CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Nineteenth meeting of the Conference of the Parties
Panama City (Panama), 14 - 25 November 2022

CONSIDERATION OF PROPOSALS FOR AMENDMENT OF APPENDICES I AND II

A. Proposal

To include *Rhodiola rosea* and *Rhodiola crenulata* in CITES Appendix II, in accordance with Article II, Paragraph 2 (a) of the Convention and satisfying Criteria B of Annex 2 a of Resolution Conf. 9.24 (Rev. CoP17).

To include all other species of the genus *Rhodiola* in CITES Appendix II, because of their similarity to the mainly traded species, in accordance with Article II, paragraph 2 (b) of the Convention and Paragraph A of Annex 2 b of Resolution Conf. 9.24 (Rev. CoP17).

Annotation

#2 All parts and derivatives except: a) seeds and pollen; and b) finished products packaged and ready for retail trade.

B. Proponent

China, European Union, Ukraine, United Kingdom of Great Britain and Northern Ireland and United States of America [*]

C. Supporting statement

1. Taxonomy

1.1 Class: Angiospermae

1.2 Order: Saxifragales

1.3 Family: Crassulaceae

1.4 Genus, species or subspecies, including author and year:

All species of the genus *Rhodiola* L. The taxonomy of the genus remains partially unresolved (Cunningham *et al.*, 2020), with the number of accepted species ranging from c. 58 to 90 according to different sources (Kew's Plants of the World Online (POWO, 2021), the Flora of China (Fu and Fu, 1984, Fu *et al.*, 2001), The Plant List (2013) and Ohba (2003)). This proposal follows the nomenclature outlined in Ohba (2003), which recognises 58 species.

[*] *The geographical designations employed in this document do not imply the expression of any opinion whatsoever on the part of the CITES Secretariat (or the United Nations Environment Programme) concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries. The responsibility for the contents of the document rests exclusively with its author.*

Annex 1 lists all species outlined in Ohba (2003) alongside their respective scientific synonyms. Common names are additionally shown for the two species most commonly traded (*R. rosea* L. and *R. crenulata* (Hook.f. & Thomson) H.Ohba).

1.5 Scientific synonyms: See Annex 1

Persueing older classifications, some nomenclatural sources consider the genus or certain species of *Rhodiola* as part of *Sedum* L., and trade in *Rhodiola* species can sometimes also be observed under the name *Sedum*. However, recognition of specific morphological features, such as well-developed rhizomes, annual flowering stems arising from the axils of the scaly radical leaves, as well as the often unisexual flowers and dioecy has accounted for the taxonomic separation of *Rhodiola* from *Sedum* (Mayuzumi and Ohba, 2004, Ohba, 2003), which has been confirmed by molecular phylogenies (Mayuzumi and Ohba, 2004, Zhang *et al*., 2014).

1.6 Common names:

See Annex 1.

1.7 Code numbers:

2. Overview

Rhodiola is a diverse genus of perennial herbs, with a wide distribution spanning across the northern hemisphere. Although species within the genus are found across a wide altitudinal range, they are commonly associated with subarctic and alpine areas. The centre of diversity is found in the People's Republic of China (hereafter China), which hosts 60per cent of the world's *Rhodiola* species, according to the Flora of China. Members of the genus are generally long-lived and slow growing, in some cases taking 20 years to reach maturity in the wild.

The rhizomes of some species of *Rhodiola,* known as "roseroot", have historically been part of traditional medicine systems across the majority of the genus' range; however, industrial use of *Rhodiola* species started in mid 20th century in the former Soviet Union, and the past 20 years have seen a rapid rise in the diversity of *Rhodiola* products available on the market and an expansion in both domestic and international trade in the genus. With several clinical trials investigating the effectiveness of *R. rosea*-containing products in treating the effects of fatigue, sleep disorders and depression, international demand is further projected to increase. Trade is currently focused on two species: *R. rosea* and *R. crenulata,* which are traded in the form of raw material (as dried rhizomes, chips, or powder) and semi-processed commodities (extracts), and finally sold to end consumers as dried coarse ground and chipped root for teas, as well as pills/tablets, concentrated extracts and powders marketed as herbal medicine, dietary supplements, sports and energy drinks, alcoholic beverages and cosmetic products. Harvesting is based on the exploitation of the large rhizomes (rootstocks) and/or whole plants, and the majority of material currently traded is wild-sourced. Harvest is focused on reproductively mature individuals, so commercial levels of exploitation have an increased potential to impact recruitment and long-term population viability.

Wild populations of *Rhodiola* are commercially exploited in Europe (where collection is focussed on *R. rosea*), as well as Central and Eastern Asia (where use includes a wider diversity of *Rhodiola* species). China is considered to play a principal role in the international trade of *Rhodiola* products. Both commercial demand and the location of extract manufacturers in China attracts cross-border trade in raw *Rhodiola* rhizomes, mainly from the Russian Federation but also from Mongolia and Kazakhstan. The principal international trade routes for end *Rhodiola* products appear to be from China to North America, Europe, Australia, and the Republic of Korea.

Estimates suggest that trade volumes are considerable. For example, eighty shipments of *Rhodiola* products from China to the United States of America (hereafter US) in a single year were estimated to consist of 2464 kg of concentrated extract, which could correspond to anywhere from about 94 000 kg to 312 320 kg of dried root and rhizome raw material. Four to five collection sites in the Xinjiang region of China were estimated to be selling about 500 000 kg of dry rhizomes of *R. rosea* annually, with the majority to be sold to extract manufacturers in east China and subsequently traded internationally. Although artificial propagation of *Rhodiola* spp. is possible, the current scale is small and there are few commercial growers.

Uncontrolled harvest has reportedly led to declines in wild populations of *R. rosea* and *R. crenulata.* Although there are no recent numerical estimates of the extent of declines, *R. rosea* populations in the Altai area of

South Siberia (Russian Federation) (one of the principal collecting areas) have been described as seriously threatened due to intense collection. The species is listed nationally as Category 3 (Rare) in the Red Book of the Russian Federation, and is in threatened categories in the national red lists of China, Austria, Bosnia and Herzegovina, Bulgaria, the Czech Republic, Germany, and four US states. In China, based on assessment of national Red Lists, *R. crenulata*, *R. rosea* and another eight species of *Rhodiola* have been put under state second class protection under the Regulation on Wild Plants Protection of China since September 2021. Based on a biological vulnerability to harvesting, increasing levels of international trade, and declines in wild populations, the two species meet the criteria for inclusion in Appendix II of CITES, in accordance with Article II, Paragraph 2 (a) of the Convention and satisfying Criteria B of Annex 2 a of Resolution Conf. 9.24 (Rev. CoP17).

Identification of specific *Rhodiola* species can be challenging even for live plants or dried rhizomes; it becomes increasingly difficult as the species undergoes processing and, at later stages, is not considered possible without molecular techniques such as DNA barcoding. The criteria for inclusion of the entire genus in Appendix II under paragraph A of Annex 2 b of Resolution Conf. 9.24 (Rev. CoP17) thus are also met; for this reason, and because *R. rosea* and *R. crenulata* products are frequently substituted and adulterated both with other *Rhodiola* species as well as with each other at early stages in the supply chain, the inclusion of the whole genus *Rhodiola* is proposed.

3. Species characteristics

3.1 Distribution

Rhodiola has a wide distribution spanning across the northern hemisphere (Ohba, 2003, see also Annex 2). The Qinghai-Xizang Plateau (QXP) and Hengduan Mountains are considered to be the centre of diversity for the genus (Fu *et al.*, 2001; You *et al.*, 2018), with the Flora of China estimating the country to be a range State for over 60per cent of the world's *Rhodiola* species, including 16 endemics (Fu *et al.*, 2001). The distribution of the two species most commonly traded is as follows:

***R. rosea*:** Circumpolar distribution across the northern hemisphere from the low-Arctic to high-temperate regions: Europe (Andorra, Austria, Bosnia & Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark (Faroe Islands and Greenland), Finland, France, Germany, Iceland, Ireland, Italy, Norway, Poland, Slovakia, Spain, Switzerland, Ukraine, United Kingdom), across temperate Asia (People's Republic of China, Democratic People's Republic of Korea, Japan, Kazakhstan, Mongolia, Russian Federation) and North America (Canada and US) (Ohba, 2003) (see Annex 2).

***R. crenulata*:** Nepal, India, Bhutan and China (Ohba, 2003) (see Annex 2).

3.2 Habitat

Rhodiola are often found on gravel slopes or valley rocks, such as limestone and granite (Fu *et al.*, 2001; Zhang *et al.*, 2014). Although the genus overall can be found at a wide altitudinal range, many species are associated with high altitudes of 3500–5000 m a.s.l. (Zhang *et al.*, 2014). Typical habitat of the two species that are most commonly traded is as follows:

***R. rosea*:** Grows in a wide range of habitats, including coastal cliffs, meadows and grasslands, edges of small streams, forest margins, forested slopes, fissures in alpine mountains, rocky scree slopes and gravel slopes (Fu *et al.*, 2001; Allen *et al.*, 2014; Cuerrier *et al.*, 2014b). It additionally grows in a wide variety of soil types, and in a wide range of pH values, from alkaline limestones to acidic soils (Allen *et al.*, 2014). The species has a wide altitudinal range, occurring from just above sea-level to 3000 m a.s.l. (Allen *et al.*, 2014).

***R. crenulata*:** Grows in thickets, grassland slopes, schist on mountain slopes, rocky places, and rock crevices (Ohba, 2003). Found between 2800 and 5600 m a.s.l. (Ohba, 2003).

3.3 Biological characteristics

Rhodiola are perennial herbs with well-developed rhizomes (Ohba, 2003). The majority of species, including those that are most exploited commercially, are dioecious (with separate male and female plants) (Ohba, 2003; Cunningham *et al.*, 2020). They are generally considered to be long-lived; although maximum ages in wild populations have not been studied, life expectancy for *R. rosea,* for example, has been estimated at over 80 years (Nekratova and Nekratov, 2005). It has been estimated

that species such as *R. rosea* may take 20 years to reach maturity in the wild (Illig, 2018), with the minimum harvesting age ranging from 15–30 years (Smelansky *et al.*, 2009). Galambosi (2006) noted that *R. rosea* flowers in wild individuals do not appear until their seventh or eighth year. The form of reproduction varies by species; some can only reproduce from seed (Alsos *et al.*, 2020) but others (including *R. rosea* and *R. crenulata*) can reproduce vegetatively by sprouting from large rhizomes (Ohba, 2003; Lei *et al.*, 2006).

Dispersal distances are thought to be relatively short (Brinckmann *et al.,* 2021b; Alsos *et al.*, 2020; Cunningham *et al.,* 2020), and seedling survival and germination rates are generally thought to be low (between 5 and 35 per cent for *R. rosea*, for example (Tasheva and Kosturkova, 2012)).

3.4 Morphological characteristics

Species of *Rhodiola* display a high level of morphological diversity (Zhang *et al.*, 2014), however they are generally characterised by well developed, fleshy rhizomes and leaves, and flowering stems borne in axils of scale leaves on the rhizomes, which are partly above ground (Fu *et al.*, 2001; Ohba, 2003). Petal colours can be white, reddish, deep purplish-red or pale yellow to greenish (Ohba, 2003).

3.5 Role of the species in its ecosystem

Rhodiola species form micro-habitats for small biota, including economically and ecologically important fungi (Cui *et al.*, 2015). Some species are also the larval foodplants of lepidoptera (Nakonieczny *et al.*, 2007; Chuluunbaatar *et al.*, 2020); *R. rosea,* for example, is a larval foodplant of *Parnassius apollo,* a swallowtail butterfly that has been in decline in parts of Europe and is now extinct in three European countries (Nakonieczny *et al.*, 2007).

4. Status and trends

4.1 Habitat trends

Rhodiola's large distribution means that it is not possible to make general statements regarding habitat trends for the genus. However, infrastructure development associated with tourism and the oil and gas industry, soil erosion, water abstraction and grazing have been highlighted as issues in discrete parts of *R. rosea'*s range (e.g. Nordic Gene Bank, 2005; Sakhalin Energy Investment Company, 2005; NPWS, 2008). In addition, forest fires as well as anthropogenic threats such as illegal clear cutting are reported to have caused fragmentation and habitat loss in the Russian Far East, negatively impacting wild medicinal plant populations, including those of *R. rosea* (Zyryanova *et al.*, 2005). In contrast, remoteness in high altitude habitats may shield *R. crenulata* from habitat loss due to agricultural clearing or human-induced fragmentation.

Climate change is considered to be a significant threat to some *Rhodiola* species, especially those limited to high altitude habitats (You *et al.*, 2018; Zhang *et al.*, 2018). In general, hotter, drier habitats are considered to be challenging for species such as *R. rosea*, which are dependent on relatively stable water supplies (Nordic Gene Bank, 2005; Kozyr, 2014). In southern Transbaikalia (Russian Federation), for example, long-term vegetation monitoring has shown how a drier climate has reduced the area of alpine meadows that include *R. rosea*, with only small clumps of the species remaining along small streams (Kozyr, 2014). Conversely, climate change could make currently unsuitable habitats at higher latitudes and elevation (such as those with permafrost) into those suitable for some *Rhodiola* species (You *et al.*, 2018).

