CONTRIBUTION TO THE IUCN RED DATA BOOK: A CASE STUDY OF CRITICALLY ENDANGERED NARROW ENDEMIC SPECIES, *ANDROSACE OJHORENSIS* Y. NASIR

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Abstract. *Androsace ojhorensis* Y. Nasir (Primulaceae) is a narrow endemic species which is restricted to its type locality only i.e. Ojhor Valley in District Chitral, Pakistan at an altitudinal range of 12000-13000 ft. A total of 95 mature individuals (flowering and fruiting individuals) were counted and recorded in 2016, 82 in 2017 and 75 in 2018. The Grazing Index (GI) for the year 2016, 2017 and 2018 was 12.63%, 29.26% and 42.66% respectively. On the basis of extensive and intensive floristic surveys and population statistics for three consecutive years (2016-2018), geographic range (Extent of Occurrence-8 km^2 and Area of Occupancy-4.407 km^2), soil erosion, grazing pressure and landslides, *Androsace ojhorensis* is categorized as Critically Endangered (CR) species according to IUCN Red List Categories and Criteria (2012). As this taxon is exposed to many threats, there is dire need to develop species-specific in-situ and ex-situ conservation strategies to implement these managements effectively at national level in order to save this narrow endemic species from extinction.
Keywords: *conservation, Androsace ojhorensis, endemism, critically endangered taxon, IUCN categories*

Introduction

Biological diversity encompasses the diversity of ecosystems, species, and genes, as well as the ecological processes that support these levels. It is essential not only for human livelihoods and survival, but also for ecosystem stability. The stability of the ecological services on which humans rely could be threatened by a loss of species (Khan et al., 2022; Khan and Badshah, 2019; Majid et al., 2015a; Mukhtar et al., 2016). Biodiversity is the

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bounty of nature which plays an important role in the ecosystem. Global biodiversity is facing decrease via extinctions due to increase in the human population, invasive species, pollution, habitat degradation and fragmentation, urbanization and overexploitation (Habib et al., 2016; Shaheen et al., 2017; Western, 2001). One of the world's most serious ecological problems is the rapid extinction of species. The situation is deteriorating in developing countries, where conservation efforts are insignificant. The main impediment to effective conservation planning is a lack of data on the conservation status of the species under consideration. Thus, assessing the conservation status of species is a basic requirement, for which the accepted standard is the IUCN category and Criteria (Majid et al., 2015b). Furthermore, climate change has become another serious issue in this regard (Thomas et al., 2004). The rate of plant extinction has reached one species per day, as a result of anthropogenic activities and other biotic abiotic stresses and this is considered to be 1000-10000 times faster than naturally occurring extinction i.e. background extinction (Akeroyd, 2002; Hilton-Taylor and Brackett, 2000). In the coming 50 years 60,000 to 100,000 plants may vanish if extinction continued at this rate (Soelberg and Jäger, 2016). At global level, a total of 33,798 tracheophytes or vascular plants, which are 12.5% of the world flora, are threatened and face the risk of extinction (Ali, 2000; Eberhardt et al., 2006; Schickhoff, 2006; Walter and Gillett, 1998). The current extinction phenomenon for which humans are almost wholly responsible is often referred to as "the sixth extinction". Endemic species have long been focus and targets of conservation efforts by conservation biologists as these species are mores exposed and vulnerable to threats of extinction due to their low population size and restricted geographic range (Myers et al., 2000; Nowak et al., 2011; Stattersfield, 1998; Vischi et al., 2004). Areas are prioritized for conservation studies and efforts on the basis of floristic endemism, species diversity or probability of species' extinctions in that area (Myers et al., 2000; Nowak et al., 2011). Many authors have expressed concern that biodiversity in Pakistan is under serious threat. They have also listed potential causes and solutions. In fact, Pakistan has been identified as having the highest rate of deforestation and thus habitat loss in the world. There have been various estimates of the number of threatened species published (Haq et al., 2010). For example, the number of phanerogams under threat, has been estimated to be between 580 and 650 (Nasir, 1991) and around 709 (Chaudhri and Qureshi, 1991). Pakistan has a rich floral diversity due to differences in geographic, climatic, and topographic factors, with over 6000 plant species. According to an IUCN survey conducted in 2009, 19 taxa from Pakistan's flora have been recorded on the red data list. However, these figures appear to be deficient and understated. According to another report based on the 19 taxa from Pakistan included in the IUCN Red List, two plant species are considered vulnerable, thirteen are considered least concern, one is considered near threatened, and three are considered data deficient (Bakht et al., 2018). As *Androsace ojhorensis* is restricted to its type locality therefore, the present study was aimed to determine its population size, geographical range, associated taxa, reproductive strategies, pollinator and various threats to which this taxon is exposed as per the IUCN criteria over a period of three years.

