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Rare and endemic species: why are they prone to extinction? *

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Abstract: A species is considered to be "rare" if it exhibits any one of the following attributes: (1) naturally occurs in a narrow geographical area, (2) occupies only one or a few specialised habitats, (3) forms only small population(s) in its range. An "endemic" species, however, grows naturally in a single geographical area, the size of which could be either narrow or relatively large. Not all endemic species are rare, just as not all rare species must necessarily be endemic. Many rare and/or endemic species exhibit one or more of the following attributes which make them especially prone to extinction: (1) narrow (and single) geographical range, (2) only one or a few populations, (3) small population size and little genetic variability, (4) over-exploitation by people, (5) declining population sizes, (6) low reproductive potential, (7) the need for specialised ecological niches, (8) growth that requires stable and nearly constant environments. When habitats of a rare and/or endemic species are damaged and/or fragmented by various human activities, the distribution ranges and population sizes of the species will be reduced, leaving them vulnerable to extinction at a much higher rate than other comparable species. Species that experience any of the above attributes must be given priority and monitored and managed carefully in an effort to promote genetic conservation.

Key words: Rare species, endemism, extinction, population, conservation biology

Nadir ve endemik türler yok-oluş olayına niçin duyarlıdır?

Özet: Bir tür şu üç özellikten herhangi birini taşırsa, o tür "nadir tür" olarak düşünülür. (1) Doğal olarak küçük bir coğrafik alanda bulunursa, (2) yalnızca bir veya birkaç özelleşmiş habitatta (yaşama ortamında) yetişirse, (3) yayılma alanında yalnızca küçük populasyon(lar) halinde bulunursa. Öte yandan bir "endemik tür" ise tek bir coğrafik alanda yetişen türdür, ama bu coğrafik alan küçük bir alan olabildiği gibi geniş bir alan da olabilir. Her endemik tür, nadir tür değildir. Aynı şekilde her nadir tür de endemik tür olmayabilir. Nadir ve endemik türlerin çoğu, aşağıdaki özelliklerden birini veya birçoğunu gösterebilirler. (1) Küçük (ya da tek bir) coğrafik bölgede yetişmek, (2) yalnızca bir veya birkaç populasyona sahip olmak, (3) populasyonların küçük olması ve çok az genetik çeşitlilik göstermesi, (4) insanlar tarafından aşırı ölçüde avlanılması ya da hasat edilmesi, (5) populasyonun gittikçe azalan bir eğilim göstermesi, (6) üreme potansiyelinin düşük olması, (7) özelleşmiş ekolojik nişlere ihtiyaç duymaları, (8) kararlı, durağan ve değişime duyarlı bir çevrede yetişmeleri. Bu özellikler, nadir ve endemik türlerin yok-oluş olayına karşı özellikle duyarlı olmasına yol açar. Nadir ve endemik türlerin yaşama ortamları değişik insan etkinlikleriyle bozulursa ya da bu ortamlar parçalara bölünürse, önce bu türlerin dağılış alanları ve populasyon büyüklükleri azalmakta, sonra da bu türler, diğer türlere kıyasla yok-oluşa doğru daha hızlı gitmektedir. Yukarıda belirtilen özelliklerden herhangi birine veya birden fazlasına sahip olan türler genetik kaynakların korunması çalışmalarında öncelikle ele alınmalı ve dikkatlice izlenip yönetilmelidir.

Anahtar sözcükler: Nadir tür, endemik tür, yok-oluş, populasyon, koruma biyolojisi

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Introduction

In this article, I will first define the concepts related to rare and endemic species. The common features of extinction prone species will then be discussed, followed by the path that leads to the extinction of a species. This information will hopefully provide the main basis for establishing strategies for biological conservation.

Generally speaking, if a species demonstrates any of the following characteristics, it is considered a rare species: (a) grows naturally in a narrow geographical area, (b) occupies only one or few specialised habitats, (c) forms only small population(s) in its range. At the opposite end of these criteria lie the species that are called common (cosmopolite) and/or abundant.

An endemic species, however, is the one that grows naturally only in a single geographic area, the size of which could be either narrow or relatively large. A species may be both rare and endemic if it lives in a narrow (and single) geographical area (Primack, 2006).