4.2 Population size

Total population sizes even for the most well-studied species (*R. rosea*) are not available, although there have been discrete studies to estimate standing stock of particular species in particular areas; these are summarised below.

***R. rosea*:** All information relates to particular harvest areas in the Russian Federation. A study in the Republic of Tuva (southern Siberia) estimated the total area of occurrence for *R. rosea* to be in the region to be 14 102 km^2, within which there was an estimated standing stock of 109.6 tonnes of *R. rosea*. Approximately 70per cent (76.8 tonnes) of this was estimated to be accessible in dense thickets for future harvesting (Sambuu and Ajunova, 2019).

Nekratova and Shurupova (2014) studied the habitat and biomass of *R. rosea* in the Kuznetsky Alatau mountain range (south central Russian Federation), which occupies an area of 38 000 km^2. *Rhodiola rosea* plant communities were determined to cover 66 ha (0.66 km^2) with a standing stock of underground biomass of 191.9 ± 18.9 kg/ha, and a total standing stock of rhizomes (dry weight) of 12.7 ± 0.8 tonnes. Around 1.2 tonnes of this was considered to be exploitable (Nekratova and Shurupova, 2014), however the methodology used to calculate this figure is unclear.

***R. crenulata*:** In Bhutan, *R. crenulata* was reported to grow in dense clumps (Krug and Milliken, 2008; Lakey and Dorji, 2016), which may be up to 2 m wide (Krug and Milliken, 2008). Recorded densities for the species range from 0.04 to 1.7 clumps/m^2 (Krug and Milliken, 2008); however, a more recent study conducted in Lingshi (a local administrative unit in north east Bhutan, on the border with China), which assessed priority species to determine whether wild harvest could be sustainable, found the species to be vulnerable and patchy in distribution, critically low in plant density (0.4 plants per m^2), and among the rarest of 16 wild-collected medicinal plant species (Lakey and Dorji, 2016). Lingshi is considered to have served as the main source of high-altitude medicinal plants for the Institute for Traditional Medicine Services in Bhutan for over 20 years (Lakey and Dorji, 2016). In China, a recent population assessment study was carried out in four provinces (Qinghai, Sichuan, Xizang, Yunnan) by Yuan *et al.* (2018). The study appears to have focused on sampling sites where *R. crenulata* occurred (rather than using random location of plots in *R. crenulata* habitat or stratified sampling along belt transects), and the plot sizes were small (2 m x 2 m), with 2–12 plots per site. Within these plots, the number of *R. crenulata* plants ranged from 1.6–5.8 plants (Yuan *et al.*, 2018), although it is not possible to determine the density of plants per hectare from this data. No population assessments of *R. crenulata* could be located from India or Nepal.

4.3 Population structure

Very little information relating to population structure is available. One study of the sex ratio of *R. rosea*, carried out in Scotland (United Kingdom of Great Britain and Northern Ireland, hereafter UK) by Richards (1988), showed that the population was skewed towards male plants (1.56:1). In a study of 179 individuals of *R. rosea* in the Altai-Sayan eco-region (Russian Federation) growing in "optimal habitats", Nekratova and Shurupova (2015) estimated individuals to have an average age of 20 to 30 years

4.4 Population trends

Only one species of *Rhodiola* has been assessed for the IUCN Red List – *R. marginata*, which is endemic to northern Bhutan. The species was categorised as Least Concern in a 2017 assessment with an unknown population trend (Bhutan Endemic Flowering Plants Workshop, 2017). However, many *Rhodiola* species have been assessed for national red lists – a full list is available in Annex 1. Known population trends of the two key species in trade are given below:

***R. rosea*:** Although no data are available on population trends across the whole of *R. rosea*'s circumpolar distribution, information on population trends is available from a number of range States.

Russian Federation: *Rhodiola rosea* is listed nationally in the Red Book of the Russian Federation as a Category 3b species (Rare; small populations occur sporadically spread across a large area) (Ministry of Natural Resources and Environment of the Russian Federation, 2008). Regionally, it is in Category 1 (CR; in danger of extinction) in one district/republic/territory, in Category 2 (VU; vulnerable and declining) in 10 districts/republics/territories, in Category 3 (rare) in 7 districts/republics/territories, and in Category 4 (Uncertain status) in the Altai Territory; this latter categorisation was made in March 2019 in response to reports of uncontrolled large quantities of *R. rosea* being harvested and exported from the area (Ministry of Natural Resources and Ecology of the Altai Region, 2019). No data could be found regarding recent population trends, however numerous estimates of dramatic declines exist from the 1970s and 1980s. Populations of *R. rosea* in the Kuznetsky Alatau mountains (Russian Federation), for example, reportedly dropped by 90.5per cent between 1976 through 1987 as a result of large-scale commercial harvesting, with the rate of decline ranging between 6per cent to 8per cent per year (Smelansky *et al.*, 2009). For the period of 1974 through 1986, reserves in the mountainous Altai Region were reported to have reduced by 76.4per cent (Smelansky *et al.*, 2009). In the early 1970s, *R. rosea* raw material in the highlands of southern Siberia was estimated at 1720 tonnes (dry weight); however, by 1979, estimated total reserves in this region amounted to 979 tonnes, of which 615 tonnes were in Altai, 265 tonnes were in Kuznetsky Alatau and Western Sayan, and 99 tonnes were in Tuva (Sambuu and Ajunova, 2019). In 2006, Galambosi (2006)

noted that natural populations of *R. rosea* in the Altai area of South Siberia remained seriously threatened due to intense collection.

Asia: A 2014 survey of 140 pastoral herders in three districts in southern Mongolia (Khanbogd soum, Manlai soum, and Bayan-Ovoo soum) found that, according to respondents, medicinal plant species that grew abundantly 20 years ago, in particular *R. rosea,* had now become scarce (Jigjsuren *et al.*, 2015). Herders attributed the observed rangeland degradation to lower rainfall, higher temperatures, increased soil erosion and resulting dust storms (Jigjsuren *et al.*, 2015). The Threatened Species List of China's Higher Plants (Qin *et al.*, 2017) lists *R. rosea* var. *rosea* and *R. sachalinensis* as Vulnerable (VU)[1] (*R. sachalinensis* is considered a separate species in this publication, with populations in the provinces of Heilongjiang and Jilin, however Ohba (2003) considers it to be a synonym of *R. rosea*).

Europe: In Iceland, the introduction of sheep was noted to have resulted in the eradication of some populations of *R. rosea* (Nordic Gene Bank, 2005). Less information is available from Western Europe, however a comparison of field observations from the early 19th century to the early 20th century indicates that some *R. rosea* populations may have disappeared (Amann, 2016). The species is considered to be Critically Endangered in Bulgaria (Peev *et al.*, 2015) and the Czech Republic (Grulich and Chobot, 2017), regionally Endangered in Austria (Niklfeld and Schratt-Ehrendorfer, 1999), Vulnerable in Bosnia and Herzegovina (Federal Ministry of Environment and Tourism, 2014), and Threatened with extinction in Germany (Metzing *et al.*, 2018).

North America: In the US, wild *R. rosea* populations are possibly locally extinct in North Carolina (NatureServe, 2022). The species is additionally considered to be Endangered in New York, North Carolina and Pennsylvania, and Threatened in Vermont (Natural Resources Conservation Service, 2019).

***R. crenulata*:** Qin *et al.*, (2017) considered the species to be Endangered[2] in China. Based on a study of *R. crenulata* numbers at 23 locations in four provinces in China, Yuan *et al.* (2018) considered that accessible populations had been "significantly reduced" due to destructive harvesting. This downward trend fits with the observations of three other studies, which noted a worsening situation for *R. crenulata* populations since the 1980s. Yan *et al.* (2003) reported that the economic value of *R. crenulata* had resulted "in heavy collections in recent years, which induced its limited distribution and fragile habitat". Lei *et al.* (2006) considered that "*Rhodiola* natural resources have decreased remarkably recently, owing to over-exploitation for medicine and shrinkage of their natural habitat". Finally, Zhang *et al*. (2018) stated that "since the 1980s, the accelerated and uncontrolled use of *R. crenulata* in China has severely reduced its population". Neither quantitative nor qualitative information on current and past trends regarding the abundance of *R. crenulata* could be found for Bhutan, India or Nepal.

4.5 Geographic trends

See section 4.4.

5. Threats

Based on rapid growth in the market for *Rhodiola* products, overcollection for commercial use is the most prominent threat to traded species; this is impacting wild populations in multiple harvesting countries (see section 4.4). According to Cunningham *et al.* (2020), growth in international trade is being principally driven by the expansion of the herbal medicine, sports medicine and energy drinks sectors, and well as the cosmetics industry. With several clinical trials investigating the effectiveness of *R. rosea*-containing products in treating stress-related health problems such as fatigue, sleep disorders and depression (e.g. Mao *et al.*, 2015; Amsterdam and Panossian, 2016), as well as their potential role in preventing and treating respiratory diseases (Panossian and Brendler, 2020), market reports have projected that international demand will continue to increase (EMR 2021; MarketWatch, 2021). The value of the global market for dry extract of

[1] R. rosea *var*. rosea: *VU B1ab(iii*); R. sachalinensis: *VU B1ab(i,ii); D1*

[2] *EN B1ab(iii*)

R. rosea root in 2015 was about USD 27.06 million, with the average market growth rate from 2011 to 2015 estimated at around 7.8per cent (QYR Chemical & Material Research Center, 2016).

As noted in section 4.1, *Rhodiola* are also threatened in discrete parts of their range by development, water abstraction, grazing and trampling. The restriction of many species to montane habitats means that climate change also poses an acute threat.

6. Utilization and trade

6.1 National utilization

National use of *Rhodiola* for medicine and food has been recorded in countries across its range. In Europe and North America, use and cultivation is focused on *R. rosea,* which has historically been part of traditional herbal medicine (Alm, 2004; Panossian *et al.*, 2010; Cuerrier *et al.*, 2014a). A wider diversity of species is used in central Asia (Bejar *et al.*, 2017), which is the centre of diversity in *Rhodiola* spp. and where the genus is part of the traditional medicine systems of China, Bhutan, Mongolia, Nepal, India, Kazakhstan, Kyrgyzstan, the Russian Federation and Uzbekistan. *Rhodiola crenulata* is considered to be the species that is in highest demand and most traded in this region, although 19 other species, including *R. rosea*, have been recorded in use (Cunningham *et al.*, 2020).

Commercial exploitation of *R. rosea* for medicinal purposes in national and international markets has been reported in Norway (Galambosi, 2006), the Russian Federation (mainly in the Republics of Altai and Khakassia, but also in the Russian Far East) (Brinckmann *et al.*, 2021b), Kazakhstan (Bejar *et al.*, 2017), and Eastern Asia (China, Mongolia) (Bejar *et al.*, 2017). Collection in European countries is considered to have less economic importance because of the high labour costs and the difficulties of transport in high mountain areas (Galambosi, 2006); many populations in Europe are also legally protected (see Annex 5). Quota-based wild *R. rosea* harvest is allowed in the state of Alaska (State of Alaska Department of Natural Resources, Division of Mining Land and Water, 2008), but recent harvest volumes are unknown.

In China, *Rhodiola* has a long history of use in Tibetan Traditional Medicine (Tao *et al.*, 2019). However, national (as well as international) use has diversified over the last 20 years, and now includes a wide variety of industrial products, like cosmetics, beverages, foods, and dietary supplements (Cunningham *et al.*, 2020; Brinckmann *et al.*, 2021b). The shift in use from chopped dried rhizome infusions into a wide variety of processed products is reflected in the rapid rise in patent applications for *Rhodiola* products observed between 1990 and 2015 (Cunningham *et al.*, 2020). Wholesale market prices for *R. crenulata* raw materials have also increased from CNY 6 /kg in 2002 (USD 0.73/kg), to CNY 35 /kg (USD 5.47) in mid-2018 (Cunningham *et al.*, 2020). Importantly, the current market for *Rhodiola* products in China is reported to be supplied entirely from wild collection (Cunningham *et al.*, 2020)[3], with several commercially exploited species being classified as threatened in the national Red List (Qin *et al.*, 2017).

6.2 Legal trade

Trade volumes for *Rhodiola* are uncertain, and there are no known genus-specific harmonized system tariff codes (HS Codes) assigned in any country for any commercial forms of the genus. However, estimates available indicate that the amount of material traded internationally for medicinal uses is considerable.