Materials and methods

Study area

Chitral lies in the extreme northwestern part of Pakistan. It stretches from 71° 13′ to 73° 52′ E longitude and 35° 15′ to 36° 54′ N latitude with a total area of 14850 km^2. Topographically, it is a rugged and uneven piece of mountainous territory with some

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perennial snow-capped peaks of eastern Hindu Kush. It shares its border with Afghanistan to the north and western side, Swat and Dir to the south and Gilgit-Baltistan to the east. Wakhan Corridor which separates Chitral from Tajikistan lies in the north of Chitral. Chitral is the junction point of three major climatic, floristic and ecological regions. Chitral is a dry temperate region and it lies beyond the reach of summer monsoon and is characterized by Subtropical-Mediterranean climate with c. 320 mm average annual precipitations. The sampled area Ojhor valley was mapped with Geospatial software which indicated different points. This study site has a wide range of distribution for *Androsace ojhorensis.* It is a region of great floristic diversity, covered mainly by Central Asian, Irano-Turanian and Sino-Japanese floristic elements with a good many endemic species (Ali and Qaiser, 1986; Nüsser and Dickore, 2002; Stewart, 1982). The vegetation of Chitral is fairly complex comprising a diverse array of formations ranging from various forest types to desert, along an altitudinal gradient spanning more than 4000 m above sea level (Nüsser and Dickore, 2002).

Experimental design

Comprehensive floristic surveys were carried out in district Chitral for three consecutive years (2016-2018) to study the population size, flowering and fruiting phenology, microhabitat conditions, absolute location, altitude, extent of occurrence (EOO), area of occupancy (AOO), habit, sociability and life form of *Androsace ojhorensis* and associated taxa. Area of occupancy (AOO) and extent of occurrence (EOO) was calculated using Geospatial Conservation Assessment Tool (Bachman et al., 2011). Various threats to the population and habitat of *Androsace ojhorensis* were also determined during these surveys. For determination of population size, only mature individuals were counted per unit area. Plants in flowering or fruiting stage were considered as mature individuals. Nature of habitat i.e. quality of habitat was determined by considering soil erosion, accessibility to the locality, deforestation, biotic pressure such as grazing and other anthropogenic impacts. Specimens were collected, processed and persevered following standard herbarium techniques. Plant species were identified with the help of Flora of Pakistan (Ali, 2008; Nasir et al., 1972; Nasir and Ali, 1972). Assessment of the conservation status of the species was carried out with the help of (Nature et al., 2001). The voucher specimens were deposited in Peshawar University Herbarium (PUP) for future reference.

$$Area\ of\ occupancy\ (AOO) = No.of\ occupied\ cells\ x\ Area\ of\ individual\ cell$$

$$Extent\ of\ Occurrence\ EOO = \frac{Numer\ of\ locations\ of\ endemic\ species}{Subpopulation\ \&\ decline\ number\ of\ mature\ individuals}$$

Results

Habit, habitat and community structure and ecology

Androsace ojhorensis is a compact caespitose stoloniferous herb. The plant grows in sunny well drained clayey slopes in alpine and subalpine zone at an altitudinal range of 12000-13000 ft. in association with are a total of 39 taxa belonging to 15 families (*Fig. 1*). *Arenaria griffithii Astragalus strobiliferus, Acantholimon lycopodioides, Cousinia racemosa, Eremostachys edelbergii, Eremurus stenophyllus, Onobrychis cornuta,*

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Pedicularis dolichorhiza and *Ranunculus pulchellus* were found to be the dominant species. The habit and life form of the observed associates are mentioned in the *Table 1*.