Depending on the scale of the geographic range, endemic species are called by a variety of different names. For example, an endemic species may be restricted only to a small, local geographic area, in which case it is called a "local endemic." As the size of the geographic range become larger, an endemic species may labelled "provincial endemic" (restricted within the borders of a province), "national endemic" (grows only within the borders of a nation), or "regional endemic" (grows only in a certain geographical region). When the distribution range of a species is restricted only to a single continent and not found in any others, as is the case for many plant and animal species in Australia, then one can also talk about a "continental endemic."

The following examples can be instructive for each of the above cited endemism types. *Sternbergia candida* Mathew et T.Baytop (Liliaceae fam.), for example, is a local endemic that grows naturally only within the borders of Fethiye (Muğla, Turkey) and its neighbourhoods. *Centaurea dursunbeyensis* Uysal & Köse is another example of a local endemic which grows naturally in limestone crevices around Dursunbey (Balıkesir) (Uysal and Köse, 2009). *Anthemis ammophila* Boiss. et Heldr. (Asteraceae fam.) (Antalya daisy) is an example of a provincial endemic species, found naturally in several localities all of which are within the borders of the Antalya province in Turkey. *Crocus ancyrensis* (Herbert) Maw (Iridaceae fam.) grows in many localities in the central Anatolian region of Turkey and its neighbourhoods. Since it is restricted to the borders of a single nation, however, it is considered a national endemic species. *Pancratium maritimum* L. (Amaryllidaceae fam.) (sea daffodil) is a regional endemic of the Mediterranean basin since it grows naturally in the coastal sands of many countries along the Mediterranean Sea. Finally, a well known pine species, *Pinus sylvestris* L. (Pinaceae fam.), is a good example of a continental endemic because it naturally grows only in Eurasia.

The placement of rare and endemic species in a three-dimensional (3-D) space

The features listed below are the 3 important criteria that determine the conservation status of a species. These are: (a) geographic range, (b) population size, and (c) habitat demands. Figure 1 illustrates the relationships among these criteria in a 3-D space. The geographic range of a species may be very narrow, very wide, or anywhere in between these extreme ranges (X, on horizontal axis) (Figure 1). The population size of a species may also range from very small to very large (Y, on vertical axis) (Figure 1). Similarly, the habitat demand or habitat preference of a species may be very specific (specialised species), or general (generalist species) (Z, the third dimension) (Figure 1).

If a species is both rare and endemic, by definition, it is located in the very lower left corner of the 3-D space. The rectangular 3-D space bordered by broken lines along the X axis represents rare species with a small population size and rather specific habitat requirements but a relatively wide geographic range. Similarly, the rectangular 3-D space along the Y axis represents rare species with restricted geographic range and rather specific habitat requirements but a relatively large population size. Finally, the rectangular 3-D space along the Z axis represents rare species with restricted geographic range and a small population size but relatively moderate habitat demands.

Any species located on the lower left corner of the 3-D space (i.e. species that are both rare and endemic)

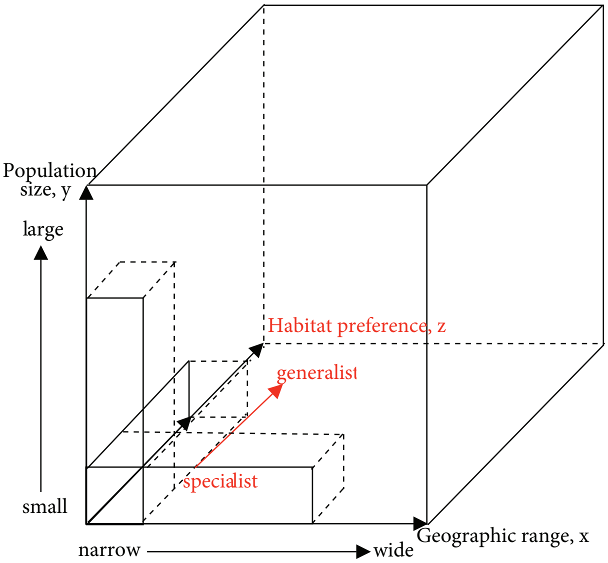

Figure 1. Three dimensional (3-D) illustration showing the place of rare and/or endemic species in relation to its geographic range (X axis), population size (Y), and habitat demands (Z).

needs the highest and most immediate rescue actions in conservation programs. Any species located on the upper far right corner of the 3-D space can be considered a generalist, with rather wide distribution range and very large population size. Such species are in very low risk of extinction and usually they are not of immediate concern for conservation purposes.