Presently, the two key species in trade (*R. rosea* and *R. crenulata*) have different supply chains (Cunningham *et al.*, 2020, Brinckmann *et al.*, 2021a). The largest populations of *R. rosea* subject to intensive commercial wild collection are reported to be in the Altai Mountains of southern Siberia and the Xinjiang Uyghur Autonomous Region in China (Brinckmann *et al.*, 2021b). Raw material that was not collected in China is principally thought to be first exported into this latter region, mainly from harvesters operating in the Russian Federation, but also from Kazakhstan and possibly Mongolia (Cunningham *et al.*, 2020; Brinckmann *et al.*, 2021b). From here, it is either sold directly to commercial enterprises as raw material, or to extraction houses in eastern China for value-addition and export in the form of bulk extracts as well as end products (Cunningham *et al.*, 2020). The Russian Federation itself however is also considered to be a major importer of *R. rosea* dried root,

[3] *Although large scale, commercially viable cultivation of* Rhodiola *has been recognised as essential to sustain future demand, the current scale is small (see section 8.4).*

especially from wild collection operations situated in neighbouring countries of Kazakhstan and Mongolia (Bejar *et al.*, 2017). There are additionally reports that substitute species for *R. rosea* are being "significantly collected" in Kyrgyzstan for export, although estimates of the volume of this trade are unavailable (G. A. Lazkov *in litt.* to Bundesamt für Naturschutz (BfN), 2020). Further harvest areas of *Rhodiola* in China are situated in the provinces of Heilongjiang and Jilin (Fu *et al.*, 2014, Brinckmann *et al.*, 2021a). However, while *Rhodiola* specimens from these regions are classified as *R. sachalinensis* by the Flora of China (Fu and Fu, 1984, Fu *et al.*, 2001), Ohba (2003) treats it as a synonym of *R. rosea*.

Less information is available regarding the key trade routes for *R. crenulata*, but the species is thought to be mainly harvested in the QXP and Sichuan (Cunningham *et al.*, 2020).

Galambosi (2006) reported that c. 20–30 tons of dry *Rhodiola* roots were exported from the Russian Federation per year, and Smelansky *et al.*, (2009) estimated that five metric tonnes (5000 kg) of *R. rosea* were exported in 2008; however these estimates are now over ten years old. Smelansky *et al.* (2009) also estimated that c. 85 tonnes of *R. rosea* rhizome (dry weight) (equivalent to 340 tonnes fresh weight) were exported from the Siberian Federal District (which includes the Republics of Altai and Khakassia) between 2006 and 2008, which was noted to be four to five times more than the amount traded domestically inside the Russian Federation. Bejar *et al.* (2017) estimated that 500 tons of dry rhizomes of *R. rosea* from 4–5 collection sites were sold from the Xinjiang region per year, with the majority to be sold to manufacturers in east China and subsequently sold internationally; however, based on interviews with traders, Cunningham *et al.* (2020) noted that at least some of the supply procured in Xinjiang originates from neighbouring Kazakhstan and the Altai Republic (Russian Federation).

China is considered to be the major exporter of value-added *Rhodiola* extracts; according to a 2016 market study, nearly 75 per cent of the world's *Rhodiola* extract volume was manufactured in China, c.13 per cent was made in Europe, c. 5 per cent in the US, and c. 7 per cent elsewhere (QYR Chemical & Material Research Center, 2016). Based on export sales data from the e-commerce website www.alibaba.com, the principal international trade routes for end *Rhodiola* products appear to be from China to the US, the UK, Australia, Canada and the Republic of Korea, although exports have also been recorded to Pakistan and New Zealand (Cunningham *et al.*, 2020).

According to Zauba Technologies Pvt Ltd US Import Data[4], there were at least 80 import shipments to the US that listed the term *Rhodiola* as part of the container description in 2018. The total weight of the 80 shipments amounted to 624 641 kg; however, most were mixed containers, for example *Rhodiola* extracts shipped together with extracts of other Chinese medicinal plants. If only 10per cent of the 2018 US imports that listed *Rhodiola* as one component were some form of *Rhodiola* extract, Cunningham *et al.* (2020) calculated that this would amount to about 62 464 kg of concentrated extract, which was estimated to correspond to anywhere from 94 000 kg to 312 320 kg of dried root and rhizome raw material manufactured into concentrated extract in one year. The average global market price of *R. rosea* dried root in 2015 was estimated at about USD 45.00 / kg (Illig, 2018).

Some *Rhodiola* species are also traded as live ornamental plants for gardening purposes. The extent of horticultural trade is difficult to gauge as there is little global data to track such trade for species that are not CITES-listed. However, no specific collector's market exists and demand is assumed to be generally low. Contacted nurseries and horticultural associations in Germany and the UK responded that plant propagation is easy and very common among nurseries, by taking and growing seeds from their own motherstocks. Offtake of seeds or living plants from wild populations is generally not known to occur and was considered very unlikely to occur due to the straightforward propagation process. The nurseries also reported international trade in live *Rhodiola* plants to be very rare.

6.3 Parts and derivatives in trade

Rhodiola trade is based on the exploitation of large rhizomes and/or whole plants (stems and rhizomes) (Nordic Gene Bank, 2005; Cunningham *et al.*, 2020), however the supply chains are complex and there is a wide variety of partially processed and fully processed products that are traded (Cunningham *et al.*, 2020). End products include cosmetics, teas, capsules, and tinctures, and raw material is also used to extract and isolate pharmacologically active constituents in drug

4 www.zauba.com

discovery and development. A list of commodities, parts and derivatives containing *R. rosea* and *R. crenulata* and defined for trade on the national and international level is shown in Annex 4.

6.4 Illegal trade

While the wide distribution of the genus and its presence in remote areas make it difficult to estimate the extent of illegal trade, seizures of illegally harvested *R. rosea* roots have been reported in the Russian Federation, with reported quantities increasing from c. 1.5 to 3.0 tonnes annually during the 2000s to 4.5 tonnes seized in 2018 and over 8 tonnes seized in 2019 (Gorny Altai News, 2020). Illegal trade in *Rhodiola* has also been reported in eastern Kazakhstan near the border with Xinjiang (Abitov, 2019) and in the Almaty region (Dysengulova, 2019), as well as in Kyrgyzstan (G. A. Lazkov *in litt.* to Bundesamt für Naturschutz (BfN), 2020). Illegal harvest in protected areas has been documented in Rila National Park (Bulgaria) (CITES MA of Bulgaria *in litt.* to Bundesamt für Naturschutz (BfN), 2021), Katunskiy Biosphere Reserve and Ust-Koksinsky District of SW Altai Republic (Russian Federation), and the UNESCO Great Altay Transboundary Biosphere Reserve (Russian Federation and Kazakhstan) (Ibisch, *et al.*, 2015). Some of this illegal activity has been noted to involve international crime organisations (Abitov, 2019).

Illegal harvest of *R. crenulata* in Bhutan was implied by Lakey and Dorji (2016), with reportedly well-organized networks of illegal medicinal plant traders operating at Bhutanese borders (at China and India) (Wangchuk *et al.*, 2009).

6.5 Actual or potential trade impacts

There are three factors to consider regarding potential impacts of trade on the long-term viability of *Rhodiola* populations:

Firstly, the genus is inherently vulnerable to overexploitation as a result of its slow growth rate, relatively low dispersal ability, and low rate of germination and seedling survival (see section 3.3). This vulnerability is compounded by the fact that harvest is destructive, with whole rhizomes or individual plants being taken. As most species are dioecious, there is also concern that unmanaged destructive harvest of stems and rhizomes may increase the distance between male and female plants, which could reduce pollination success in mountain areas where pollinators are scarce (Cunningham *et al.*, 2020). Commercial *Rhodiola* exploitation additionally focuses on the large, more commercially valuable, but reproductively mature individuals within populations, which produce the most seed (Cunningham *et al.*, 2020). Harvesting of these individuals is likely to have a disproportionate impact on recruitment and thus the viability of populations. As highlighted in section 4.4, there is evidence that large scale commercial harvesting can lead to dramatic population declines; quantitative estimates from certain areas in the Russian Federation, for example, documented declines for *R. rosea* of 76 per cent to 90 per cent over a period of 11–12 years in the late 1970s/early 1980s, primarily as a result of overharvesting. The species is currently categorised as threatened in 11 districts/republics/territories of the Russian Federation, with its population status in the principal harvesting area (the Altai Territory) considered to be uncertain. Similarly, accessible populations of *R. crenulata* in China have been reported to have been "significantly reduced" due to destructive harvesting (Lei *et al.*, 2006; Yuan *et al.*, 2018; Zhang *et al.*, 2018), and *R. crenulata* and *R. rosea* are both listed in threatened categories of China's Red Data Book (see section 4.4).

Secondly, the current market for *Rhodiola* relies on wild-sourced (rather than cultivated) plants (see section 8.4), and very little information is available regarding whether there are appropriate controls to manage harvest to sustainable levels (see section 8.1), despite indications that the volume of *Rhodiola* plants in trade is considerable (see section 6.2).

Thirdly, the market for *Rhodiola* products is undergoing rapid diversification and demand is expected to increase (see section 6.1).

Given these actual and potential trade impacts, management and monitoring measures to ensure that current and future trade in *Rhodiola* products is compatible with the survival of the species are needed. Alongside inclusion in Appendix II, additional complimentary measures could include third party voluntary certification of sustainable wild collection; increasing capacity for conventional cultivation through sustainable wild collection of seed; selective collection of small cuttings of male plants for tissue culture; vegetative propagation, and the development of wild cultivation techniques such as assisted production (see Cunningham *et al.*, 2020).

7. Legal instruments

7.1 National

Legislative measures to protect national populations of *R. rosea* and *R. crenulata* are in place in a number of range States, including China and the Russian Federation – these are outlined in Annex 5. The two species also occur in protected areas (see section 8.5). See also the summary of range country responses in Annex 3.

7.2 International

There are no known international instruments or controls in place that specifically relate to *Rhodiola* spp. to either protect or regulate the use of the species across international borders.

8. Species management

8.1 Management measures

No management plans could be located for any of the two most traded species, however there are a number of legal and habitat protection measures that regulate the harvest of *Rhodiola* species (see Annex 5).

***R. rosea*:** In the Russian Federation, Article 8.35 of the *Code of Administrative Offenses of the Russian Federation* 195 of 2001 (Government of the Russian Federation, 2001) regulates the collection and possession of rare and endangered animal and plant species listed in the Red Book of the Russian Federation. *Rhodiola rosea*'s Category 3b status means that transport across the customs border for export is restricted. However, materials harvested from populations in the Tuva Republic (southern Siberia), Altai Territory (western Siberia; bordering Republic of Altai and Kazakhstan), Krasnoyarsk Krai (Siberia), and Magadan Oblast (Far East Region) were reported to be specifically excluded from these provisions (Lyapustin *et al.*, 2013). In the Altai Territory, *R. rosea* had previously been categorized as a "resource plant" (legal to harvest) in the area's regional Red Book (Kamelin and Shmakov, 2006). Up until the 2019 (regional) decision to place *R. rosea* into Category 4 (status "Uncertain, requires monitoring") in the updated Red Book of the Altai Territory, it was reported that there had been no controls or monitoring (Katun-24-News, 2019).

There are examples of targeted management of the species reversing negative population trends. In southern Ural mountains (Republic of Bashkortostan, Russian Federation), for example, wild populations of *R. rosea* were previously threatened by extinction. Starting in 2001, Abramova and Muldashev (2008) successfully combined mass *ex situ* production of *R. rosea* in nurseries with reintroduction into natural habitats in 17 different populations in the Kurkak and Kuzgun-Tash mountains.

***R. crenulata*:** Aside from the protection outlined in Annex 5, and the presence of the species in protected areas outlined in section 8.5, it is unclear if any specific management measures or monitoring are implemented across the range of *R. crenulata*.

8.2 Population monitoring

See section 8.1.

8.3 Control measures

8.3.1 International

No control measures were identified.

8.3.2 Domestic

See section 8.1.

8.4 Captive breeding and artificial propagation

Large scale, commercially viable cultivation of ***R. rosea*** was recognised as essential to sustain future demand as early as the 1990s (Galambosi, 2006); the species is now being cultivated experimentally and sometimes commercially (albeit at a relatively small scale) in several countries including Bulgaria (Bozhilova, 2011; CITES MA of Bulgaria *in litt.* to Bundesamt für Naturschutz (BfN), 2021), Canada (Radford, 2020), China (Chengdu Tiandi Net Information Technology Ltd, 2018), Finland (Nordic Gene Bank, 2005; Galambosi and Galambosi, 2015), Germany (Hoppe, 2017), Italy (Istituto di servizi per il mercato agricolo alimentare, 2013), Latvia (J.A. Brinckmann *in litt.* to Bundesamt für Naturschutz (BfN), 2020), Lithuania (Kučinskaitė *et al.*, 2007), Moldova (Duca, 2011), Mongolia (Zimmermann and Dorjgotov, 2008), Norway (Nordic Gene Bank, 2005), Poland (Adamczak *et al.*, 2016), Russian Federation (Kauppinen *et al.*, 2012; Naturica Siberica, 2021), Slovenia (Jan, 2013), Sweden (Nordic Gene Bank, 2005), Switzerland (Vouillamoz *et al.*, 2012), the UK (Peschel *et al.*, 2016), the US (Illig, 2018; USDA, 2021), and possibly Kyrgyzstan (iCAP Investment, 2008).