Table 1. *Habit and life form of the observed associates with Androsace ojhorensis Y. Nasir*

S. No	Botanical Name	Family	Habit	Life form
1.	*Acantholimon chitralicum* Rech. f. and Schiman-Czeika	Plumbaginaceae	Herb	Chamaephyte
2.	*Acantholimon leptostachyum* Aitch. & Hemsl.	Plumbaginaceae	Herb	Chamaephyte
3.	*Acantholimon lycopodioides* (Girard) Boiss.	Plumbaginaceae	Herb	Chamaephyte
4.	*Acantholimon lycopodioides* (Girard) Boiss.	Plumbaginaceae	Herb	Chamaephyte
5.	*Acantholimon munroanum* Aitch. & Hemsl.	Plumbaginaceae	Herb	Chamaephyte
6.	*Adonis aestivalis* L.	Ranunculaceae	Herb	Therophyte
7.	*Allium chitralicum* Wang & Tang	Alliaceae	Herb	Geophyte
8.	*Arenaria griffithii* Boiss.	Caryophyllaceae	Herb	Chamaephyte
9.	*Arenaria orbiculata* Royle ex.Edg.	Caryophyllaceae	Herb	Chamaephyte
10.	*Arnebia euchroma* (Royle ex Benth.) I.M. Johnston	Boraginaceae	Herb	Therophyte
11.	*Artemisia* sp.	Asteraceae	Herb	Chamaephyte
12.	*Astragalus lasiosemius* Boiss.	Papilionaceae	Herb	Chamaephyte
13.	*Astragalus staintonianus* Ali	Papilionaceae	Herb	Therophyte
14.	*Astragalus strobiliferus* Royle ex Benth.	Papilionaceae	Herb	Chamaephyte
15.	*Astragalus toppinianus* Ali	Papilionaceae	Herb	Hemicryptophyte
16.	*Astragalus oihorensis* Ali	Papilionaceae	Herb	Chamaephyte
17.	*Calamagrostis emodensis* Griseb	Poaceae	Herb	Hemicryptophyte
18.	*Chesneya cuneata* (Benth.) Ali	Papilionaceae	Herb	Therophyte
19.	*Cicer microphyllum* Benth.	Papilionaceae	Herb	Chamaephyte
20.	*Cousinia multiloba* DC.	Asteraceae	Herb	Chamaephyte
21.	*Cousinia racemosa* Boiss.	Asteracee	Shrub	Chamaephyte
22.	*Cousinia subscaposa* Rech.f.	Asteraceae	Herb	Chamaephyte
23.	*Cousinia schugnanica* Juz	Asteraceae	Herb	Chamaephyte
24.	*Draba pakistanica* Jafri	Brassicaceae	Herb	Therophyte
25.	*Ephedra* sp.	Ephedraceae	Shrub	Nanophanerophyte
26.	*Eremostachys edelbergii* Rech. f.	Lamiaceae	Herb	Chamaephyte
27.	*Eremostachys speciossa* Rech.f.	Lamiaceae	Herb	Chamaephyte
28.	*Eremurus stenophyllus* (Boiss. & Buhse) Baker	Asphodelaceae	Herb	Geophyte
29.	*Gypsophila sedifolia* Kurz	Caryophyllaceae	Herb	Therophyte
30.	*Lonicera semenovii* Regel	Caprifoliaceae	Shrub	Nanophanerophyte
31.	*Matthiola flavida* Boiss.	Brassicaceae	Herb	Therophyte
32.	*Nepeta glutinosa* Benth.	Lamiaceae	Herb	Therophyte
33.	*Onobrychis cornuta* (Linn.) Desv.	Papilionaceae	Herb	Chamaephyte
34.	*Oxytropis chitralensis* Ali	Papilionaceae	Herb	Hemicryptophyte
35.	*Oxytropis immersa* (Baker ex Aitch.) Bunge ex Fedtschenko var. *immerse*	Papilionaceae	Herb	Hemicrytophyte
36.	*Pedicularis dolichorhiza* Schrenk	Scrophulariaceae	H	Geophyte
37.	*Pedicularis pycnantha* Boiss.	Scrophulariaceae	Herb	Geophyte
38.	*Ranunculus pulchellus* C. A. Mey	Ranunculaceae	Herb	Therophyte
39.	*Rhodiola heterodonta* (Hook.f., & Thomson) Boriss	Crassulaceae	Herb	Geophyte
40.	*Saussurea leptophylla* Hemsl.	Asteraceae	Shrub	Chamaephyte

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Figure 1. *Androsace ojhorensis (A) habitat; (B) habit; (C) flower*

Flowering and fruiting phenology

Flowering and fruiting phenology was observed in June in the plant.

