated area of Israel – is in an area of very high probability of destruction due to high urbanisation, giving it a habitat vulnerability value of 4 (Table 1). The flower diameter of *I. atropurpurea* is 6 to 8 cm (Sapir et al. 2002), giving it an attractivity value of 3 (Table 1). *I. atropurpurea* is a narrowly endemic species distributed along the coastal plain of Israel, giving it a distribution value of 4 (Table 1). Summarising the parameters values for *Iris atropurpurea*, the red number calculated is 12, indicating *I. atropurpurea* as being a high priority for conservation.

In the same way all the plant species of Israel were scored for the parameters of the red number. Only 2290 of the autochthony species for Israel were analysed. Species exclusive to the Hermon Mt., Jordan and Sinai, as well as episodic, cultivated and taxonomically doubtful species, were not included. Species entry criterion for the red list was based upon rarity, i.e., species that were present in less than 110 sites. The number of sites for each species modified from the Rotem database, where approximately 630,000 observations of plants and their localities (coordinates) were gathered. The data were accumulated since the establishment of Rotem in 1981, provided by many amateur and expert naturalists, who recorded plants in wild habitats. Information on biological traits of growth form, pollination system, climate region and chorotype is available for most of the species in the database (Fragman et al. 1999b).

After listing the rare species, the other parameters were scored and red numbers were calculated for those species. Only the 370 species that received red numbers of 6 or above were chosen for the "red list" of endangered plants (see appendix 1). The highest possible score for a species is 17, but the red numbers for plant species in the Israeli flora do not exceed 14 (for *Astragalus oocephalus*). The average red number in the red list is 7.65, with a standard deviation of 1.57. According to the checklist of the Israeli flora (Fragman et al. 1999b), the total number of wild species in Israel (including Golan Heights and the Palestinian Authority) is 2399. The number of autochtonous plants in Israel (excluding vagrants, episodic and species escaped from cultivation) is 2290, and of those 16.15% are in the red list of endangered plants.

Biological traits of the plants in the Red List

Growth form

Growth form distribution in the red plant list was compared to the distribution of growth form in the Israeli flora (Table 2). The frequency of herbaceous plants (annuals, biennials, geophytes and hemicryptophytes) in the red plant list is much higher than woody plants (chamaephytes and trees). Distribution of growth form in red list plants is significantly different than in the whole flora ($\chi^2 = 55.36$; df = 9; $p < 0.0001$; Table 2). The growth forms mostly influencing the difference are annuals ($\chi^2 = 7.65$; df = 1; p = 0.005), chamaephytes ($\chi^2 = 6.94$; df = 1; p = 0.008), hemicryptophytes ($\chi^2 = 12.82$; df = 1; $p < 0.001$) and aquatic plants ($\chi^2 = 21.64$; df = 1; $p < 0.001$). We also tested the differences between plants functional types (Kelly 1996) for red numbers. No differences were found between woody (trees, shrubs and chamaephytes) and non-woody (annuals, biennials, geophytes and hemicryptophytes) plants (Mann-Whitney U = 7167, p = 0.24). Comparisons between annuals and perennial herbs (biennials, geophytes and hemicryptophytes) and between trees and shrubs (including chamaephytes) revealed no difference (Mann-Whitney U = 10439, p = 0.63 and Mann-Whitney U = 239, p = 0.77, respectively).

Pollination system

Two hundred and seventy six (74.6%) of the species in the red list are animal-pollinated, while 69 (18.6%) are wind-pollinated. Compared to the distribution of pollination systems in the Israeli flora (Table 3), only water-pollinated species are over-represented in the red list ($\chi^2 = 14.43$; df = 1; p = 0.0001). Fragman et al. (1999a) showed that among the extinct species of Israel, aquatic plants are more prone to extinction due to their extensive habitat loss. Our results of higher proportion of water-pollinated species in the red list prompt the conservation urgency of aquatic species prior of their extinction.

Natural rarity of plants is theoretically 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 (Gaston & Kunin 1997; Kunin & Shmida 1997). Harper (1979) found wind pollination to be under-represented among rare plants, biologically explained by the inefficiency of wind pollination whenever the mates are sparse (Harper 1979). But in the Israeli 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).

Table 2. Distribution of growth forms in the Israeli flora and in the Red List of endangered species. Criteria are not mutually exclusive.

Growth form	Israeli flora		Red List	
	# of species	%	# of species	%
Annuals	1169	51	139	37.5
Chamaephytes	305	13.3	28	7.5
Biennials	33	1.4	8	2.1
Geophytes	192	8.3	39	10.5
Hemicryptophytes	510	22.2	108	29.1
Parasites	21	0.9	4	1
Aquatic	42	1.8	18	4.8
Shrubs	68	2.9	8	2.1
Trees	90	3.9	14	3.7
Vines	32	1.3	4	1

Table 3. Number of species of pollination systems in the Israeli flora and in the Red List of endangered species.

Pollination System	Israeli flora		Red List	
	# of species	%	# of species	%
Animal	1755	76.6	276	74.6
Wind	444	19.3	69	18.6
Mixed (animal+wind)	12	0.5	3	0.8
Water	23	1	11	2.9
Fern /No Data	56	2.4	11	2.9

Climate region

Out of the red list, 271 species are Mediterranean, 88 are desert species and 65 species occur in the Transit belt, which is a unique area bordering the Mediterranean and the desert regions in Israel (Aronson & Shmida 1992) (Table 4). Examining the whole flora, the Mediterranean species on the red list are over-represented ($\chi^2 = 22.57$; df = 1; $p < 0.0001$), but Transition and Desert species occur less frequently than expected ($\chi^2 = 17.1$; df = 1; $p < 0.0001$ and $\chi^2 = 5.43$; df = 1; p = 0.019, respectively). This result emphasises the urgent need for preservation measures for the Mediterranean climate zone in Israel, which was the most damaged in recent years.

Chorotype

Species in the red list are categorised on the basis of their distribution type (chorotype; Danin & Plitmann 1987). Each species are categorised according to the main chorotype, for example, Mediterranean-Irano-Turanian chorotype is categorised as Mediterranean. More than 44% of the species in the red list are Mediterranean species (Table 5), but this proportion is significantly less than the expected according to the Mediterranean chorotype proportion in the Israeli flora ($\chi^2 = 6.74$; df = 1; p = 0.009). Fourteen cosmopolitan species are in the red list, more then expected according to the proportion in the Israeli flora ($\chi^2 = 9.4$; df = 1; p = 0.002), because many of the cosmopolitan species in Israel are growing in the threatened aquatic habitats. Sudanian and Tropical species, which grow mainly in oases along the Dead Sea valley are also over represented in the list ($\chi^2 = 7.43$; df = 1; p = 0.006). A possible explanation can be the inclusion of water springs along the rift-valley, where those species grow.