Several other *Rhodiola* species are being cultivated experimentally in China (including *R. crenulata*, *R. fastigiata* and *R. kirilowii* (Chengdu Tiandi Net Information Technology Ltd, 2018)), however these are not yet commercially available. *Rhodiola sachalinensis* (which is considered a synonym of *R. rosea* in this proposal, according to Ohba (2003)) is reportedly cultivated extensively as a field crop in northeastern China, e.g. in Jilin Province (Bai *et al.*, 2012), and was reported to be among the two *Rhodiola* species cultivated in China that cover the largest planting area (the other being *R. angusta*) (Brinckmann *et al.*, 2021a, Cui *et al.,* 2015). Cultivation has been noted to be challenging due to low salidroside levels in cultivated plants, root rot, and leaf wilt (Yan *et al.*, 2004; Liu and Cheng, 2011; Bai *et al.*, 2012). Cultivation of high altitude *Rhodiola* species such as *R. crenulata* is also considered to be challenging due to its unique growing requirements (Lakey and Dorji, 2016).

8.5 Habitat conservation

Rhodiola spp. are found in several protected areas. ***Rhodiola rosea*** has been recorded in protected areas in Bulgaria (Bulgarian Academy of Sciences & Ministry of Environment and Water, 2011), Croatia (CITES SA of Croatia *in litt.* to Bundesamt für Naturschutz (BfN), 2020), Norway (Cuerrier *et al.,* 2014), and the Russian Federation (including the Baschelak State Nature Reserve, the Cascade of Waterfalls on the Shinok River Nature Reserve in the Altai Territory (Ministry of Natural Resources and Ecology of the Altai Region, 2021a, 2021b) and the Kurilsky State Nature Reserve (Ministry of Natural Resources and Ecology of the Russian Federation, 2021)). The current Global Snow Leopard and Ecosystem Protection (GSLEP) programme, to which 12 countries are signatories (Afghanistan, Bhutan, China, India, Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Pakistan, Russian Federation, Tajikistan and Uzbekistan), is an initiative also relevant to *R. rosea* (Charles *et al.*, 2016). In China, *R. sachalinensis* (which corresponds to populations in the provinces of Heilongjiang and Jilin, and which is a synonym of *R. rosea* according to Ohba (2003)) is listed as a key protected plant species occurring in the ecologically critical area (ECA) of broad-leaved Korean pine mixed forest in the Changbai Mountain Nature Reserve (CMNR) (Yu *et al.*, 2014).

Rhodiola crenulata has been recorded in Jigme Khesar Strict Nature Reserve (formerly Toorsa Strict Nature Reserve) in Bhutan (Wangdi and Sherub, 2013), the Wolong National Nature Reserve in China (Tan *et al.*, 2017), and within the Annapurna Conservation Area in Nepal (Joshi *et al.*, 2015).

8.6 Safeguards

The suggested Annotation #2 - All parts and derivatives except: a) seeds and pollen; and b) finished products packaged and ready for retail trade - addresses basic trade pattern in *Rhodiola*, in that it includes those products (raw material as well as semi-processed commodities, such as powder and bulk extracts exported for further processing in import countries) that first appear in international trade as exports of range States and that dominate the primary trade on the intenational level and cause the main demand for the wild resource (see also Annex 4). It is thus in accordance with the guiding principles provided in Resolution Conf. 11.21 (Rev. CoP18) on Use of annotations in Appendices I and II. Further on, unnecessary burden on CITES-Authorities around the world will be avoided by excluding finished products, which presumably occurs in small transactions and more fragmented than trade in raw and semi-processed specimens.

While international trade in finished products from range States still occurs, this is considered minor compared to trade in raw and semi-processed commodities. Final value-adding is not anticipated to increase in range States or to shift from importing countries to range States as a putative reaction of

Annotation #2, because in many instances production facilities would first have to be established but also due to specific consumer demands in importing countries for certain regional or domestic features, qualities and standards of finished *Rhodiola* products.

National legislation to protect the genus is in place in multiple range States, incl. in China as one of the current main export countries of *Rhodiola* products (see Annex 5).

9. Information on similar species

The identification of *Rhodiola* species in the field is hindered by morphological similarities and the unresolved taxonomy of the genus, with identification problems compounded as products are dried and processed (Cunningham ***et al.***, 2020). In China, *Rhodiola* are generally not traded at a species-specific level but are instead traded under three categories: “big flower” (da hua, which primarily corresponds to *R. crenulata*), “small flower” (xiao hua, which corresponds to a diversity of species) and “rose red” (meigui hong, which primarily corresponds to *R. rosea*) (Cunningham *et al.*, 2020). Traders are reported to generally be able to distinguish the three broad categories of *Rhodiola* trade names (Cunningham ***et al.***, 2020), but, as noted above, these categories do not correspond to discrete species.

The *Rhodiola* market is additionally thought to be diversifying (Bernard, 2016), and adulteration (or interchangeability) of products from the two main species with other *Rhodiola* spp. (as well as with each other) has been found to be relatively common (Bejar *et al.*, 2017; see Annex 1). For example, Xin *et al.* (2015) used DNA barcoding to show that, in China, only 40per cent of 36 samples of products labelled as *R. crenulata* were authentic, with the remainder consisting of *R. serrata*, *R. rosea*, and three other species. Booker *et al.* (2016a, 2016b) additionally found that commercial samples labelled as containing *R. rosea* frequently contained other species, particularly *R. crenulata*, as well as *R. serrata*.

Mixing of different species is thought to occur at an early stage of the supply chain (Cunningham *et al.*, 2020), thus presenting a challenge to enforcement if only a selection of few species is included in the CITES Appendices. In addition, the high rates of species interchangebility mean that there is a danger that harvesting pressure might readily shift to other species if only a subset is protected. For these reasons, it is important that the entire genus is included in Appendix II.

10. Consultations

A consultation will be distributed by the European Union to all other range States and responses will be summarized in Annex 3. A number of range States have provided preliminary views.

11. Additional remarks

12. References

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Annex 1a: Full list of accepted *Rhodiola* species, infraspecifics and synonyms according to Ohba (2003), their national red list status, known presence in international trade, and status as substitutes. In case species names or their synonyms (incl. the authority, respectively) have been provided in a different manner in POWO[5], IPNI[6], the GBIF taxonomic backbone[7] or the Flora of China (hereafter: FoC)[8] than in Ohba (2003), the name originally published in Ohba (2003) is provided in the table at first place, followed by the name(s) provided in the mentioned data bases in square brackets, in order to enable potential harmonization. Unless otherwise specified, information in the last three columns is from J. Brinckmann *in litt.* to Bundesamt für Naturschutz (BfN), 2020. LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered, DD = Data Deficient.

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
Rhodiola algida (Ledeb.) Fisch. & C.A.Mey.	*Chamaerhodiola algida* (Ledeb.) Nakai (1934) *Sedum algidum* var. *euphorbioides* (Schltdl. ex Ledeb.) Raym.-Hamet (1929) *Chamaerhodiola euphorbioides* (Schltdl. ex Ledeb.) Nakai (1934) *Sedum algidum* Ledeb. (1830) *Sedum algidum* var. *altaicum* Maxim. (1883) *Sedum algidum* var. *jeniseense* Maxim. (1883)	Mongolia Russian Federation: Republic of Khakassia Altai territory	Rare (1995) Cat. 4 - Status Uncertain (2012) Cat. 3 – Rare (2006)	Not known to occur.	Not known to occur.	Potentially a substitute of *R. crenulata* in China. Occurs in same areas as *R. rosea* in the Altai-Sayan Region (Russian Federation), so could be used as

5 *POWO (2022). Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet;* http://www.plantsoftheworldonline.org/ *Retrieved 24 February 2022.*

6 *IPNI (2021). International Plant Names Index. Published on the Internet http://www.ipni.org, The Royal Botanic Gardens, Kew, Harvard University Herbaria & Libraries and Australian National Botanic Gardens. Retrieved 24 February 2022*.

7 *GBIF.org (2022), GBIF Home Page. Available from: https://www.gbif.org Retrieved 24 February 2022.*

8 *eFloras (2008). Published on the Internet http://www.efloras.org Retrieved 24 February 2022*

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum euphorbioides Schltdl. ex Ledeb. (1843)	Republic of Altai Krasnoyarsk Territory	Cat. 3 – Rare (2017) Cat. 2 – Vulnerable (2012)			a substitute for *R. rosea*.
Rhodiola alsia (Fröd.) S.H.Fu *Rhodiola alsia* subsp. *alsia* *Rhodiola alsia* subsp. *kawaguchii* H.Ohba	*Sedum alsium* Fröd. (1942) *Sedum doratocarpum* Fröd. (1942)	People's Republic of China[9]	LC (2013)	Not known to occur. Mainly used in Xizang.	Not known to occur.	Reportedly used in Tibetan medicine as a substitute for other *Rhodiola* species, possibly including *R. crenulata* (Bejar *et al.*, 2017; Cuerrier *et al.*, 2014a).
Rhodiola amabilis (H.Ohba) H.Ohba	*Sedum amabile* H.Ohba (1976)					
Rhodiola angusta Nakai	*Rhodiola ramosa* Nakai (1914) *Rhodiola komarovii* Boriss. (1939)	China	NT (2013)	Not known to occur.	Not known to occur.	Not known to occur.

[9] *Hereafter referred to as China*

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum angustum (Nakai) Nemoto (*nom. illeg.*) *Sedum fenzelii* Fröd. (1936) *Sedum komarovii* (Boriss.) Chu (1959) *Sedum ohbae* Kozhevn. (1989)	Democratic People's Republic of Korea	NT (2005)			
Rhodiola atsaensis (Fröd.) H.Ohba	*Sedum atsaense* Fröd. (1943)	China	LC (2013)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola atuntsuensis (Praeger) S.H.Fu	*Chamaerhodiola atuntsuensis* (Praeger) Nakai (1934) *Rhodiola aporontica* (Fröderström) S.H.Fu (1965) *Rhodiola brevipetiolata* (Fröd.) S.H.Fu (1965) *Rhodiola concinna* (Praeger) S.H.Fu (1965) *Rhodiola nobilis* subsp. *atuntsuensis* (Praeger) H.Ohba (1982) *Rhodiola venusta* (Praeger) S.H.Fu (1965) *Sedum aporonticum* Fröd. (1944) [POWO/IPNI/GBIF: *Sedum aporonticum* Fröd. (1942)] *Sedum atuntsuense* Praeger (1921) *Sedum brevipetiolatum* Fröd. (1944) [POWO/IPNI/GBIF: *Sedum brevipetiolatum* Fröd. (1942)] *Sedum concinnum* Praeger (1921) *Sedum venustum* Praeger (1921)	China	EN based on criteria B1ab (i,iii); D (2017)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola bupleuroides (Wall. ex Hook.f. & Thomson) S.H.Fu	*Sedum bupleuroides* Wall. ex Hook.f. & Thomson (1858)	China	LC (2013)	Not known to occur.	Not known to occur.	Not known to occur.

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
Rhodiola bupleuroides var. *bupleuroides*	*Sedum cooperi* Praeger (1919) (*nom. illeg.*) *Sedum gorisii* Raym.-Hamet (1929)					
Rhodiola bupleuroides var. *parva* (Fröd.) H.Ohba	*Sedum bupleuroides* var. *parvum* Fröd. (1943)					
Rhodiola calliantha (H.Ohba) H.Ohba	*Sedum callianthum* H.Ohba (1974)	China	EN based on criteria D (2017)	Not known to occur.	Not known to occur.	Potentially a confounding material in the supply of *R. crenulata*.
Rhodiola chrysanthemifolia (H.Lév.) S.H.Fu	*Sedum chrysanthemifolium* H.Lév. (1931)	China	LC (2013)	Not known to occur.	Not known to occur.	Used in Tibetan medicine as a substitute for other *Rhodiola* species, possibly including *R. crenulata* (Bejar *et al.*, 2017; Cuerrier *et al.*, 2014a).
Rhodiola chrysanthemifolia subsp. *chrysanthemifolia*	*Rhodiola dielsiana* (H.Limpr.) S.H.Fu (1965) *Rhodiola ovatisepala* (Raym.-Hamet) S.H.Fu (1965) *Rhodiola ovatisepala* var. *chingii* S.H.Fu (1965) *Rhodiola trifida* (Wall. ex Hook.f. & Thomson) H.Jacobsen (1973) *Sedum dielsianum* H.Limpr. (1922) *Sedum linearifolium* var. *balfourii* (Raym.-Hamet) Raym.-Hamet (1913) *Sedum linearifolium* var. *dielsianum* (H.Limpr.) Raym.-Hamet (1926) *Sedum linearifolium* var. *forrestii* (Raym.-Hamet) Raym.-Hamet (1913) *Sedum linearifolium* var. *ovatisepalum* Raym.-Hamet (1926)					