Distribution

Androsace ojhorensis is a narrow endemic which is found only in its type locality i.e. Ojhor Gol, Chitral (*Fig. 2*).

(a) Extent of occurrence (EOO): 8 km^2

(b) Area of occupancy (AOO): 4.407 km^2

Population size

Total number of 95 mature individuals were observed in 2016, 82 in 2017 and 75 in 2018. The grazing index for the year 2016, 2017 and 2018 was found to be 12.63%, 29.26% and 42.66% respectively which shows that it was less grazed in 2016 and moderately grazed in 2017 and 2018. Therefore, it is clear that it is a very rare species with a continuous decline in population size (*Table 2*).

Table 2. *Locality, altitude, population statistics and GI of Androsace ojhorensis* Y. Nasir

S. No.	Locality	Altitude and absolute location	Population size in June			Grazed individuals per year		
			2016	2017	2018	2016	2017	2018
1.	Sosoom-Ojhor	12000-13000 ft. 36° 04’ 50.78” N 71° 50’ 52.57” E	95	82	75	12	24	32
2.	Average		84			22.6		
3.	Grazing index (GI) per year					12.63%	29.26%	42.66%
4.	Symbol of Grazing index					+	++	++

Mode of reproduction

Both methods of reproduction i.e. sexual and asexual reproduction were observed.

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(a) Sexual reproduction

The flowering phenology of this species in begins early June and flower production is maximum from 10th June to 20th June. Young individual plants and seedlings were also observed in different populations. Flowering phenology in young individual plants with scape length of 1-2 cm was also observed. Small honey bees were observed as probable pollinator in populations which were in flowering phenological stage. Fruit type in this species is 2-seeded rarely 3-seeded capsule and estimated average number of capsular fruits observed per plant was 120.