Table 4. Number of species in the climatic regions in the Israeli flora and in the Red List of endangered species. Criteria are not mutually exclusive.

Climate Zone	# of species in the flora	# of species in the Red List
Mediterranean	1617	271
Transit	859	65
Desert	897	88

Table 5. Number of species of each chorotype in the Israeli flora and in the Red List of endangered species. Species categorised by their main chorotype, include mixed chorotype, e.g. Mediterranean chorotype includes also Mediterranean-Irano-Turanian.

Chorotype	Israeli flora		Red List	
	# of species	%	# of species	%
Cosmopolitan	39	1.7	14	3.7
Holoarctic	12	0.5	3	0.8
Euro-Siberian	134	5.8	27	7.3
Mediterranean	1236	53.9	163	44
Irano-Turanian	235	10.2	45	12.1
Saharo-Arabian	293	12.7	20	5.4
Sudanian-Tropical	142	6.2	36	9.7
Others	199	8.6	62	16.7

Extinct species

Thirty-four plant species became extinct in Israel since 1965 (see also Fragman et al., 1999a, but they are considered vagrant species alongside the autochtonous plants). For these species red numbers are calculated by applying the rarity parameter to the number of sites before extinction (appendix 2). Although before extinction the number of sites is theoretically one, we considered the known sites before 1965, and "extinct" species is a species that was not found since 1965.

Analysis of the red numbers ("*Post Mortem*" analysis) revealed an average red number of 8.71, with standard deviation of 1.96, significantly higher than the average of the current red list (student's t-test, p = 0.0042). Only four extinct plant species scored red numbers of 5, while the other 29 species scored red numbers of 6 to 11. Of the four species that scored a red number value of 5, two (*Reseda globulosa* and *Trifolium filiforme*) were restricted to two sites only without contribution of another parameter. The other two species (*Dorycnium hirsutum*, and *Hypecoum aegyptiacum*) were recorded from three sites and were also peripheral populations. The maximal red number of the extinct species is 11, demonstrate that a relatively low red number may not be an obligate predictor to extinction threat. Only 15 species were limited to one site before extinction, indicating that rarity is not the only factor of extinction in Israeli flora. It is important to note that no endemic species became extinct. An explanation may be the relatively large number of sites for most of the endemic species. The only four Israeli endemic species that are restricted in their distribution (*Anchusa negevensis* and *Lathyrus lentiformis* – one site; *Vicia basaltica* and *V. esdraelonensis* – three sites; see appendix 1), still exist in their type locality (A. Danin, U. Plitman and O. Cohen, per. comm.; Fragman & Shmida 1994–1997). Half (17) of the extinct species were peripheral populations at the border of the distribution. No sub-endemic or regional endemic species became extinct. These results stress the differentiation between parameters for assessing extinction probability and parameters for conservation priorities, as are in the red number.

Discussion

Extinction of plant species during the last century is considered to be mainly due to human activity (Channell & Lomolino 2000; Dafni & Agami 1976; Duncan & Young 2000; Fragman et al. 1999a; Myers et al. 2000; Pimm & Raven 2000). Several factors affect anthropogenic extinction probability, most of them are included in the red number method suggested in this paper. Rarity may be caused by biological constraints (Fiedler & Ahouse 1992; Levin 2000), or due to habitat destruction and fragmentation. Many causes of rarity are listed in Fiedler and Ahouse (1992), but we argue that the parameter of habitat destruction is, and will be, the most threatening cause for rarity and extinction on a global scale (Pimm & Raven 2000), and especially in Israel. Although rarity is an important parameter for predicting natural extinction, it is not an exclusive factor when dealing with anthropogenic threat, and may result in an underestimation of the threat if considered exclusively (McIntyre 1992). Various forms of rarity (Fiedler & Ahouse 1992; Rabinowitz 1981; Soule 1986) are not sufficient for determining conservation priorities or anthropogenic extinction probability. The red number emphasises the difference between rare species and threatened species. We do not know the reason for the rarity of all the rare species, but we assume that heavy urbanisation and development in Israel in the last fifty years is the main cause. The Israeli flora provides a demonstration that habitat destruction, and not rarity, is the main cause of extinction (Fragman et al. 1999a).

Biological traits of the plants in the red list provide an insight to the difference between natural rarity and between the urgency of preservation. Kelly and Woodward (1996) analysed the flora of Great Britain and found that shrubs are less common than trees, and wind-pollinated plants are more rare than non-wind pollinated (Kelly & Woodward 1996). They also hypothesised a number of other relationships between life history traits and rarity, but none were found to be significant. The red number contains a relatively high component of rarity, potentially up to 1/3 of its value, but no such trends were found in both growth forms and in the pollination systems. The value of a plant species to conservation, as expressed in the red number, is not sensitive to the rarity/commonness correlations of biological traits.

Population size (i.e. number of mature individuals) of a species is one of the parameters considered in IUCN criteria (IUCN 2001) and also combined in rarity forms (Rabinowitz 1981). In spite of this, we did not use population size due to its un-pragmatic nature in plants, given their diverse life forms, which affect mainly the density and local abundance. There is an apparent difference between trees, which are easy to count, and between annuals, where thousands of individuals can grow in a square of 10x10 cm (A. Shmida, unpublished data). The exact number of individuals could be counted only in very rare species with a significantly small amount of individuals. Although there are some debates, we regard the number of sites as a reliable representation of population size, because of the correlation between distribution range and abundance (Brown 1984; Gaston et al. 2000; He & Gaston 2000). From the conservation point of view, in the cases of populations restricted to a few sites, a single disturbance event can destroy the whole population, no matter its size.