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum ovatisepalum (Raym.-Hamet) H.Ohba (1975) *Sedum trifidum* Wall. ex Hook.f. & Thomson (1858) *Sedum trifidum* var. *balfourii* Raym.-Hamet (1912) *Sedum trifidum* var. *forrestii* Raym.-Hamet (1912)					
***Rhodiola chrysanthemifolia* subsp. *liciae* (Raym.-Hamet) H.Ohba**	*Rhodiola liciae* (Raym.-Hamet) S.H.Fu (1965) *Sedum liciae* Raym.-Hamet (1909)	China (*R. liciae*)	EN based on criteria B1ab(i,iii); C1; D (2017)			
Rhodiola chrysanthemifolia subsp. *sacra* (Raym.-Hamet) H.Ohba	*Rhodiola alterna* S.H.Fu (1979) *Rhodiola sacra* (Raym.-Hamet) S.H.Fu (1965) *Rhodiola sacra* var. *tsuiana* (S.H.Fu) S.H.Fu (1985) *Rhodiola tieghemii* (Raym.-Hamet) S.H.Fu (1965) *Rhodiola tsuiana* S.H.Fu (1965) *Sedum sacrum* (Raym.-Hamet) H.Ohba (1974) *Sedum linearifolium* var. *sacrum* Raym.-Hamet (1926) *Sedum linearifolium* var. *tieghemii* (Raym.-Hamet) Raym.-Hamet (1926) *Sedum tieghemii* Raym.-Hamet (1908)	China (*R. alterna*) China (*R. sacra* var. *sacra*)	CR based on criteria C1 (2017) VU based on criteria D1 (2017)			
***Rhodiola chrysanthemifolia* subsp. *sexfolia* (S.H.Fu) H.Ohba**	*Rhodiola sexfolia* S.H.Fu (1965) [POWO/IPNI/GBIF/FoC: *Rhodiola sexifolia* S.H.Fu (1965)]	China (*R. sexifolia*)	EN based on criteria B1ab(i,iii); C1; D			

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
[POWO/IPNI/GBIF: *Rhodiola chrysanthemifolia* subsp. *sexifolia* (S.H.Fu) H.Ohba]						
Rhodiola coccinea (Royle) Boriss.	*Sedum coccineum* Royle (1835) *Sedum quadrifidum* subsp. *coccineum* (Royle) Kozhevn. (1988)	China Russian Federation: Republic of Altai Tajikistan	LC (2013) Cat. 2 - Vulnerable (2017) VU (2020)	Not known to occur.	Not known to occur.	Substitution for *R. crenulata* is conceivable, due to the fact that it is the closest relative to *R. crenulata* (Zhu *et al.*, 2018) and is also used in Chinese medicine. However, no reports of this substitution have been documented.
Rhodiola coccinea subsp. *coccinea*	*Chamaerhodiola asiatica* (D.Don) Nakai (1934) *Rhodiola asiatica* D.Don (1825) *Rhodiola juparensis* (Fröd.) S.H.Fu (1965) *Sedum asiaticum* (D.Don) DC. (1828) [POWO: *Sedum asiaticum* (D.Don) Spreng. (1827)] *Sedum juparense* Fröd. (1935)					
***Rhodiola coccinea* subsp. *scabrida* (Franch.)** H.Ohba	*Chamaerhodiola scabrida* (Franch.) Nakai (1934) *Rhodiola likiangensis* (Fröd.) S.H.Fu (1965) *Rhodiola scabrida* (Franch.) S.H.Fu (1965) *Sedum brachystylum* Fröd. (1942) *Sedum likiangense* Fröd. (1935)					

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum scabridum Franch. (1896)					
Rhodiola crenulata (Hook.f. & Thomson) H.Ohba	*Rhodiola euryphylla* (Fröd.) S.H.Fu (1965) *Rhodiola megalophylla* (Fröd.) S.H.Fu (1965) *Rhodiola rotundata* (Hemsl.) S.H.Fu (1965) *Sedum bupleuroides* var. *rotundatum* (Hemsl.) Fröd. (1930) *Sedum crenulatum* Hook.f. & Thomson (1858) *Sedum euryphyllum* Fröd. (1931) *Sedum megalanthum* Fröd. (1935) *Sedum megalophyllum* Fröd. (1942) *Sedum rotundatum* Hemsl. (1896) *Sedum rotundatum* var. *oblongatum* C.Marquand & Shaw (1929)	China	EN based on criteria B1ab(iii) (2017)	See section 6.2 of the proposal	Known by "small flower *Rhodiola* species" as per local folk taxonomy in China. Potentially confounding species in the commercial supply of *R. crenulata* may include *R. rosea*, and other species including *R. calliantha*, *R. cretinii*, *R. dumulosa*, *R. heterodonta*, *R. kirilowii*, *R. linearifolia*, *R. quadrifida*, *R. robusta*, *R. sachalinensis*, and *R. serrata* (United States Pharmacopeial Convention, 2016).	Known to be misrepresented and traded as a substitute for *R. rosea* (Bejar *et al.*, 2017).

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
Rhodiola cretinii (Raym.-Hamet) H.Ohba	*Chamaerhodiola cretinii* (Raym.-Hamet) Nakai (1934) *Rhodiola crassipes* var. *cretinii* (Raym.-Hamet) H.Jacobsen (1973) *Sedum crassipes* var. *cretinii* (Raym.-Hamet) Fröd. (1930) *Sedum cretinii* Raym.-Hamet (1916) *Sedum wallichianum* var. *cretinii* (Raym.-Hamet) H.Hara (1966)	China	DD (2013)	Not known to occur.	Not known to occur.	Potentially confounding species in the commercial supply of *R. crenulata* (United States Pharmacopeial Convention, 2016).
Rhodiola cretinii subsp. *cretinii*						
Rhodiola cretinii subsp. *sino-alpina* (Fröd.) H.Ohba	*Rhodiola sino-alpina* (Fröd.) S.H.Fu (1965) *Sedum rosea* var. *sino-alpinum* Fröd. (1931)					
Rhodiola discolor (Franch.) S.H.Fu	*Sedum bupleuroides* var. *discolor* (Franch.) Fröd. (1930) *Sedum discolor* Franch. (1896)	China	NT (2013)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola dumulosa (Franch.) S.H.Fu	*Chamaerhodiola dumulosa* (Franch.) Nakai (1934) *Chamaerhodiola wulingensis* Nakai (1934) *Rhodiola dumulosa* fa. *farreri* (W.W.Sm.) H.Jacobsen (1973) *Rhodiola wulingensis* (Nakai) Kitag. (1979) *Sedum dumulosum* Franch. (1883) *Sedum dumulosum* var. *rendlei* (Raym.-Hamet) Fröd. (1930) *Sedum farreri* W.W.Sm. (1916) *Sedum rariflorum* N.E.Br. (1914) *Sedum rendlei* Raym.-Hamet (1913)	China	LC (2013)	Possibly as an adulterant or substitute species.	Not known to occur.	Potentially confounding species in the commercial supply of *R. crenulata* (United States Pharmacopeial Convention, 2016).

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum talihsiense Fröd. (1936) *Sedum wulingense* (Nakai) Kitag. (1939)					
Rhodiola fastigiata (Hook.f. & Thomson) S.H.Fu	*Chamaerhodiola fastigiata* (Hook.f. & Thomson) Nakai (1934) [IPNI: *Chamaerhodiola fastigiata* (Hook.f. & Thomson) Nakaiapud Nakai & Kitag. (1934)] *Sedum fastigiatum* Hook.f. & Thomson (1858) *Sedum quadrifidum* var. *fastigiatum* (Hook.f. & Thomson) Fröd. (1930)	China	LC (2013)	Possibly as an adulterant or substitute species.	Not known to occur.	Reportedly used as a substitute for both *R. crenulata* and *R. rosea* (Bejar *et al.*, 2017; Booker *et al.*, 2016; Xin *et al.*, 2015).
Rhodiola gelida Schrenk ex Fisch. & C.A.Mey.	*Chamaerhodiola gelida* (Schrenk ex Fisch. & C.A.Mey.) Nakai (1934) *Sedum dubium* Paulsen (1922) *Sedum gelidum* (Schrenk ex Fisch. & C.A.Mey.) Karelin & Kirilow (1842)	China Tajikistan	LC (2013) LC (2020)	Possibly as adulterant or substitute for *R. crenulata*.	Not known to occur.	*R. gelida* was identified to be one of four species represented as *R. crenulata* purchased at pharmacies and hospitals in China (Xin *et al.*, 2015).
Rhodiola handelii H.Ohba	*Sedum handelii* (H.Ohba) R.Stephenson (*nom. inval.*)	China	DD (2013)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola heterodonta (Hook.f. & Thomson) Boriss.	*Sedum heterodontum* Hook.f. & Thomson (1858) *Sedum rosea* var. *heterodontum* (Hook.f. & Thomson) Fröd. (1930)	China	LC (2013)	Possibly as an adulterant or substitute for *R. crenulata* in China (Bejar, *et al.*, 2017).	Possibly by *R. himalensis*, which shares the same common name in parts of India.	Potentially confounding species in the commercial supply of *R. crenulata* in China (United

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
				Harvested in Jammu & Kashmir for trade, but it is not known to what extent this trade is documented or legal (Rana and Rawat, 2019).		States Pharmacopeial Convention, 2016).
Rhodiola himalensis (D.Don) S.H.Fu	*Chamaerhodiola himalensis* (D.Don) Nakai (1934) *Sedum himalense* D.Don (1825) *Sedum quadrifidum* var. *himalense* (D.Don) Fröd. (1930)	India: Sikkim	NT (2017)	Traded in Bhutan. Illegal harvesting of *R. himalensis* in Nepal suggests that it is possibly in international trade as an adulterant or substitute.	Substitution may occur in Jammu & Kashmir, India, where it shares the same common name as *R. heterodonta* ("Dharber").	Reportedly used as a substitute for *R. crenulata* and/or *R. rosea* (Liu *et al.*, 2013; Zhang et al., 2015; Ruhsam and Hollingsworth, 2018; Zhu *et al.*, 2018). Possibly substituted for *R. heterodonta*, which shares the same common name in North-West India.
Rhodiola himalensis subsp. *bouvieri* (Raym.-Hamet) H.Ohba	*Chamaerhodiola bouvieri* (Raym.-Hamet) Nakai (1934) *Rhodiola bouvieri* (Raym.-Hamet) H.Ohba (1976) *Rhodiola himalensis* var. *bouvieri* (Raym.-Hamet) H. Jacobsen (1973) *Sedum bouvieri* Raym.-Hamet (1916) *Sedum quadrifidum* var. *bouvieri* (Raym.-Hamet) Fröd. (1930)					
Rhodiola himalensis subsp. *himalensis*	*Sedum coriaceum* Wall. ex Hook.f. & Thomson (1858)	China	LC (2013)			
Rhodiola himalensis subsp. *taohoensis* (S.H.Fu) H.Ohba	*Rhodiola taohoensis* S.H.Fu (1965) *Sedum himalense* subsp. *taohoense* (S.H.Fu) Kozhevn. (1989)	China	EN based on criteria B1ab(i,iii) (2017)			

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
Rhodiola hobsonii (Prain ex Raym.-Hamet) S.H.Fu	*Sedum hobsonii* Prain ex Raym.-Hamet (1913) *Sedum mirabile* H.Ohba (1974) *Sedum praegerianum* W.W.Sm. (1915)	China	EN based on criteria D (2017)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola hookeri S.H.Fu	*Rhodiola bhutanica* (Praeger) S.H.Fu (1965) *Sedum bhutanense* Praeger (1921) *Sedum bhutanicum* Praeger (1921) (*nom. illeg.*) *Sedum elongatum* Wall. ex Hook.f. & Thomson (1858) (*nom. illeg.*) *Sedum hookeri* N.P.Balakr. (1970) (*nom. illeg.*) *Sedum thomsonianum* H.Ohba (1973) (*nom. illeg.*)					
Rhodiola humilis (Hook.f. & Thomson) S.H.Fu	*Chamaerhodiola humilis* (Hook.f. & Thomson) Nakai (1934) *Rhodiola karpelesae* (Raym.-Hamet) S.H.Fu (1965) *Sedum barnesianum* Praeger (1921) *Sedum humile* Hook.f. & Thomson (1858) *Sedum karpelesae* Raym.-Hamet (1911) *Sedum levii* Raym.-Hamet (1909)	China	VU based on criteria B1ab(i,iii) (2017)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola imbricata Edgew.	*Sedum imbricatum* (Edgew.) Walp. (1848) *Sedum imbricatum* Hook.f. & Thomson (1858) (*nom. illeg.*)	India: Jammu & Kashmir Leh-Ledakh	 EN (2011) EN (2018)	Trade appears to be local or regional within India and Pakistan.	Not known to occur.	Not known to occur.