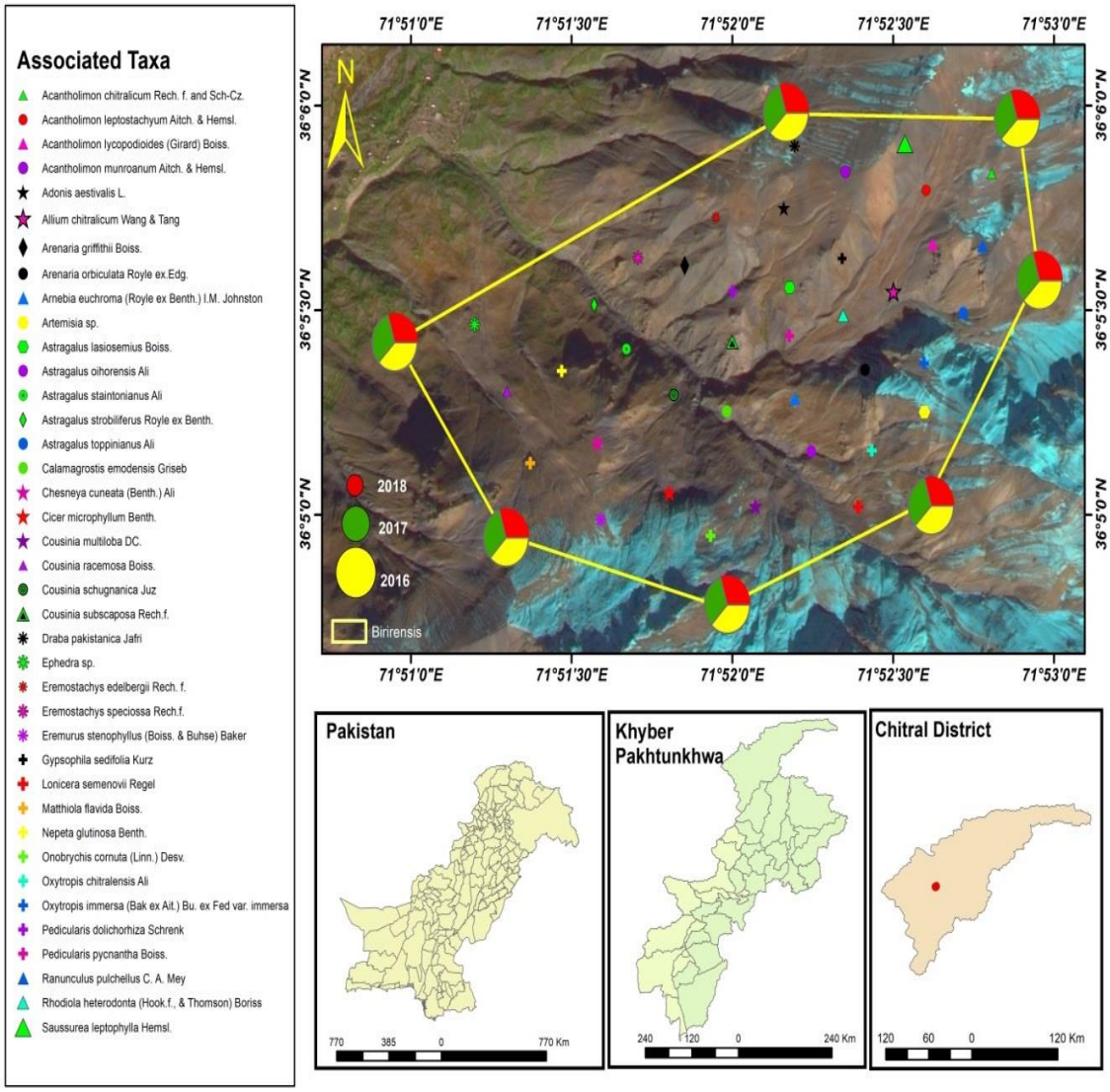

Figure 2. *Location, associated species, population statistics, extent of occurrence (EOO), area of occupancy (AOO) of Androsace ojhorensis* Y. Nasir

(b) Vegetative reproduction

As *Androsace ojhorensis* is a stoloniferous herbaceous plant, therefore, it also reproduces vegetatively through extensive columnar branching from its rootstock. It was

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observed that high moisture content in soil favors the vegetative reproduction usually in the plants which are found in periphery or edge of the microhabitats or populations (*Table 3*).

Table 3. *Environmental characteristics of the sampling site for Androsace ojhorensis Y. Nasir*

Main Location	Altitude (ft)	Slope (º)	Aspect	Soil type	Habit of Taxon
Sosoom-Ojhor	12000-13000	North-facing (12^0)	Top Hills	Sandy loam	Herb

Threats

Grazing, soil erosion and landsliding.

Conservation status

Extent of occurrence is 8 km^2 (i.e. less than 100 km^2) and its area of occupancy is 4.407 km^2 (i.e. less than 10 km^2). This is a rare species with continuous decline in population size. Therefore, based on the values of extent of occurrence, area of occupancy and population statistics, it is placed under Critically Endangered Category. The conservation status of *Androsace ojhorensis* is summarized according to the alphanumerical hierarchical numbering system of the criteria (IUCN, 2012) as: CR B B1a b (i) (ii) (iii) (v) B2 a b (i) (ii) (iii) (v) C Ci.

Grazing index

The grazing indexes calculated for this endemic species were counted per unit area following Ali and Qaiser (2009).

Percentage of grazed individuals	Symbol	Grazing index
1-20%	+	Less grazed
21-50%	++	Moderate grazed
51-80%	+++	Extensively grazed
81-100%	++++	Critically grazed

Discussion

Biodiversity loss is the most serious issue faced by the humans around the globe because the survival of all life forms is directly or indirectly linked with the biodiversity conservation (Nowak et al., 2011, 2020; Sala et al., 2000). Plant biodiversity loss and extinction is enormously high in developing countries including Pakistan. In Pakistan the conservation status of only 60 endemic and rare plant species has been evaluated in the last two decade (Abbas et al., 2010; Alam and Ali, 2010; Ali and Qaiser, 2010b, a, 2011; Jan and Ali, 2009; Muhammad et al., 2017; Shaheen et al., 2019). Because of the narrow distribution and small population size, the endemics are more threatened and exposed to extinction as compared eurychorous species (Mills and Schwartz, 2005). Proper floristic surveys and field observations and studies are critical to the setting of conservation priorities and assessment of the conservation status of plant taxa (Golding and Smith, 2001; Hedenäs et al., 2002; Ungricht et al., 2005; Willis et al., 2003). Conservation assessments based principally on herbarium collections may be misleading and it is