IUCN conservation categories

The IUCN (International Union for Conservation of Nature) has established 9 categories of species (Figure 2) (IUCN, 2001). These categories are useful as a diagnostic tool to determine the risk of extinction and establish conservation strategies for the involved species. As data become available and information accumulates on a species (by taxonomic experts, conservationists, and other biologists), its conservation status is constantly being re-evaluated (www.iucnredlist.org) (Ekim et al., 2000). It is also possible that a species considered to be extinct could be re-discovered after several years, causing its IUCN conservation status to be re-evaluated (Kandemir, 2009).

The expressions below need clarification to prevent confusion in following the IUCN categories. A species is considered extinct when no member of the species remains alive anywhere in the world. The expression "extinct in the wild" refers to species in which individuals remain alive only in captivity or

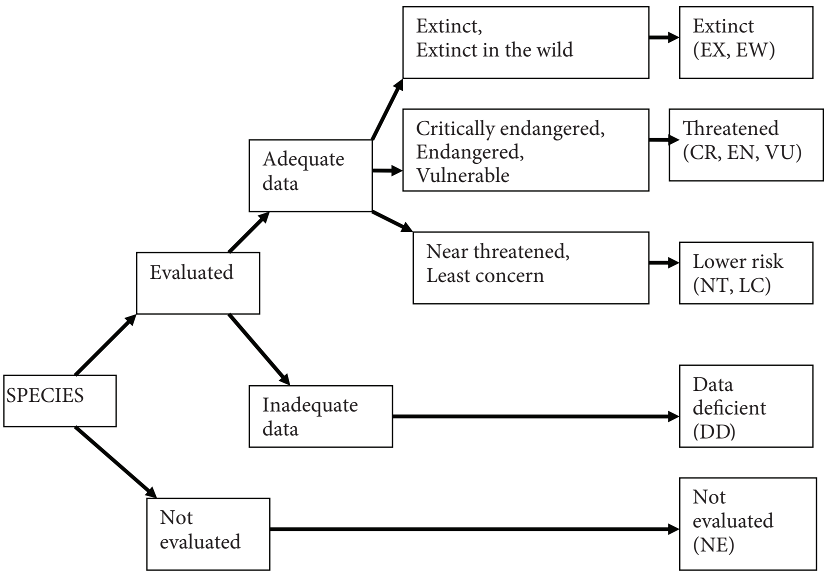

Figure 2. IUCN Conservation (or Red List) categories. Defining such categories helps to determine extinction risk and establish conservation strategies for the involved species. (Redrawn by the author, based on information in IUCN 2001.)

under human care, and no subjects are present in natural habitats. A "locally extinct" or "extirpated" species refers to a species which is no longer found in an area where it used to live before although it still lives elsewhere in the wild.

Common features of extinction prone species

Species that exhibit one or more of the following features are vulnerable to extinction (Primack, 2006):

a - Species with a narrow (or single) geographic range,

b - Species with only one or few populations,

c - Species with a small population size,

d - Species with a declining population size,

e - Species hunted or harvested by people,

f - Species with low reproductive ability and/or germplasm-dispersal-ability,

g - Species that require specialised habitat and niche conditions.

The above listed characteristics of extinction-prone species are generally not independent of one another. For example, species with specialised niche requirements also tend to have a small population size. Species that face the full range of these characteristics are the ones that are most vulnerable to extinction. Each of these groups is briefly discussed below.

a - Species with a narrow (or single) geographic range: As the geographic range of a species become larger, the probability of its extinction becomes smaller (Figure 3). For example, Thomas et al. (2004) estimated that more than one million species, mainly those with narrow ranges, could become extinct by 2050, merely as a result of global climate change. Among the species with comparable geographic ranges, those with special niche and habitat requirements are more vulnerable to extinction than those less demanding (generalist) species. Similarly, species with a smaller population size have a higher probability of extinction than those with larger population sizes (Figure 3).

b - Species with only one or few populations: This category is related to the previous one, because species with only one or few populations will also tend to have a narrow or single geographical range. Species with only a single population remaining obviously have greater risk of extinction than those