An evaluation method for conservation should be suitable for universal application. The red number suggested here is a pragmatic method, which can be easily modified for conservation needs of any country or geographical region. Conservation efforts depend on resources and can increase if the resources improve. Changes in decisions on how to distribute the resources are easier with the red number method, it only requires changes in the threshold. The quantitative characteristics of the red number make it easy to update the values whenever new data are gathered. On the other hand, for quantitative and accurate data there is a need for an extensive field survey, which is not always feasible. In that case, estimating the values of the parameters according to expert knowledge will give a temporary evaluation. Successive approximation may improve the red number's evaluation throughout the time of survey. Red lists of species for a certain area may also decrease in size whenever the status of a species is changed. An optimistic option is inclusion in a "blue list" of species that are experiencing lasting overall stabilisation or an increase in abundance in the region considered (Gigon et al. 2000). All in all, the red number method can supply a powerful quantitative weapon in the struggle for conservation.

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Appendix 1

List of the "Red Plants" of Israel with the parameters scoring. Threshold for inclusion in the list is Red Numbers above 6.
Legend: Rar = rarity; Dec = Habitat vulnerability and declining rate; Att = Attractivity; Dis = Distribution type; 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; T – Trees; V – Vines. Poll = Pollination System: H – Water Pollination; W – Wind Pollination; Z – Animal Pollination; X – Mixed (W+Z) Pollination. Climate = Climate Zone: M – Mediterranean; D – Desert; T – Transition. Chorotype: M – Mediterranean; IT – Irano-Turanian; SA – Saharo-Arabian; ES – Euro-Siberian; COS – Cosmopolitan; HOL – Holoarctic; SUD – Sudanian; T – Tropical; blank – others.

Species	Rar	Dec	Att	Dis	**RN**	GF	Poll	Climate	Chorotype
Achillea aleppica DC.	5			1	**6**	H	Z	T	IT
Acinos rotundifolius Pers.	6			1	**7**	A	Z	T	M-IT
Adonis aestivalis L.	3	2	2	1	**8**	A	Z	M+T+D	M-IT-ES
Aegialophila pumilio (L.) Boiss.	2	4	2	1	**9**	H	Z	M	M
Aeluropus lagopoides (L.) Trin.	2	4		1	**7**	H	W	T+D	M-IT-SA
Aeluropus littoralis (Gouan) Parl.	2	4		1	**7**	H	W	M+D	M-IT
Aethionema carneum (Banks & Sol.) Fedtsch.	6				**6**	A	Z	T	IT
Agrostemma githago L.	4	2	2	1	**9**	A	Z	M	M-ES-IT
Alcea striata (DC.) Alef.	2		3	1	**6**	H	Z	D	IT
Alisma gramineum Legeune	6	4	1		**11**	Q	Z	M+D	
Alisma plantagoaquatica L.	3	3		1	**7**	H	Z	M	COS
Alkanna galilaea Boiss.	2	3		3	**8**	H	Z	M	M
Alliaria petiolata (M. Bieb.) Car. & Gra	6			1	**7**	A	Z	M	
Allium albotunicatum O. Schwarz	4			3	**7**	G	Z	M	IT
Allium negevense Kollm.	2		1	4	**7**	G	Z	D	SA
Allium papillare Boiss.	3	3		1	**7**	G	Z	D	SA
Allium sinaiticum Boiss.	2	3	1	1	**7**	G	Z	D	SA
Allium tardiflorum Kollm. & Shmida	2			4	**6**	G	Z	M	
Althaea officinalis L.	6	4	2	1	**13**	H	Z	M	ES-IT-M
Alyssum szowitsianum Fisch. & Mey.	5			1	**6**	A	Z	D	
Ambrosia maritima L.	2	4			**6**	A	W	M	M
Ammannia auriculata Willd.	3	4			**7**	A	Z	M	T
Amygdalus arabica Olivier	3		2	1	**6**	T	Z	T	IT
Amygdalus ramonensis Danin	1		2	4	**7**	T	Z	D	
Anchusa negevensis Danin	6	1	1	4	**12**	H	Z	D	
Anchusa ovata Lehm.	2	3		1	**6**	A	Z	M	IT
Androsace maxima L.	3	3			**6**	A	Z	T+D	M-IT
Andzeiowskia cardamine Reichenb.	6			1	**7**	A	Z	M	
Anthemis chia L.	2	2	1	1	**6**	A	Z	M	M
Anthemis hyalina DC.	6				**6**	A	Z	M	IT
Anticharis glandulosa Asch.	6	2		1	**9**	A	Z	D	
Antinoria insularis Parl.	3	4		1	**8**	A	W	M	
Arabidopsis pumila (Stephan) Busch	6	3			**9**	A	Z	T+D	IT
Arabis alpina Schlecht.	5			1	**6**	H	Z	M	M-IT
Arabis auriculata Lam.	6				**6**	A	Z	D	M-IT
Aristida sieberiana Trin.	2	4		1	**7**	H	W	M	SUD
Aristolochia scabridula Boiss.	6			1	**7**	H	Z	M	
Asphodelus refractus Boiss.	5			1	**6**	G	Z	D	SA
Aster tripolium L.	4	4			**8**	H	Z	M	ES-M-IT
Astragalus fruticosus Forssk.	4	3		1	**8**	H	Z	T+D	SA
Astragalus guttatus Banks & Sol.	4	1		1	**6**	A	Z	T+D	IT
Astragalus oocephalus Boiss.	6	4	3	1	**14**	H	Z	M	IT
Astragalus scorpioides Pourr.	6			1	**7**	A	Z	T	M-IT
Atriplex lasiantha Boiss.	6	2		1	**9**	A	W	M+T+D	M-IT
Avena clauda Durleu	4	3		1	**8**	A	W	M+T	IT-M
Avena eriantha Durieu	4	3		1	**8**	A	W	M	
Avena longiglumis Durleu	3	3		1	**7**	A	W	M+T	M