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
Rhodiola integrifolia Raf.	*Rhodiola rosea* subsp. *integrifolia* (Raf.) H.Hara (1952) *Rhodiola rosea* var. *integrifolia* (Raf.) Jeps. (1925) *Sedum integrifolium* (Raf.) A.Nelson (1909) *Sedum rhodiola* Torrey (1827) (*nom. illeg.*) *Sedum rhodioloides* Raf. (1832) *Sedum rosea* subsp. *integrifolium* (Raf.) Hultén (1945) *Sedum rosea* var. *integrifolium* (Raf.) A.Berger (1930) *Tolmachevia integrifolia* (Raf.) Á.Löve & D.Löve (1976)	Canada:	N5 - Secure (2015)	Not known to occur.	Not known to occur.	Possibly substituted for *R. rosea* in Canada (Cuerrier *et al.*, 2014b).
		Alberta	S3 – Vulnerable (2015)			
		British Columbia	S5 - Secure (2015)			
		Northwest Territories	S4 – Apparently Secure (2015)			
		Yukon Territory	S5 – Secure (2015)			
		United States of America	Status is reported under each subspecies, below			
Rhodiola integrifolia subsp. *integrifolia*	*Rhodiola alaskana* Rose (1903) *Rhodiola atropurpurea* (Turcz.) Trautv. & C.A.Mey. (1856) *Rhodiola borealis* Boriss. (1939) *Rhodiola caespitosa* (Ledeb.) Nakai (1938) *Rhodiola caespitosa* fa. *humilis* (Regel & Tiling) Nakai (1938) *Rhodiola caespitosa* fa. *involucrata* (Regel & Tiling) Nakai (1938)	United States of America:				
		South Dakota	S1 – Critically Imperilled (2020)			
		Wyoming	S3 – Vulnerable (2020)			

Species	Synonyms in albhabetical order	Conservation status	International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Rhodiola caespitosa fa*. lanceolata* (Regel & Tiling) Nakai (1938)				
	Rhodiola caespitosa fa*. ovata* (Regel & Tiling) Nakai (1938)				
	Rhodiola polygama (Rydb.) Britton & Rose (1903)				
	Rhodiola rosea subsp. *atropurpurea* (Turcz.) H.Jacobsen (1973)				
	Rhodiola rosea subsp. *borealis* (Boriss.) A.P.Khokhr. & Kurajev (1992) [POWO/IPNI/GBIF: *Rhodiola rosea* subsp. *borealis* (Boriss.) A.P.Khokhr. & Kuvaev (1992)]				
	Rhodiola rosea subsp. *polygama* (Rydb.) H.Jacobsen (1973)				
	Rhodiola rosea var. *alaskana* (Rose) H.Jacobsen (1973)				
	Sedum alaskanum (Rose) J.K.Henry (1915)				
	Sedum atropurpureum Turcz. (1840)				
	Sedum atropurpureum var. *caespitosum* Ledeb. (1843)				
	Sedum frigidum Rydb. (1901)				
	Sedum integrifolium var. *atropurpureaum* (Turcz.) R.Stephenson (1994) (*nom. inval.*)				
	Sedum polygamum Rydb. (1901)				
	Sedum rhodiola var. *atropurpureum* (Turcz.) Maxim. (1883)				
	Sedum rhodiola var. *humile* Regel & Tiling (1858)				
	Sedum rhodiola var. *involucratum* Regel & Tiling (1858)				
	Sedum rhodiola var. *lanceolatum* Regel & Tiling (1858)				

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum rhodiola var. *ovatum* Regel & Tiling (1858) *Sedum rhodiola* var. *tenuifolium* Regel & Tiling (1858) *Sedum rosea* var. *alaskanum* (Rose) A.Berger (1930) *Sedum rosea* var. *aleuticum* Fröd. (1937) [POWO/IPNI: *Sedum rosea* var. *aleuticum* Fröd. ex Hultén (1937)] *Sedum rosea* var. *atropurpureum* (Turcz.) Praeger (1921) *Sedum rosea* var. *frigidum* (Rydb.) Hultén (1945) [IPNI: *Sedum rosea* subsp. *frigidum* (Rydb.) Hultén (1945)] *Sedum rosea* var. *polygamum* (Rydb.) Fröd. (1930) *Tolmachevia atropurpurea* (Turcz.) Á.Löve & D.Löve (1976)					
Rhodiola integrifolia subsp. *leedyi* (Rosend. & J.W.Moore) H.Ohba (The name *Rhodiola integrifolia* subsp. *leedyi* (Rosend. & J.W.Moore) Moran, originally listed in Ohba (2003), is an isonym published in 2001, whereas the name by Ohba was already published in 1999)	*Sedum integrifolium* subsp. *leedyi* (Rosendahl & J.W.Moore) R.T.Clausen (1975) *Sedum rosea* var. *leedyi* Rosend. & J.W.Moore (1947) *Tolmachevia integrifolia* subsp. *leedyi* (Rosend. & J.W.Moore) Á.Löve & D.Löve (1985)	United Sates of America	Threatened (1992)[10]			
		Minnesota	EN**Error! Bookmark not defined.**			
		New York	EN**Error! Bookmark not defined.**			

10 *US Fish & Wildlife Service – Division of Scientific Authority* in litt*. to Bundesamt für Naturschutz (BfN), 2022*

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
Rhodiola integrifolia subsp. *neomexicana* (Britton) H.Ohba	*Rhodiola neomexicana* Britton (1903) *Rhodiola rosea* subsp. *neomexicana* (Britton) H.Jacobsen (1973) *Sedum integrifolium* subsp. *neomexicanum* (Britton) R.T.Clausen (1975) *Sedum rosea* var. *neomexicanum* (Britton) A.Berger (1930) *Tolmachevia integrifolia* subsp. *neomexicana* (Britton) Á.Löve & D.Löve (1985)	United Sates of America	N2 - Imperilled (2020)			
Rhodiola integrifolia subsp. *procera* (R.T.Clausen) H.Ohba	*Sedum integrifolium* subsp. *procerum* R.T.Clausen (1975) *Tolmachevia integrifolio* subsp. *procera* (R.T.Clausen) Á.Löve & D.Löve (1985)	The USA does not currently recognize this subspecies as a distinct taxon, as per the Flora of North America. Instead, it is considered a synonym of *R. integrifolia* subsp. *integrifolia*.				
***Rhodiola ishidae* (Miyabe & Kudô) H.Hara**	*Rhodiola himalensis* var. *ishidae* (Miyabe & Kudô) H.Jacobsen (1973) *Rhodiola stephanii* var. *hondoensis* Nakai (1938) *Rhodiola stephanii* var. *longifolia* Nakai (1938) *Sedum ishidae* Miyabe & Kudô (1921)	Russian Federation Sakhalin region	Cat. 3d - Rare (2019)	Not known to occur.	Not known to occur.	Not known to occur.

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
***Rhodiola junggarica* Chang Y.Yang & N.R.Cui ex Chang Y.Yang**		China	DD (2013)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola kaschgarica Boriss.		China	CR based on criteria C1 (2017)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola kirilowii (Regel) Regel & Maxim. [POWO/GBIF/FoC: *Rhodiola kirilowii* (Regel) Maxim.; IPNI: *Rhodiola kirilowi* Regel ex Maxim.]	*Rhodiola kirilowii* var. *rubra* (Praeger) H.Jacobsen (1973) *Rhodiola linearifolia* Boriss. (1939) *Rhodiola longicaulis* (Praeger) S.H.Fu (1965) *Rhodiola macrolepis* (Franch.) S.H.Fu (1965) *Rhodiola robusta* (Praeger) S.H.Fu (1965) *Sedum kirilowii* Regel (1858) *Sedum kirilowii* cv. *Rubrum* (s.a.) *Sedum kirilowii* var. *altum* Fröd. (1924) *Rhodiola kirilowii* var. *latifolia* S.H.Fu (1965)*Sedum macrolepis* Franch. (1885) *Sedum kirilowii* var. *linifolium* Regel & Schmalh. (1878) *Sedum kirilowii* var. *rubrum* Praeger (1921) *Sedum longicaule* Praeger (1917) *Sedum robustum* Praeger (1917) [POWO/IPNI/GBIF: *Sedum robustum* Praeger (1921)] *Sedum rosea* fa. *kirilowii* (Regel) Thell. & Zimm. (1916)	China	LC (2013)	Internationally, online retailers have been identified (in Canada, UK, and US) that offer herbal supplements from *R. kirilowii*. Trade of this species, may also occur from China to international buyers through e-commerce in medicines containing *R. kirilowii* extracts. Quantitative data on international trade are not currently available.	Possibly substituted by *R. wallichiana* var. *cholaensis*, with which it is mixed and used interchangeably.	Listed as one of several potential confounding materials in the supply of official *R. crenulata* (United States Pharmacopeial Convention, 2016). Possibly substituted for *R. wallichiana* var. *cholaensis*, as the two species are mixed and used interchangeably.

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
Rhodiola litwinowii Boriss.		China Kyrgyzstan	DD (2013) LC (2005)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola lobulata (N.B.Singh & U.C.Bhattach.) H. Ohba	*Rhodiola imbricata* var. *lobulata* N.B.Singh & U.C.Bhattach. (1985)					
Rhodiola ludlowii H.Ohba	*Sedum ludlowii* (H.Ohba) Kozhevn. (1989)					
***Rhodiola macrocarpa* (Praeger) S.H.Fu**	*Chamaerhodiola eurycarpa* (Fröd.) Nakai (1934) *Rhodiola eurycarpa* (Fröd.) S.H.Fu (1965) *Sedum eurycarpum* Fröd. (1924) *Sedum macrocarpum* Praeger (1921) *Sedum progressum* Diels (1930)	China	LC (2013)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola marginata Grierson		Bhutan	LC (2017)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola nepalica (H.Ohba) H.Ohba	*Sedum nepalicum* H.Ohba (1974)			Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola nobilis (Franch.) S.H.Fu	*Chamaerhodiola horrida* (Praeger) Nakai (1934) *Chamaerhodiola nobilis* (Franch.) Nakai (1934) *Sedum horridum* Praeger (1921) *Sedum nobile* Franch. (1896)	China	VU based on criteria A2c (2017)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola pachyclados (Aitch. & Hemsl.) H.Ohba	*Rhodiola primuloides* var. *pachyclados* (Aitch. & Hemsl.) H.Jacobsen (1973)					

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum pachyclados Aitch. & Hemsl. (1880)					
Rhodiola pamiroalaica Boriss.	*Sedum pamiroalaicum* (Boriss.) C.-A.Jansson (1970)	China Tajikistan	LC (2013) LC (2020)	Not known to occur.	Possibly substituted by *R. rosea* in Kyrgyzstan as both species share habitat, are very similar in appearance, and are collected for preparation of medicines (Keusgen, 2018).	Possibly substituted for *R. rosea* in Kyrgyzstan as both species share habitat, are very similar in appearance, and are collected for preparation of medicines (Keusgen, 2018).
Rhodiola prainii (Raym.-Hamet) H.Ohba	*Sedum apiculatum* Craib ex Raym.-Hamet (1929) (*nom. inval.*) *Sedum prainii* Raym.-Hamet (1909) *Sedum stewartii* Craib ex Raym.-Hamet (1929) (*nom. inval.*)	China	EN based on criteria B1ab(i,iii); C1 (2017)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola primuloides (Franch.) S.H.Fu	*Sedum primuloides* Franch. (1896)			Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola primuloides subsp. *kongboensis* H.Ohba		China	DD (2013)			
Rhodiola primuloides subsp. *primuloides*	*Rhodiola pleurogynantha* (Hand.-Mazz.) S.H.Fu (1965) *Sedum pleurogynanthum* Hand.-Mazz. (1922)	China	DD (2013)			

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum primuloides var. *pleurogynanthum* (Hand.-Mazz.) Fröd. (1930)					
Rhodiola *purpureoviridis* (Praeger) S.H.Fu	*Sedum bupleuroides* var. *purpureoviride* (Praeger) Fröderström (1930) *Sedum purpureoviride* Praeger (1917)			Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola purpureoviridis subsp. *phariensis* (H.Ohba) H.Ohba	*Rhodiola phariensis* (H.Ohba) S.H.Fu (1980) *Sedum phariense* H.Ohba (1973)	China	DD (2013)			
R. purpureoviridis subsp. *purpureoviridis*		China	LC (2013)			
Rhodiola quadrifida (Pall.) Fisch. & C.A.**Mey.**	*Chamaerhodiola quadrifida* (Pall.) Nakai (1934) *Kirpicznikovia quadrifida* (Pall.) Á.Löve & D.Löve (1976) *Rhodiola quadrifida* var. *major* Fisch. & C.A.Mey. (1841) *Rhodiola quadrifida* var. *minor* Fisch. & C.A.Mey. (1841) *Sedum quadrifidum* Pall. (1776)	China	LC (2013)	Possibly, as an adulterant or substitute for *R. crenulata* or *R. rosea* in China.	Possibly by *R. rosea*, as both species are used in Mongolian medicine.	Possibly for *R. rosea* in Mongolia and the Russian Federation. In China, it is a substitute for *R. rosea* (Bejar *et al.*, 2017) and also a confounding species in the commercial supply of *R. crenulata* (United States Pharmacopeial
		Russian Federation:				
		Irkutsk Region	Cat. 2 – Vulnerable (2010)			
		Krasnoyarsk Territory	Cat. 2 – Vulnerable (2012)			
		Magadan Region	Cat. 3 – Rare (2019)			
		Republic of Altai	Cat. 3 – Rare (2017)			

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
		Republic of Sakha	Cat. 3 – Rare (2017)			Convention, 2016). *R. quadrifida* has also been identified as one of four species represented as *R. crenulata* purchased at pharmacies and hospitals in China (Xin *et al.*, 2015).
*Rhodiola recticauli*s Boriss.	*Sedum recticaule* (Boriss.) Wendelbo (1952)	China	DD (2013)	Not known to occur.	Not known to occur.	Not known to occur.
		Tajikistan	LC (2020)			
Rhodiola rhodantha (A.Gray) H.Jacobsen	*Clementsia rhodantha* (A.Gray) Rose (1903) *Sedum rhodanthum* A.Gray (1862)	United States of America:		Not known to occur.	Not known to occur.	Not known to occur.
		Utah	S2 – Imperilled (2020)			
		Wyoming	S4 – Apparently Secure (2020)			
Rhodiola rosea L.	*Rhodiola arctica* Boriss. (1939) *Rhodiola elongata* (Ledeb.) Fisch. & C.A.Mey. (1841) *Rhodiola hideoi* Nakai (1938)	Austria	EN (1999)	See section 6.2 of the proposal	*R. crenulata* and other *Rhodiola* species (Bejar *et al.*, 2017).	Reportedly used as a substitute for *R. crenulata* (Liu *et al.*, 2013;
		Bosnia & Herzegovina	VU (2014)			