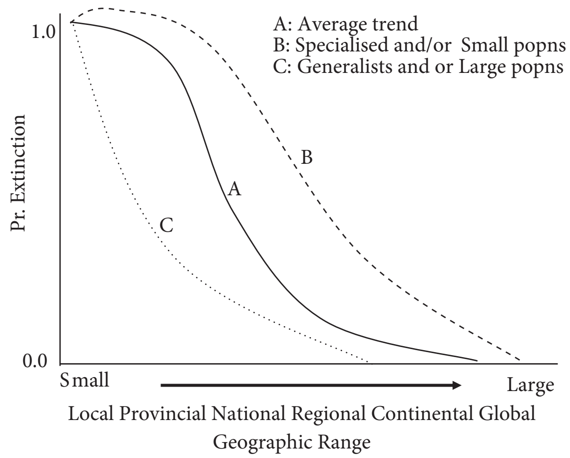

Figure 3. Probability (Pr.) of extinction of species depending on the size of the geographic range.

with more than one population. Any chance factor, such as a disease or the intrusion of human activity, may result in habitat destruction, population decline, and the eventual extinction of a species with only one or few populations.

c - Species with a small population size: Small populations may pose a number of difficulties for a species. They are likely to have low genetic variability and experience inbreeding depression. Furthermore, they are more vulnerable to environmental changes and demographic variation. Therefore, small populations are more likely to go locally extinct. Lande (1988) has also discussed the genetic and demographic consequences of small population sizes in greater detail. A long term study by Jones and Diamond (1976) on bird species living in the Channel Islands off the coast of California showed that extinction rates decrease as the size of the breeding population increases. For example, populations with fewer than 10 breeding pairs had about a 40% probability of extinction over 80 years, whereas populations with 100 breeding pairs had about 10% probability of extinction. It can be seen, then, that populations with more than 100 breeding pairs have a very low probability of extinction.

These findings are also relevant for botanical studies. A study on a plant species, *Ipamopsis aggregate* (Pursh.) V. Grant, reported that seed germination in small populations was considerably lower than that seen in relatively large populations (Heschel & Paige, 1995).

A theoretical study on an idealised population at various effective population sizes (N_e) has indicated that loss of genetic variability is higher over time in smaller populations than it is in larger populations (Groom et al., 2006). For example, after 10 generations there was a loss of genetic variability of about 40% with an effective population size of 10, a loss of 65% with an effective population size of 5, and 95% loss occurred with an effective population size of 2. The main reason for this loss was genetic drift, which often operates in small populations (Groom et al., 2006).

Reduced genetic variability means greater susceptibility to various deleterious genetic processes such as inbreeding depression, the loss of evolutionary potential, and the loss of the ability to adapt to changing conditions. Each of these factors, either alone or in combination, may contribute to a decline in population size, which, in turn leads to eventual extinction (Frankham, 2005). Several other genetic and non-genetic factors that affect the population size, genetic diversity, and adaptation of a species are summarised in Figure 4.

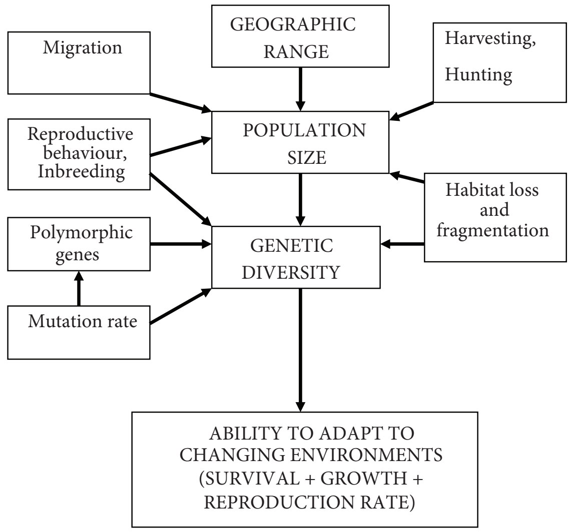

Figure 4. Factors affecting population size, genetic diversity, and adaptation.

d - Species with declining population size: A population may be large, but show signs of decline over time. Unless the cause(s) of decline is identified and corrected, the final outcome is a small population size and, ultimately, the related problems that such populations face (Figure 4).

e - Species hunted or harvested by people: Over-exploitation (over-harvesting or over-hunting) can rapidly reduce the population size of a species. If the harvesting is not regulated by national laws, local ethics, and/or international regulations (such as CITES), the species can be driven to extinction. For example, a study on a medicinal plant by Ghimire et al. (2005) showed that recovery of original density was very slow in the years following intensive harvesting (75% and 100% reduction of original density). When no harvesting was permitted, however, this situation was able to change quickly; density levels increased to about twice that of the original density after 3 years of no harvesting.

f - Species with low reproductive ability and/or germplasm-dispersal-ability: Species with low biotic (reproductive) potential and low dispersal ability (particularly in species with a larger size) are more prone to extinction. In plants, species with large and/or short-lived seeds are more vulnerable than those with smaller, long-lived seeds (Kolb & Diekmann, 2005). Species that are able to produce both by seeds and clonal means have a higher chance of survival.