Species	Rar	Dec	Att	Dis	**RN**	GF	Poll	Climate	Chorotype
Bacopa monnieri (L.) Pennell	3	3		1	**7**	H	Z	T+D	T
Ballota philistaea Bornm.	1	3		3	**7**	H	Z	M	M
Bellevalia longipes Post	2	3	1	1	**7**	G	Z	M	IT
Bellevalia macrobotrys Boiss.	2	3	1		**6**	G	Z	M	M-IT
Bellevalia zoharyi Feinbrun	3		1	3	**7**	G	Z	D	IT
Bergia ammanioides Heyne	6	4			**10**	A	Z	M	T
Biarum auranitcum Mout.	5			3	**8**	G	Z	M	
Biarum olivierii Blume	5			2	**7**	G	Z	D	SA
Bidens tripartita L.	3	3		1	**7**	A	Z	M	M
Brachiaria eruciformis (Sm.) Griseb.	5	2			**7**	A	W	M	M-IT-T
Brachiaria mutica (Forssk.) Stapf	2	4		1	**7**	H	W	M+T	T
Brassica cretica Lam.	6		1	1	**8**	C	Z	M	M
Bupleurum orientale Snogerup	3	4		1	**8**	A	Z	M+T	ES-M-IT
Butomus umbellatus L.	1	4	2	1	**8**	H	Z	M	ES-M-IT
Callipeltis factorovskyi (Eig) Ehrend.	3	3		2	**8**	A	W	M+T	M-IT
Callitriche lenisulca Clav.	3	3		1	**7**	F	H	M	HOL
Callitriche truncata Guss.	2	3		1	**6**	H	H	M	
Calystegia soldanella (L.) R. Br.	3	4			**7**	H	Z	M	
Campanula peregrina L.	6		2	1	**9**	H	Z	M	
Cardopatium corymbosum (L.) Pers.	2	2	1	1	**6**	H	Z	M	M
Carex acutiformis EHRH.	3	3		1	**7**	H	W	M	ES-M-IT
Carex hallerana Asso	5	2		1	**8**	H	W	M	M-IT
Carex pseudocyperus L.	4	3			**7**	H	W	M	ES-M-IT
Carlina racemosa L.	6	4		1	**11**	A	Z	M	M
Catabrosa aquatica (L.) Beauv.	3	4		1	**8**	H	W	M	ES-M-IT
Catapodium marinum (L.) C. E. Hubb.	3	4		1	**8**	A	W	M	M
Centaurea ascalonica Bornm.	2	3		4	**9**	F	Z	T	M
Centaurium erythraea Rafn	2		3	1	**6**	F	Z	M	M-IT
Centaurium maritimum (L.) Fritsch	2	4		1	**7**	A	Z	M	M
Cephalaria syriaca (L.) Schrad.	1	3	1	1	**6**	A	Z	M+T	M-IT
Ceratophyllum submersum L.	3	3			**6**	Q	H	M	ES-M-IT
Chorispora purpurascens (Banks & Sol.) Eig	3	2	1	1	**7**	A	Z	T+D	IT
Chrozophora plicata (Vahl) Juss.	3	4		1	**8**	A	Z	M+T	SUD
Chrysanthemum viscosum Desf.	1	4	2	1	**8**	A	Z	M	M
Cirsium alatum (S. G. Gmel.) Bobrov	5	4		1	**10**	H	Z	T	IT
Cirsium gaillardotii Boiss.	2	3		1	**6**	H	Z	M	M
Cirsium vulgare (Savi) Ten.	6			1	**7**	H	Z	M	
Cladium mariscus (L.) Pohl	2	3		1	**6**	H	W	M	COS
Colchicum brachyphyllum Boiss. & Hausskn.	2	3	2	1	**8**	G	Z	M	M
Colchicum feinbruniae K. Pers.	1		3	3	**7**	G	Z	M	M
Colchicum schimperi Janka ax Stef.	6		2	1	**9**	G	Z	D	
Cometes abyssinica R. Br.	6			1	**7**	A	W	D	SUD
Consolida hispanica (Costa) Greuter & Burdet	3	2	2	1	**8**	A	Z	M	
Convolvulus fatmensis Kunze	6		1	1	**8**	F	Z	D	SA
Corchorus trilocularis L.	3	3		1	**7**	A	Z	M+T	T
Cordia sinensis Lam.	4	2	1	1	**8**	T	Z	D	SUD
Corrigiola litoralis L.	4	4		1	**9**	F	Z	M	M
Corrigiola palaestina Chaudh.	5	4		1	**10**	H		M	
Crambe orientalis L.	6			1	**7**	H	Z	M+T	
Crepis pulchra L.	5		1	1	**7**	A	Z	M	
Crepis zacintha (L.) Babc.	6			1	**7**	A	Z	M	M
Crocus hermoneus Kotschy ex Maw	3	4	2	3	**12**	G	Z	M	M
Crucianella maritima L.	1	4		1	**6**	C	Z	M	M
Crypsis acuminata Trin.	3	4		1	**8**	A	W	M	M
Crypsis minuartioides (Bornm.) Mez	3	4		4	**11**	A	W	M	M
Cucumis acidus Jacq.	3	4			**7**	H	Z	M+T	IT
Cupressus sempervirens L.	6				**6**	T	W	M+T	M-IT