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Rhodiola iremelica Boriss. (1939) *Rhodiola krivochizhinii* Sipliv. (1974) *Rhodiola lapponica* Gand. (1886) (*nom. inval.*) *Rhodiola maxima* Nakai (1938) *Rhodiola minor* Mill. (1768) *Rhodiola odora* Salisb. (1796) *Rhodiola odorata* Lam. (1778) *Rhodiola roanensis* (Britton) Britton (1903) [IPNI: *Rhodiola roanensis* Britton (1903)] *Rhodiola rosea* subsp. *arctica* (Boriss.) Á.Löve (1961) *Rhodiola rosea* subsp. *elongata* (Ledeb.) H.Jacobsen (1973) *Rhodiola rosea* subsp. *krivochizhinii* (Sipliv.) S.B.Gontch. (1999) *Rhodiola rosea* subsp. *roanensis* (Britton) H.Jakobsen (1973) *Rhodiola rosea* subsp. *sachalinensis* (Boriss.) S.B.Gontch. (1999) *Rhodiola rosea* subsp. *tachiroei* (Franch. & Sav.) H.Jacobsen (1973) *Rhodiola rosea* var. *microphylla* (Fröd.) S.H.Fu (1965) *Rhodiola rosea* var. *oblonga* (Regel & Tiling) H.Hara (1937) *Rhodiola rosea* var. *scopolii* (A.Kern. ex Simonk.) Soó (1974) *Rhodiola rosea* var. *tachiroei* (Franch. & Sav.) H.Hara ex Honda (1957) (*nom. inval.*)	Bulgaria	CR (2001)		Other *R. rosea* products have been found to contain *R. himalensis* (Ruhsam and Hollingsworth, 2018).	United States Pharmacopeial Convention, 2016).
		Canada:	N5 – Secure (2015)			
		Labrador	S4-S5 – Apparently Secure to Secure (2015)			
		New Brunswick	S3 – Vulnerable (2015)			
		Newfoundland	S4-S5 – Apparently Secure to Secure (2015)			
		Nova Scotia	S4 – Apparently Secure (2015)			
		Quebec	S4 - Apparently Secure (2015)			
		China *(R. rosea* f. *purpurascens & R. rosea* var. *microphylla)*	LC (2013)			

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Rhodiola rosea var. *vulgaris* (Regel & Tiling) H.Hara (1937) *Rhodiola sachalinensis* Boriss. (1939) *Rhodiola scopolii* A.Kern. ex Simonk. (1887) *Rhodiola sibirica* Sweet (1839) *Rhodiola tachiroei* (Franch. & Sav.) Nakai (1938) *Rhodiola telephioides* (Maxim.) S.H.Fu (1980) *Sedum altaicum* G.Don (1834) *Sedum arcticum* (Boriss.) Rønning (1959) *Sedum caerulans* H.Lév. & Vaniot (1904) *Sedum elongatum* Ledeb. (1830) *Sedum rhodiola* DC. (1805) *Sedum rhodiola* subvar. *continentale* Maxim. (1883) *Sedum rhodiola* var. *crispum* Regel & Tiling (1858) *Sedum rhodiola* var. *elongatum* (Ledeb.) Maxim. (1883) *Sedum rhodiola* var. *latifolium* Regel & Tiling (1858) *Sedum rhodiola* var. *lingulatum* Regel & Tiling (1858) *Sedum rhodiola* var. *linifolia* Regel & Schmalh. (1878) *Sedum rhodiola* var. *oblongum* Regel & Tiling (1858) *Sedum rhodiola* var. *scopolii* (A.Kern. ex Simonk.) Rouy & Camus (1901)	China *(R. rosea* var. *rosea)*	VU based on criteria B1ab(iii) (2017)			
		China *(R. sachalinensis)*	VU based on criteria B1ab(i,iii); D1 (2017)			
		Czech Republic	CR (2012)			
		Democratic People's Republic of Korea *(R. elongata)*	NT (2005)			
		Finland	LC (2019)			
		France:	LC (2019)			
		Alsace	CR (2014)			
		Aquitaine	VU (2018)			
		Midi-Pyrénées	LC (2013)			

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum rhodiola var. *tachiroei* Franch. & Sav. (1878)	Rhône-Alpes	LC (2015)			
	Sedum rhodiola var. *viride* Regel & Tiling (1858)	Germany	Threatened (2018)			
	Sedum rhodiola var. *vulgare* Regel & Tiling (1858)					
	Sedum roanense Britton (1903)	Denmark				
	Sedum rosea (L.) Scop. (1771)					
	Sedum rosea subsp. *arcticum* (Boriss.) Kozhevn. (1989)	Greenland	LC (2018)			
	Sedum rosea subvar. *continentale* (Maxim.) Maxim. ex A.Berger (1930)	Iceland	LC (2018)			
	Sedum rosea var. *elongatum* (Ledeb.) Praeger (1921)	Ireland	LC (2016)			
	Sedum rosea var. *microphyllum* Fröd. (1938)	Kazakhstan	Included, but classification unknown			
	Sedum rosea var. *roanense* (Britton) A.Berger (1930)					
	Sedum rosea var. *tachiroei* (Franch. & Sav.) Praeger (1921)	Mongolia	VU based on criteria A1acd (2018)			
	Sedum rosea var. *vulgare* (Regel & Tiling) Maxim. ex Praeger (1921)					
	Sedum sachalinense (Boriss.) Vorosch. (1966)	Norway	LC (2015)			
	Sedum subopposítum var. *telephioides* Maxim. (1883)					
	Tolmachevia krivochizhinii (Sipliv.) Á.Löve & D.Löve (1976)	Russia:	Cat.3b – Rare & small population (2017)			
		Altai Territory	Cat.4 – Uncertain (2019)			

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
		Arkhangelsk Region	Cat.2 – Vulnerable (2008)			
		Chelyabinsk region	Cat.1 – CR (2017)			
		Chukchi Autonomous District	Cat.4 – Uncertain status (2008)			
		Irkutsk Region	Cat.2 – Vulnerable (2010)			
		Kamchatka Territory	Cat.2 – Vulnerable (2018)			
		Kemerovo Region	Cat.3 – Rare (2012)			
		Khanty-Mansiysky Autonomous District	Cat.3 – Rare (2013)			
		Murmansk Region	Cat.3 – Rare (2020)			

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
		Nenets Autonomous District	Cat.2 – Vulnerable (2006)			
		Perm Territory	Cat.2 – Vulnerable (2008)			
		Republic of Altai	Cat.2 – Vulnerable (2017)			
		Republic of Khakassia	Cat.2 – Vulnerable (2012)			
		Republic of Komi	Cat. 3 – Rare (2019)			
		Republic of Sakha	Cat.2 – Vulnerable (2017)			
		Sakhalin Region	Cat. 3b – Rare & small population (2019)			
		Trans-Baikal Territory	Cat. 3 – Rare (2017)			

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
		Tyumen Region	Cat.2 – Vulnerable (2004)			
		Yamalo-Nenetsky Autonomous District	Cat.2 – Vulnerable (2010)			
		Slovakia	LC (2015)			
		Switzerland	LC (2016)			
		Ukraine	VU (2012)			
		United Kingdom of Great Britain and Northern Ireland	LC (2014)			
		United States of America:				
		Maine	Vulnerable to Secure (2019)			
		New York	Endangered (2019)			
		North Carolina	Endangered (2019)			

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
			Possibly extirpated			
		Pennsylvania	Endangered (2019)			
		Vermont	Threatened (2019)			
Rhodiola saxifragoides (Fröd.) H.Ohba	*Sedum saxifragoides* Fröd. (1936)	Pakistan	VU (2001)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola semenovii (Regel & Herder) Boriss.	*Clementsia semenovii* (Regel & Herder) Boriss. (1969) *Cotyledon semenovii* (Regel & Herder) O.Fedtsch. & B.Fedtsch. (1909) *Rhodiola kansuensis* (Fröd.) S.H.Fu (1965) *Sedum semenovii* (Regel & Herder) Mast. (1878) *Sedum semenovii* var. *kansuense* Fröd. (1938) *Umbilicus linearifolius* Franch. (1883) *Umbilicus linifolius* Ost.-Sack. & Rupr. (1869) [POWO/IPNI: *Umbilicus linifolius* Rupr. (1869)] *Umbilicus semenovii* Regel & Herder (1866)	China (*R. kansuensis*)	CR based on criteria B1ab(i,iii); C1; D (2017)	Not known to occur.	Not known to occur.	Reportedly used interchangeably with *R. crenulata*, *R. heterodonta*, *R. kirilowii*, and *R. quadrifida* in China and other parts of Asia.
Rhodiola serrata H.Ohba	*Sedum serratum* (H.Ohba) Kozhevn. (1989)	China	LC (2013)	As an adulterant or substitute for *R. crenulata* or *R. rosea*.	Not known to occur.	Potentially found as an adulterant or substitute for *R. rosea* (Bejar *et*

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
						al., 2017) and as a confounding species in the commercial supply of *R. crenulata* (United States Pharmacopeial Convention, 2016). *R. serrata* was also identified as one of four species represented as *R. crenulata* purchased at pharmacies and hospitals in China (Xin *et al.*, 2015).
Rhodiola sherriffii H.Ohba	*Sedum sherriffii* (H.Ohba) Kozhevn. (1989)	China	EN based on criteria D (2017)	Not known to occur.	Not known to occur.	Not known to occur.
***Rhodiola sinuata* (Royle ex Edgew.)** S.H.Fu	*Rhodiola fui* Boriss. (1969) *Rhodiola linearifolia* (Royle) S.H.Fu (1956) (*nom. illeg.*) *Sedum garwalicum* Fröd. (1942) *Sedum linearifolium* Royle (1835) *Sedum linearifolium* var. *genuinum* Raym.-Hamet (1926) (*nom. inval.*)	China	LC (2013)	Not known to occur.	Not known to occur.	Not known to occur.

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum linearifolium var. *pauciflorum* (Edgew.) C.B.Clarke (1878) *Sedum linearifolium* var. *sinuatum* (Royle ex Edgew.) Raym.-Hamet (1926) *Sedum mucronatum* Edgew. (1846) *Sedum pauciflorum* Edgew. (1846) *Sedum sinuatum* Royle ex Edgew. (1846)					
Rhodiola smithii (Raym.-Hamet) S.H.Fu	*Rhodiola sangpo-tibetana* (Fröd.) S.H.Fu (1965) *Sedum chumbicum* Prain ex Raym.-Hamet (1929) (*nom. inval.*) *Sedum sangpo-tibetanum* Fröd. (1937) *Sedum smithii* Raym.-Hamet (1913)	China	VU based on criteria D1 (2017)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola staminea (Paulsen) S.H.Fu	*Sedum stamineum* Paulsen (1922)			Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola stapfii (Raym.-Hamet) S.H.Fu	*Sedum stapfii* Raym.-Hamet (1913)	China	LC (2013)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola stephanii (Cham.) Trautv. & C.A.Mey. [POWO: *Rhodiola stephani* (Cham.) Trautv. & C.A.Mey.; IPNI: *Rhodiola stephani* Trautv. & C.A.Mey.]	*Chamaerhodiola stephanii* (Cham.) Nakai (1934) [POWO/IPNI: *Chamaerhodiola stephani* (Cham.) Nakai (1934)] *Rhodiola crassipes* var. *stephanii* (Cham.) H.Jacobsen (1973) [POWO: *Rhodiola crassipes* var. *stephani* (Cham.) H.Jacobsen (1973)] *Rhodiola krylovii* Polozhij & Revjakina (1979) *Rhodiola pinnatifida* Boriss. (1939) *Sedum crassipes* var. *stephanii* (Cham.) Fröd. (1930)	China	NT (2013)	Not known to occur.	Not known to occur.	Not known to occur.