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possible that populations documented in herbarium collections may no longer exist (Randrianasolo et al., 2002). This holds good for relatively far-flung and inaccessible areas such as Chitral. Vegetative reproduction is an important strategy for survival in plants growing in alpine and subalpine habitats where the ecological niches of species are narrow and probably a large proportion of seeds do not find favorable habitats for germination and population establishment (Alam and Ali, 2010). As the *Androsace ojhorensis* produces 240-360 seeds per plant annually and production of seedlings from seeds is extremely low due to its small geographic range and highly specialized habitat. Therefore, the vegetative reproduction is most important and suitable strategy for its conservation (Alam and Ali, 2010). The north-facing slopes are less exposed to direct sunlight and the soil is more moisturized and damp as compared to south-facing slopes (Alam and Ali, 2010; Ali and Qaiser, 2012; Jan and Ali, 2009). Therefore, this taxon is moisture and shade-loving species due to its presence on north-facing slopes. As *Androsace ojhorensis* is endemic to its type locality with its extent of occurrence (EOO) is 8 km^2 and area of occupancy (AOO) is 4.407 km^2. The dwindling population size and high grazing over a period of three consecutive years makes this taxon more extinction. Such narrow endemics taxa are more vulnerable to extinction due to their declining population, small geographic range, habitat fragmentation, grazing and soil erosion (Bernardos et al., 2006; Fenu et al., 2011; Martinell et al., 2011). According to the IUCN Red List Categories and Criteria (Nature et al., 2001), this taxon is placed under B1 and B2 of Critically Endangered category because its extent of occurrence is less than 100 km^2 (i.e. 8 km^2) and its area of occupancy is also less than 10 km^2 (i.e., 4.407 km^2). Furthermore, as the number of mature individuals of the taxon is 75 (less than 250), therefore it falls in the criterion "C" of Critically Endangered category. Therefore, the narrow and small geographic range and small population size with continuous decline recommend to keep this taxon under Critically Endangered (CR) category at global level. The conservation status of *Androsace ojhorensis* is summarized according to the alphanumerical hierarchical numbering system of the criteria (IUCN, 2012) as: CR B B1a b (i) (ii) (iii) (v) B2 a b (i) (ii) (iii) (v) C Ci Where: CR. Critically Endangered, B. Geographic range, B1. Extent of occurrence less than 100 km^2, a. Found only at a single location, b. Continuous decline observed in; (i). Extent of occurrence (ii). Area of occupancy (iii). Number of subpopulations (v). Number of mature individuals (B2). Area of occupancy less than 10 km^2 (a). Found only at a single location (b). Continuous decline observed in; (i). Extent of occurrence (ii). Area of occupancy (iii). Number of sub-populations (v). Number of mature individuals (C). Population size and decline (C1). An estimated continued decline of at least 25%.

Conclusions

This study reveals that narrow endemic plants highly contribute towards communities' services in many ways. Plant biodiversity loss and extinction is enormously high in developing countries including Pakistan. This study highlighted the threat status of *Androsace ojhorensis* endemic and the nature of the factors that threaten them. Local knowledge is based on selection of the best species for medicinal purpose. Most of the narrow endemics have medicinal uses in their locality for the nomads. Such narrow endemics taxa are more vulnerable to extinction due to their declining population, small geographic range, habitat fragmentation, and grazing and soil erosion. Conservation assessments based principally on herbarium collections may be misleading and it is possible

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that populations documented in herbarium collections may no longer exist. This holds good for relatively far-flung and inaccessible areas such as Chitral. Governmental and Non-Governmental Organizations to take useful measures for threatened plants and their conservation with special focus on endemic species to mitigate their extinction risk. For wise use, conservation efforts are necessary for their future protection from extinction risk.

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