Species	Rar	Dec	Att	Dis	**RN**	GF	Poll	Climate	Chorotype
Cuscuta gennesaretana Sroelov	3	2		1	**6**	P	Z	M	M
Cuscuta monogyna Vahl	4	2		1	**7**	P	Z	M+T	M-IT
Cutandia maritima (L.) W. Barbey	2	4		1	**7**	A	W	M	M
Cymodocea rotundata Ehrenb. & Hemprich	4	3		1	**8**	Q	H		T
Cyperus corymbosus Rottb.	5	3		1	**9**	H	W	M	T
Cyperus eleusinoides Kunth	6	2		1	**9**	H	W	D	T
Cyperus nitidus Lam.	5	3			**8**	H	W	M	T
Cyperus papyrus L.	1	4	3	1	**9**	H	W	M	T
Dactylorhiza romana (Sebast.) Soo	6	1	1	1	**9**	G	Z	M	
Daucus guttatus Sm.	6	1		1	**8**	A	Z	M+T	M
Dianthus cyri Fisch. & Mey.	6	4		1	**11**	A	Z	M	IT
Echinops gamlensis Shmida	3			4	**7**	H	Z	M+T	
Echinops viscosus DC.	2	2	2	2	**8**	H	Z	M	M
Elaeagnus angustifolia L.	3	4	1	1	**9**	T	Z	M	M
Elatine alsinastrum L.	6	3		1	**10**	Q	Z	M	
Elatine macropoda Guss.	2	3		1	**6**	A	Z	M	M-ES
Elymus elongatus (Host) Runemark	2	4		1	**7**	H	W	M	M-ES
Elymus hispidus (Opiz) Melderis	6			1	**7**	H	W	M	ES-M-IT
Enarthrocarpus arcuatus Labill.	2	4	1	1	**8**	A	Z	M	M
Enneapogon persicus Boiss.	5			1	**6**	H	W	D	IT-SUD
Ephedra alata Decne.	6			1	**7**	C	X	D	SA
Epipactis veratrifolia Boiss. & Hohen	3	2	1		**6**	G	Z	M+D	M-IT
Equisetum ramosissimum Desf.	1		3	2	**6**	H		M+D	COS
Eragrostis sarmentosa (Thunb.) Trin.	3	3			**6**	A	W	M+T	M-IT
Erodium subintegrifolium Eig	1	3	2	4	**10**	A	Z	M	M
Eryngium barrelieri Boiss.	3	3		1	**7**	H	Z	M	M
Eryngium maritimum L.	1	4	1		**6**	H	Z	M	M
Euphorbia dendroides L.	5	2		1	**8**	S	Z	M	M
Euphorbia forsskalii Gay	6			1	**7**	A	Z	D	SUD
Euphorbia hirsuta L.	3	3		1	**7**	H	Z	M	M
Euphorbia microsphera	3	4		1	**8**	A	Z	M	IT
Euphorbia phymatosperma Boiss. & Gaill.	5			1	**6**	A	Z	D	IT
Fagonia tenuifolia Steud. & Hochst.	5			1	**6**	C	Z	D	SA
Ferula biverticillata Thieb.	6	2	2	1	**11**	H	Z	T	M
Ferula daninii Zohary	2		1	4	**7**	H	Z	D	IT
Ferula meironensis sp. nov.	3			4	**7**	H	Z	M	
Filago argentea (Pomel) Chrtek & Holub	6			1	**7**	A	W	D	SA
Fraxinus syriaca Boiss.	1	3	1	1	**6**	T	W	M	M-IT
Fuirena pubescens (Poir.) Kunth	3	3			**6**	H	W	M	T
Gagea villosa (M. Bieb.) Duby	1	3	1	1	**6**	G	Z	M	ES-M
Galium chaetopodum Rech. fil.	2	3		3	**8**	A	Z	M	M
Galium elongatum C. Presl	6				**6**	H	Z	M	M
Galium hierochuntinum Bornm.	2			4	**6**	A	Z	T+D	SA
Galium philistaeum Boiss.	1	4		4	**9**	A	Z	M	M
Galium rivale (Sm.) Griseb.	2	3		1	**6**	H	Z	M	ES-M
Glaucium arabicum Fresen.	3		3	1	**7**	H	Z	D	IT
Glaucium flavum Crantz	1	3	3	1	**8**	F	Z	M	M
Glyceria plicata (Fries) Fries	4	3		1	**8**	H	W	M	M-IT
Gonocytisus pterocladus (Boiss.) Spach	3	1	1	1	**6**	S	Z	M	M
Grewia villosa Willd.	5	2		1	**8**	S	Z	D	SUD
Halophila stipulacea (Forssk.) Asch.	6	4			**10**	Q	H		SUD
Hammada ramosissima (Eig) Iljin	6			3	**9**	C	W	D	
Hemarthria altissima (Poir.) Stapf & C. E. Hubb.	3	3			**6**	H	W	M	M
Hydrocotyle ranunculoides L. fil.	3	3			**6**	Q	Z	M	T
Hydrocotyle sibthopioides Lam.	3	3			**6**	Q	Z	M	T
Hypericum amblyosepalum Hochst.	2	2	3	1	**8**	C	Z	M	M-IT
Hypericum hircinum L.	3	3	3	1	**10**	S	Z	M	M

Species	Rar	Dec	Att	Dis	RN	GF	Poll	Climate	Chorotype
Hypericum tetrapterum Fries	6	3	2	1	**12**	C	Z	M	M-ES
Hyphaene thebaica (L.) Mart.	6	4	1	1	**12**	T	W	D	SUD
Hypochoeris glabra L.	3	4		1	**8**	A	Z	M	ES-M-IT
Iberis odorata L.	6	1		1	**8**	A	Z	T	M
Ipomoea sagittata Poir.	1	4	3	1	**9**	V	Z	M	M-T
Iris atrofusca Baker	1		3	3	**7**	G	Z	T+D	
Iris atropurpurea Baker	1	4	3	4	**12**	G	Z	M	M
Iris bismarckiana Regel	1	1	3	4	**9**	G	Z	M+T	M
Iris grant-duffii Baker	2	4	3	2	**11**	G	Z	M	M
Iris haynei Baker	1		3	3	**7**	G	Z	T	M
Iris hermona Dinsm.	1		3	4	**8**	G	Z	M	M-IT
Iris lortetii W. Barbey	1		3	4	**8**	G	Z	M+T	M
Iris mariae W. Barbey	1	1	3	4	**9**	G	Z	D	SA
Iris petrana Dinsm.	1		3	4	**8**	G	Z	D	IT
Iris pseudacorus L.	4	4	3	1	**12**	G	Z	M	ES-M-IT
Iris regis-uzziae Feinbrun	1		2	3	**6**	G	Z	D	IT
Juncus articulatus L.	3	4		1	**8**	H	W	M	ES-M-IT
Juncus capitatus Weigel	6	4		1	**11**	A	W	M+T	ES-M-T
Juncus inflexus L.	2	4			**6**	H	W	M	COS
Juniperus oxycedrus L.	5		1	1	**7**	T	W	M	M
Lachnophyllum noeanum Boiss.	2	3		1	**6**	F	Z	M+T	IT
Lallemantia iberica (M. Bieb.) Fisch. & Mey.	3	2		1	**6**	A	Z	T	IT
Lathyrus cassius Boiss.	1	3	2	1	**7**	A	Z	M	M
Lathyrus gleospermus Warb. & Eig	2	3	1	1	**7**	A	Z	M	M
Lathyrus lentiformis Plitm.	6			4	**10**	A	Z	M	M
Lathyrus setifolius L.	3	4		1	**8**	A	Z	M	M
Lathyrus spathulatus (M. Bieb.) Fiori	2		3	1	**6**	H	Z	M	M
Lathyrus sphaericus Retz.	3	4		1	**8**	A	Z	M	
Launaea resedifolia (L.) O.Kuntze	3	4		1	**8**	A	Z	M+T	SA
Lavandula stoechas L.	2	3	2	1	**8**	C	Z	M	M
Lavatera bryoniifolia Mill.	2		3	1	**6**	S	Z	M	M
Leersia hexandra Sw.	2	3		1	**6**	H	W	M	T
Legousia hybrida (L.) Delarbre	5			1	**6**	A	Z	M	ES-M
Lepidium aucheri Boiss.	5	3		1	**9**	A	Z	D	
Lilium candidum L.	2		3	1	**6**	G	Z	M	M
Limonium graecum (Poir.) O. Kuntze	2	4		1	**7**	H	Z	M	M
Linaria pelisseriana (L.) Mill.	3	4	1	1	**9**	A	Z	M	M
Linaria simplex (Willd.) DC.	5	2			**7**	A	Z	M+T	
Linaria triphylla (L.) Mill.	3	4	1	1	**9**	A	Z	M	M
Lindenbergia sinaica (Decne.) Benth.	6	3		1	**10**	C	Z	D	SA
Linum maritimum L.	5	4		1	**10**	H	Z	M	M
Lisaea strigosa (Banks & Sol.) Eig	4	3		1	**8**	A	Z	T	IT
Lloydia rubroviridis (Boiss.& Kotschy) Baker	6		1	1	**8**	G	Z	D	IT
Lobularia libyca (Viv.) Meissn.	3	2		1	**6**	A	Z	D	SA
Lolium multiflorum Lam.	2	3		1	**6**	A		M	M-IT
Lolium persicum Boiss. & Hohen	3	3		1	**7**	A	W	M	
Lotus cytisoides L.	3	4		1	**8**	C	Z	M	M
Lotus glaber Mill.	2	4	1	1	**8**	H	Z	M+T+D	ES-M-IT
Lotus glinoides Delile	3	2		1	**6**	A	Z	D	SUD
Lupinus luteus L.	1	4	2	1	**8**	A	Z	M	M
Lupinus micranthus Guss.	1	3	1	1	**6**	A	Z	M	M
Lythrum borysthenicum (Schrank) Litv.	6	3		1	**10**	A	Z	M	M-SA
Maerua crassifolia Forssk.	4	3	1	1	**9**	T	Z	D	SUD
Malva oxyloba Boiss.	3	3		1	**7**	A	Z	M	M
Maresia nana (DC.) Batt.	3	3		1	**7**	A	Z	M	M
Matthiola arabica Boiss.	6			1	**7**	H	Z	D	IT
Medicago italica Fiori	2	4		1	**7**	A	Z	M	M