In the face of changing environments (either human-induced or natural), a species has to either migrate to suitable habitats or adapt to the new habitat conditions. Otherwise, the species will go extinct. It should be kept in mind, however, that the rate of adaptation (i.e. genetic changes) is often far behind (and unable to catch up with) the rate of rapid human-induced environmental changes. For this reason, species that are unable to disperse and colonise new areas have a higher risk of extinction.

g - Species that require specialised habitat and niche conditions: Species with a low tolerance range (those with specialised niche requirements) have a greater tendency to become extinct when changes occur in the environment. Examples of these types of species include wetland plants, plants with specific pollinators, and plants that require specific dispersal agents.

Many species are found in stable environments where human disturbance is minimal, such as old stands, core areas of forests, and wild pastures (pastures with no cultivation). Facing changes in the physical and chemical environments of such areas, certain species are unable to adapt and fail to rebuild their populations fast enough to avoid extinction.

The path to extinction (4 Ds)

There are 4 processes, which can be thought of as the 4 Ds, that follow each other in subsequent order before extinction takes place. These are destruction, degradation, decline, and, finally, disappearance (extinction). Species vulnerable to extinction are more susceptible and more rapidly affected by each of these processes. Figure 5 summarises the diversity of human activities and associated events that contribute to the 4 D process.

Summary and conclusion

Many rare and/or endemic species have one or more of the following characteristics: (1) They have a narrow (or single) geographical range, (2) they have only one or a few populations remaining, (3) they show small population size and little genetic variability, (4) they are usually over-exploited (over-hunted and over-harvested) by people, (5) they exhibit declining population sizes, (6) they have low reproductive ability, (7) they show specialised niche demands, (8) they grow in stable and nearly constant environments. All of these attributes, either alone or in combination, make a species prone to extinction at an increased rate. When habitats of a rare and/or endemic species are damaged and/or fragmented by mismanagement and various other human activities, the distribution ranges, population sizes, and genetic variability of the species will be reduced and its members will become vulnerable to extinction at a faster rate than other species. Species with any one or more of the above attributes must be carefully monitored and managed in an effort to maintain biodiversity.

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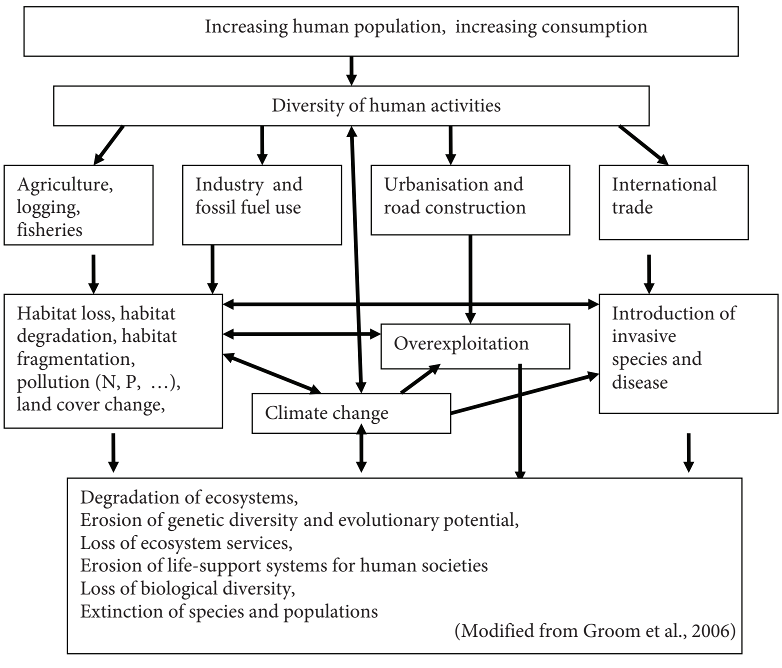

Figure 5. Major forces that threaten biological diversity and that lead to the extinction of a species.

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