Species	Rar	Dec	Att	Dis	**RN**	GF	Poll	Climate	Chorotype
Medicago murex Willd.	3	4		1	**8**	A	Z	M	M
Mentha aquatica L.	1	3	2	1	**7**	H	Z	M	COS
Momordica balsamina L.	3	2		1	**6**	V	Z	M	T
Mosheovia galilaea Eig	4	3		3	**10**	A	Z	M+T	M
Myosurus minimus L.	3	3		1	**7**	A	Z	M	M-ES
Myriophyllum spicatum L.	3	4			**7**	H	H	M	ES-M-IT
Myrtus communis L.	1	2	3	1	**7**	S	Z	M	M
Narcissus serotinus L.	1	3	3	1	**8**	G	Z	M	M
Nigella nigellastrum (L.) Willk.	4	1		1	**6**	A	Z	T	
Nigella segetalis M. Bieb.	6			1	**7**	A	Z	D	
Nonea melanocarpa Boiss.	3	2	1		**6**	A	Z	M+T	IT
Nuphar lutea (L.) Sm.	2	3	3	1	**9**	H	Z	M	ES-M-IT
Nymphaea nauchali Burm. f.	4	3	3	1	**11**	H	Z	M	T
Oenanthe fistulosa L.	3	4			**7**	H	Z	M	ES-M
Oenanthe pimpinelloides L.	4	4		1	**9**	H	Z	M	ES-M
Oenanthe prolifera L.	1	3	1	1	**6**	H	Z	M	M
Oldenlandia capensis L. f.	4	4			**8**	A	Z	M	T
Onopordum macrocephalum Eig	6			1	**7**	H	Z	T+D	IT
Onosma gigantea Lam.	2	3	2	1	**8**	H	Z	M+T	M
Ophioglossum lusitanicum L.	3	4		1	**8**	H		M	M-ES-T
Ophioglossum polyphyllum A. Braun	5			1	**6**	H		D	
Orchis coriophora L.	5	3	1	1	**10**	G	Z	M	M-IT
Orchis israelitica Baumann & Dafnil	1		1	4	**6**	G	Z	M	M
Orchis laxiflora Lam.	1	3	3	1	**8**	G	Z	M	M-IT
Orchis syriaca Boiss. & Bal.	6		1	1	**8**	G	Z	M	
Ornithogalum fuscescens Boiss. & Gaill.	2	3		3	**8**	G	Z	M	M
Ornithogalum platyphyllum Boiss.	5	2		1	**8**	G	Z	M	
Orobanche lavandulacea Reichenb..	2	2		3	**7**	P	Z	M	M-IT
Orobanche palaestina Reut.	3	2	1	1	**7**	P	Z	M	M
Paeonia mascula (L.) Mill.	3		3	1	**7**	H	Z	M	M-ES
Papaver decaisnei Hochst. & Steud.	5	1	1	1	**8**	A	Z	D	
Parapholis filiformis (Roth) C. E. Hubb.	3	4		1	**8**	A	W	M	M
Paronychia echinulata Chater	3	4		1	**8**	A	Z	M	M
Paronychia palaestina Eig	3	4		3	**10**	C	Z	M	M
Periploca graeca L.	3	3	1	1	**8**	V	Z	M	M-IT
Petrorhagia arabica (Boiss.) Ball & Heyw.	5			1	**6**	A	Z	D	SA
Petrorhagia zoharyana Liston	2			4	**6**	A	Z	M+T+D	M-IT
Phlomis chrysophylla Boiss.	6		1	1	**8**	C	Z	T	
Phlomis pungens Willd.	1	2	2	1	**6**	H	Z	M+T	IT-M
Phlomis syriaca Boiss.	6		1		**7**	C	Z	T	
Phragmites frutescens H. Scholz	3	2		1	**6**	H		M	
Pimpinella corymbosa Boiss.	2	2	1	1	**6**	H	Z	M+T	IT
Plantago chamaepsyllium Zohary	6			1	**7**	A	W	D	SA
Platanus orientalis L.	1	4	1	1	**7**	T	W	M	M-IT
Polygonum acuminatum Kunth	3	3	1	1	**8**	H	Z	M	T
Polygonum cedrorum Boiss. & Kotschy	6			1	**7**	C	Z	M	
Polygonum lanigerum R. Br.	3	3	1	1	**8**	H	Z	M	T
Polygonum maritimum L.	2	4		1	**7**	C	Z	M	M-ES
Polygonum setosum Jacq.	5			1	**6**	H	Z	M	
Potamogeton crispus L.	4	3			**7**	Q	W	M	COS
Potamogeton densus L.	3	3			**6**	Q	H	M	
Potamogeton pectinatus L.	3	3			**6**	Q	W	M	COS
Potentilla reptans L.	6	1	1	1	**9**	H	Z	M	M-IT
Psilliostachys spicata (Willd.) Nevski	2	2	1	1	**6**	A	Z	D	IT
Pteridium aquilinum (L.) Kuhn	5	3	1	1	**10**	H		M	COS
Pteris vittata L.	4	3	2	1	**10**	H		M	M-ES
Ptilostemon chamaepeuce (L.) Less.	6			1	**7**	C	Z	M	M-IT

Species	Rar	Dec	Att	Dis	RN	GF	Poll	Climate	Chorotype
Pulicaria inuloides (Poir.) DC.	6				**6**	A	Z		
Ranunculus constantinopolitanus (DC.) D'urv.	2	2	2	1	**7**	H	Z	M	M-IT
Ranunculus millefoliatus Vahl.	6			1	**7**	H		M	
Ranunculus sceleratus L.	2	3		1	**6**	A	Z	M	ES-M-IT
Ranunculus sphaerospermus Boiss. & Blanche	3	3		1	**7**	Q	Z	M	M
Rheum palaestinum Feinbrun	2		3	3	**8**	H	Z	D	IT
Rhizocephalus orientalis Boiss.	6			1	**7**	A	W	D	IT
Rhus pentaphylla (Jacq.) Desf.	6	3		1	**10**	T	W	M	M
Romulea columnae Sebast. & Mauri	6	2		1	**9**	G	Z	M	M
Rosa phoenicia Boiss.	1	3	3	1	**8**	S	Z	M	M
Rostraria obtusiflora (Boiss.) Holub	2	4		1	**7**	A	W	M	IT-M
Rubia tinctorum L.	4	3	1	1	**9**	V	Z	M+T	M-IT
Rumex rothschildianum Aarons.	3	4		4	**11**	A	W	M	M
Ruppia maritima L.	3	4			**7**	Q	H	M+D	COS
Sagina maritima G. Don	3	3		1	**7**	A		M	
Salix alba L.	1	2	2	1	**6**	T	X	M	M-ES-IT
Salix pedicellata Desf.	6		1	1	**8**	T	X	M	
Salsola orientalis S. G. Gmel.	6			1	**7**	C	W	D	IT
Salsola soda L.	3	3		1	**7**	A	W	M	HOL
Salvia ceratophylla L.	6		2		**8**	H	Z	D	IT
Salvia eigii Zohary	2	2	2	4	**10**	H	Z	M	M
Salvia multicaulis Vahl	6	3	3		**12**	C	Z	D	IT
Salvia sclarea L.	5		2	1	**8**	H	Z	M	M-IT
Sambucus nigra L.	6		1	1	**8**	S	Z	M	
Sarcocornia fruticosa (L.) Scott	1	4		1	**6**	C	W	M+T+D	M
Sarcocornia perennis (Mill.) Scott	3	4		1	**8**	C	W	M+T	M
Satureja thymbrifolia Hedge & Feinbrun	5	1		3	**9**	C	Z	D	IT-SA
Scandix australis L.	3	2		1	**6**	A	Z	M	
Scandix palaestina (Boiss.) Boiss.	2	3		3	**8**	A	Z	M	M
Scandix stellata Banks & Sol.	6			1	**7**	A	Z	D	
Scirpus supinus L.	6	4		1	**11**	A	W	M	COS
Scrophularia hierochuntina Boiss.	1	3		3	**7**	H	Z	M	M
Sedum litoreum Guss.	2	4		1	**7**	A	Z	M	M
Sideritis curvidens Stapf	6			1	**7**	A	Z	M	
Silene macrodonta Boiss.	5	4		1	**10**	A	Z	M+T	M
Silene modesta Boiss. & Blanche	2	4		3	**9**	A	Z	M	M
Silene oxyodonta Barbey	2		1	3	**6**	A	Z	T+D	M
Silene papillosa Boiss.	6	4	1	2	**13**	A	Z	M	M
Silene sedoides Poir.	2	4		1	**7**	A	Z	M	M
Solenostemma arghel (Delile) Hayne	6		1		**7**	C	Z	D	SUD
Sonchus suberosus Zohary & P.H.Davis	2		1	3	**6**	C	Z	T+D	SUD
Sparganium erectum L.	2	4		1	**7**	H	W	M	COS
Spirodela polyrhiza (L.) Schleiden	3	3			**6**	Q	H	M	COS
Stachys arvensis (L.) L.	3	4		1	**8**	A	Z	M	ES-M
Stachys longispicata Boiss. & Kotschy	3	3		1	**7**	H	Z	M	M-IT
Stachys spectabilis Choisy ex DC.	5	3		1	**9**	H	Z	M	M-IT
Stachys zoharyana Eig	4			4	**8**	A	Z	M	M
Stipagrostis drarii (Tackh.) DeWinter	6			1	**7**	H	W	D	
Suaeda palaestina Eig & Zohary	2	3		3	**8**	C	W	D	SA-SUD
Suaeda splendens (Pourr.) Gren. & Godr.	3	3			**6**	A	W	M	M
Suaeda vermiculata Forssk.	4	2			**6**	C	W	D	SA
Tanacetum negevensis Shmida	3			4	**7**	C	Z	D	
Teesdalia coronopifolia (Berg.) Thell.	5			1	**6**	A	Z	M	
Tephrosia nubica (Boiss.) Baker	6	4		1	**11**	C	Z	D	SUD
Teucrium orientale L.	3		3	1	**7**	H	Z	M	
Teucrium parviflorum Schreb.	3	2	1	1	**7**	H	Z	T	IT
Teucrium procerum Boiss. & Blanche	3	4	2	2	**11**	H	Z	M	M-IT

Species	Rar	Dec	Att	Dis	**RN**	GF	Poll	Climate	Chorotype
Teucrium scordium L.	2	4		1	**7**	H	Z	M	M-IT
Teucrium spinosum L.	3	3		1	**7**	A	Z	M	M
Thalictrum isopyroides C. A. Mey	5			1	**6**	H	W	D	
Thelypteris palustris Schott	5	4		1	**10**	H		M	HOL
Tolpis barbata (L.) Gaertn.	3	4		1	**8**	A	Z	M	M
Tordylium syriacum L.	6				**6**	A	Z	M	M
Trachomitum venetum (L.) Woodson	3	3	1	1	**8**	H	Z	M+D	M-IT
Tragopogon collinum DC.	3		3	1	**7**	H	Z	D	IT
Trichodesma ehrenbergii Schweinf. ex Boiss.	3	2		1	**6**	A	Z	D	SUD
Trifolium angustifolium L.	6			1	**7**	A	Z	M	M
Trifolium billardieri Spreng.	5	4	1	3	**13**	A	Z	M	M
Trifolium hirtum All.	5			1	**6**	A	Z	M	
Trigonella noeana Boiss.	6			1	**7**	A	Z	D	
Trigonella spicata Sm.	3	3		1	**7**	A	Z	M+T	M-IT
Triplachne nitens (Guss.) Link	3	4		1	**8**	A	W	M	M
Tripodion vulneraria L.	6	3		1	**10**	F	Z	M	M-ES
Trisetaria michelii (Savi) Parl.	5	4			**9**	A	W	M	
Turgenia latifolia (L.) Hoffm.	3	2		1	**6**	A	Z	T	M-IT-ES
Typha elephantina Roxb.	6			1	**7**	H	W	M+D	
Urtica kioviensis Rogow.	5			1	**6**	H	W	M	ES
Utricularia exoleta R. Br.	5	3			**8**	Q	Z	M	T
Valantia muralis L.	3	4		1	**8**	A	W	M	M
Valerianella carinata Loisel	5			1	**6**	A	Z	M	ES-M-IT
Valerianella kotschyi Boiss.	3	4		1	**8**	A	Z	M	IT
Vallisneria spiralis L.	6	3			**9**	Q	H	M	COS
Velezia fasciculata Boiss.	6	4		1	**11**	A	Z	M	M
Verbascum berytheum Boiss.	2	4		3	**9**	H	Z	M	M
Veronica anagalloides Guss.	3	4		1	**8**	Q	Z	M	ES-M-IT
Veronica lysimachioides Boiss.	2	3		1	**6**	Q	Z	M	M
Vicia basaltica Plitman	4			4	**8**	A	Z	M	
Vicia esdraelonensis Warb. & Eig	4	4		4	**12**	A	Z	M	M
Vicia hulensis Plitm.	2	2		4	**8**	A	Z	M	M
Wolffia arrhiza (L.) Horkel ex Wimm.	2	4			**6**	Q	H	M	COS
Xolantha guttata (L.) Raf.	1	4	1	1	**7**	A	Z	M	ES-M
Zaleya pentandra (L.) Jeffrey	3	3			**6**	H	Z	M	SUD
Ziziphora tenuior L.	6				**6**	A	Z	T+D	IT
Ziziphus nummularia (Burm. f.) Wight & Walk.-Arn.	6		1	1	**8**	T	Z	D	
Zygophyllum album L. f.	3	4		1	**8**	C	Z	T+D	SA

Appendix 2

Extinct plant species of Israel and their scores for the Red Number parameters. For legend and explanations see appendix 1. Rarity is calculated according the number of sites before extinction.

Species	Rar	Dec	Att	Dis	**RN**	GF	Poll	Climate	Chorotype
Agrimonia eupatoria L.	6			1	**7**	H	Z	M	ES-M
Alopecurus arundinaceus Poir.	6	4		1	**11**	H	W	M	ES-M-IT
Anthephora laevis Stapf & C.E. Hubb	6			1	**7**	H	W	D	
Berula erecta (Huds.) Coville	4	4		1	**9**	H	Z	M	ES-M
Bunium ferulaceum Sm.	3	4		1	**8**	H	Z	M	M
*Capparis decidua (*Forssk.) Edgew.	4	4		1	**9**	S	Z	D	SU
Convolvulus pilosellifolius Desr.	3	4		1	**8**	C	Z	D	IT
Cyperus jeminicus Rottb.	6	4			**10**	H	W	D	SU
Digera muricata (L.) Mart.	6	4		1	**11**	A	W	M	T
Dorycnium hirsutum (L.) Ser.	5				**5**	C	Z	M	M
Erodium alnifolium Guss.	5	4		1	**10**	A	Z	M	M
Ficus pseudosycomorus Decne.	6				**6**	T	Z	D	SU-IT
Galium humifusum M. Bieb.	6	4		1	**11**	H	Z	M+T	M-IT
Halopeplis amplexicaulis (Vahl) Ung.-Sternb.	5	4			**9**	A	W	D	M
Hydrocharis morsus-ranae L.	6	4			**10**	H	Z	M	ES-M
Hydrocotyle vulgaris L.	6	4			**10**	Q	Z	M	ES-M
Hypecoum aegyptiacum (Forssk.) Asch. & Schw.	4			1	**5**	A	Z	D	SA
Juncus sphaerocarpus Nees	3	4			**7**	A	W	M	ES-M
Lemna trisulca L.	6	4			**10**	Q	H	M	COS
Leopoldia deserticola (Rech. f.) Feinbrun	6		1	1	**8**	G	Z	D	
Leptadenia pyrotechnica (Forssk.) Decne.	5	4		1	**10**	S	Z		SU-SA
Ludwigia palustris (L.) Elliott	6	4			**10**	Q	Z	M	T
Marsilea minuta L.	5	4			**9**	H	-2	M	
Nymphaea alba L.	3	4	3	1	**11**	Q	Z	M	ES-M
Phyllitis sagittata (DC.) Guin. & Heyw.	5	3		1	**9**	H	-2	M+D	M
Potamogeton lucens L.	3	4			**7**	Q	W	M	
Ranunculus ophioglossifolium Vill.	3	4			**7**	A	Z	M	M-IT
Reseda globulosa Fisch. & Mey.	5				**5**	A	Z	T+D	IT
Rorippa amphibia (L.) Bess.	6	4		1	**11**	H	Z	M	ES
Rumex roseus L.	6	4			**10**	H	W	T	IT
Salvia bracteata Banks & Sol.	3	4	2	1	**10**	C	Z	M+T	IT
Scutellaria galericulata L.	6	4	1		**11**	H	Z	M	ES
Trifolium filiforme L.	5				**5**	A	Z	M	M-ES
Utricularia australis R. Br.	6	4			**10**	Q	Z	M	HOL