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum dentatum Steph. ex Cham. (1831) (*nom. inval.*) *Sedum pinnatifidum* (Boriss.) Kozhevn. (1989) *Sedum stephanii* Cham. (1831) [POWO/IPNI: *Sedum stephani* Cham. (1831)]					
Rhodiola subopposita (Maxim.) H.Jacobsen	*Sedum subopposita* Maxim. (1883)	China	DD (2013)	Not known to occur.	Not known to occur.	Not known to occur.
Rhodiola tangutica (Maxim.) S.H.Fu	*Rhodiola algida* var. *tangutica* (Maxim.) S.H.Fu (1980) *Rhodiola gannanica* K.T.Fu (1991) *Sedum algidum* var. *tanguticum* Maxim. (1883)	China China (*R. gannanica*)	VU based on criteria B1ab(i,iii); D1 (2017) EN based on criteria D (2017)	Possibly as an adulterant or substitute for *R. crenulata* or *R. rosea* in China.	Not known to occur.	Likely traded as one of 18 "small flower" *Rhodiola* species used as substitutes for *R. rosea*, *R. sachalinensis*, and *R. crenulata* (Cunningham *et al.*, 2020).
Rhodiola tibetica (Hook.f. & Thomson) S.H.Fu	*Chamaerhodiola stracheyi* (Hook.f. & Thomson) Nakai (1934) *Chamaerhodiola tibetica* (Hook.f. & Thomson) Nakai (1934) *Sedum quadrifidum* var. *tibeticum* (Hook.f. & Thomson) Fröd. (1930) *Sedum stracheyi* Hook.f. & Thomson (1858) *Sedum tibeticum* Hook.f. & Thomson (1858) *Sedum tibeticum* var. *strachyei* (Hook.f. & Thomson) C.B.Clarke (1878)	China	EN based on criteria D (2017)	Not known to occur.	Not known to occur.	Not known to occur.

Species	Synonyms in albhabetical order	Conservation status		International Trade?	Species substituted by other species?	Species is used as substitute for other species?
Rhodiola wallichiana (Hook.f.) S.H.Fu	*Chamaerhodiola crassipes* (Wall. ex Hook.f. & Thomson) Nakai (1934) *Rhodiola crassipes* (Wall. ex Hook.f. & Thomson) Boriss. (1939) *Rhodiola crassipes* var. *choloensis* (Praeger) H.Jacobsen (1973) *Rhodiola wallichiana* var. *cholaensis* (Praeger) S.H.Fu (1965) *Sedum asiaticum* C.B.Clarke ex Hook.f. (1878) (*nom. illeg.*) *Sedum crassipes* var. *cholaense* Praeger (1919) *Sedum crassipes* Wall. ex Hook.f. & Thomson (1858) *Sedum wallichianum* Hook. (1844)	China	LC (2013)	Potentially traded as an adulterant or substitute for *R. crenulata*, *R. kirilowii*, or *R. rosea*.	Substitution by *R. kirilowii* possible in China. From 1977 to 1985, the *Rhodiola* monograph of the Pharmacopoeia of the People's Republic of China listed the common name for *R. kirilowii* as "Dazhu", which is the Chinese name for a variety of *R. wallichiana* (Tao *et al.*, 2019).	Because of the historical confusion between *R. kirilowii* and *R. wallichiana*, the potential appears to exist for *R. wallichiana* to be found as a substitute for *R. crenulata* or *R. rosea*. Despite having larger flowers, it is also possible that *R. wallichiana* is in the "small flower" hong jing tian trade category.
Rhodiola yunnanensis (Franch.) S.H.Fu *Rhodiola yunnanensis* subsp. *forrestii* (Raym.-Hamet) H.Ohba	*Sedum yunnanense* Franch. (1896) *Rhodiola forrestii* (Raym.-Hamet) S.H.Fu (1965) *Rhodiola papillocarpa* (Fröd.) S.H.Fu (1965) *Rhodiola yunnanensis* var. *forrestii* (Raym.-Hamet) H.Jacobsen (1973)	China	LC (2013)	As an adulterant or substitute for the official species, *R. crenulata* and *R. rosea* in China.	Not known to occur.	Potentially a confounding species in the commercial supply of *R. rosea* (United States Pharmacopeial Convention,

Species	Synonyms in albhabetical order	Conservation status	International Trade?	Species substituted by other species?	Species is used as substitute for other species?
	Sedum yunnanense var. *forrestii* Raym.-Hamet (1912) *Sedum yunnanense* var. *muliense* Fröd. (1936) (*nom. inval.*) *Sedum yunnanense* var. *oblanceolatum* Fröd. (1936) (*nom. inval.*) *Sedum yunnanense* var. *papillocarpum* Fröd. (1936) (*nom. inval*.) *Sedum yunnanense* var. *strictum* Fröd. (1936) (*nom. inval.*)				2014). One of the species included in the broad "small flower" trade category xiao hua hong jing tian.
Rhodiola yunnanensis subsp. *yunnanensis*	*Rhodiola henryi* (Diels) S.H.Fu (1965) *Rhodiola rotundifolia* (Fröd.) S.H.Fu (1965) *Rhodiola sinica* (Diels) H.Jacobsen (1973) *Rhodiola yunnanensis* var. *henryi* (Diels) H.Jacobsen (1973) *Rhodiola yunnanensis* var. *valerianoides* (Diels) H.Jacobsen (1973) *Sedum henryi* Diels (1900) *Sedum mengtzeanum* Ulbrich ex Raym.-Hamet (1929) *Sedum sinicum* Diels (1900) *Sedum valerianoides* Diels (1900) *Sedum yunnanense* var. *henryi* (Diels) Raym.-Hamet (1929) *Sedum yunnanense* var. *oxyphyllum* Fröd. (1942) *Sedum yunnanense* var. *rotundifloium* Fröd. (1936) (*nom. inval.*) *Sedum yunnanense* var. *valerianoides* (Diels) Raym.-Hamet (1912)				

Annex 1b: Common names of the two most traded *Rhodiola* species, *R. crenulata* and *R. rosea* (including its synonym *R. sachalinensis*).

Species	Language	Common and Traded Names
***Rhodiola crenulata* (Hook.f. & Thomson) H.Ohba**	English	Big flower rhodiola, Tibetan rhodiola
	Bhutanese (Dzongkha)	sro-lo dmar-po, solo marpo, tser, tsemarp, tsepara, lamichop, yamishem, jatshoen
	Chinese	大花 红景天 (da hua hong jing tian), 紅景天 (hongjingtian)
	Tibetan	ཙོ་ལོ་དམར་པོ (transliteration: “sro lo dmar po”)
***Rhodiola rosea* L.**	English	Rhodiola, Arctic root, Golden root, King’s crown, Roseroot, Rosewort, Snowdown rose *R. sachalinensis:* Sakhalin rhodiola, high mountain rhodiola, red-spotted stonecrop
	French	Rhodiole, Rhodiole rose, Orpin rose, Orpin rosat, Racine d’or, Racine arctique
	Spanish	Raíz y rizoma de Rhodiola, Raíz del ártico
	Bulgarian	Златен корен, Златоврьх, Розов златоврьх
	Canadian (French)	Couronne du roi, Orpin rosat
	Canadian (Inuktitut)	tullirunaq, tullirunnak, tulligunnak, utsuqammat, utsuKammak
	Chinese	红景天 (hong jing tian), qiang wei (rose smell) hong jing tian, "rose" (megui, 玫瑰) hong jing tian *R. sachalinensis:* 库页红景天 (ku ye hong jing tian), 高山紅景天 (gao shan hong jing tian)

Czech	Kořen rozchodnice růžové
Danish	Rosenrodrhizom, Rosenrod
Estonian	Roosilõhnaline kuldjuur
Faeroeish	Rósuhjálpirót
Finnish	Pohjanruusujuuri, Ruusujuuri
Gaelic	Lus nan laoch
German	Rosenwurzwurzelstock, Gewöhnliche Rosenwurz, Rosenwurz
Hungarian	Rózsás varjúháj gyökértörzs
Icelandic	Burnirót, Sværfla
Italian	Legn rodio, Legno rodio
Japanese	イワベンケイ (iwa benkei) *R. sachalinensis:* イワベンケイ (iwa benke), ホンジンティエン (hong jing tian)
Kazakh	Қызғылт семізот, алтынтамыр
Komi	dzurtanturun
Korean	*R. sachalinensis:* 홍경천 (hong kyung cheon), 홍경천 추출물 (hong kyung cheon extract), 홍경천 추출액발효물 (fermented hot water extract of hong kyung cheon)
Latvian	Zeltsakne
Lithuanian	Rausvoji radiole

Mongolian	yagaan mu’gez, altan gagnuur
Norwegian	Rosenrot. Additionally, Alm (2004) documents over 50 other common names
Polish	Kłącze różeńc
Romanian	Rădăcină arctică, Rădăcină de aur, Rădăcina de Rhodiola rosea
Russian	Родиолы розовой корневища и корни, Родиола розовая, Золотой корень (golden root), розовый корень (pink root) *R. sachalinensis:* Родиола сахалинская (Sakhalin rhodiola)
Sámi	gálberássi, gálberráhta
Slovak	Podzemok rodioly ružovej
Slovenian	Korenika navadnega rožnega Korena
Swedish	Fjällkaktus, Arktisk rosenrot, Vanlig rosenrot, *Rhodiola rosea* (Rosenrot) torkad rot och jordstam
Tuvan	улуг-оът (“Ulug-ot” = “big grass” or “great grass”)
Ukrainian	Золотий корінь (golden root), Родіола рожева (pink rhodiola)

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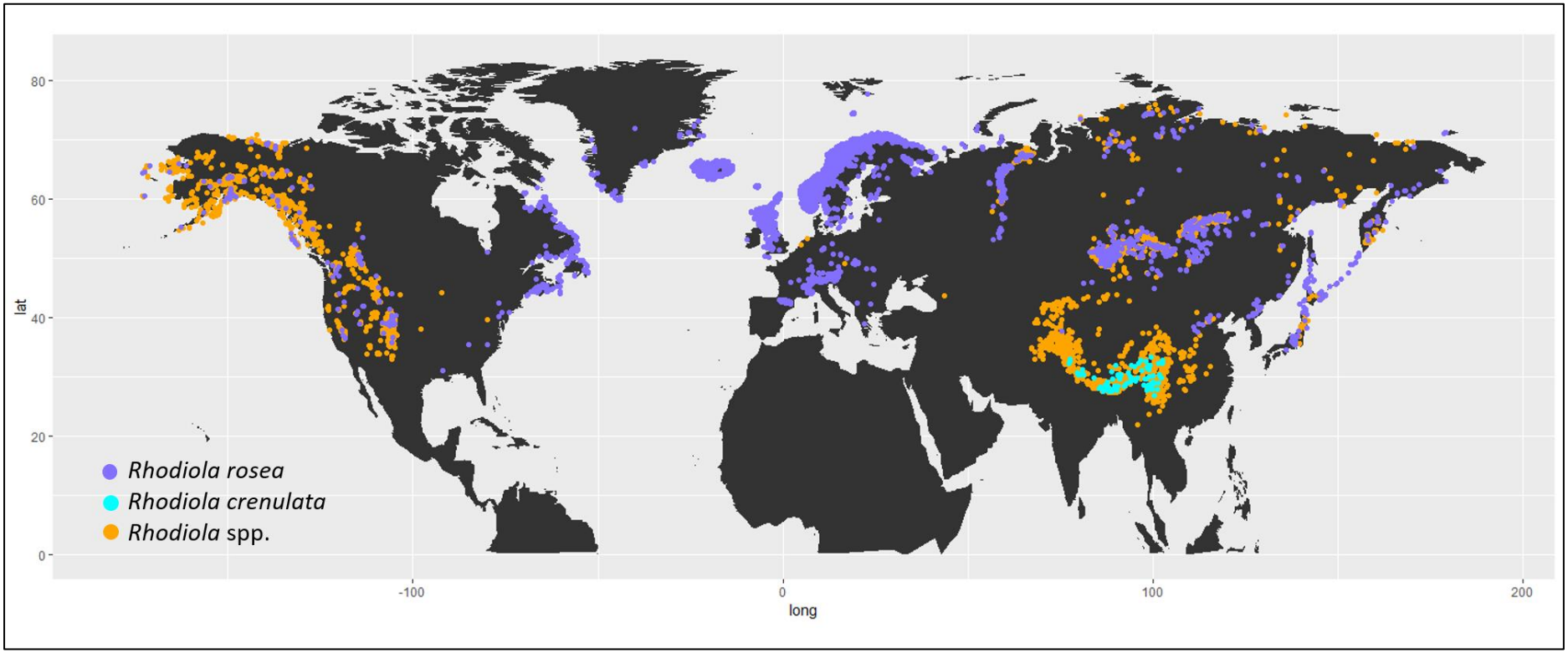
Annex 2: Distribution of the genus *Rhodiola* spp. and the two most traded *Rhodiola* species.

Distribution of *Rhodiola* species according to Global Biodiversity Information Facility (GBIF) data[11], with *R. rosea* and *R. crenulata* being separately depicted, while all other species included in the data are merged. Note that the GBIF backbone taxonomy for *Rhodiola* does not fully correspond to the taxonomy indicated by Ohba (2003)[12].



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Annex 3: Summary of responses of Range States of *Rhodiola* species

Range State	Response
Afghanistan	
Andorra	
Bhutan	Supports listing in Appendix II
Bosnia and Herzegovina	
Canada	No definitive position given
Democratic People's Republic of Korea	Not consulted as DPRK is not a party to CITES
People's Republic of China	Co-proponent
Iceland	
India	
Iran	Supports listing in Appendix II
Japan	
Kazakhstan	
Kyrgyzstan	
Mongolia	
Myanmar	
Nepal	
Norway	Supports listing in Appendix II
Pakistan	Supports listing in Appendix II
Russian Federation	
Switzerland	Notes that listing of *Rhodiola* would make sense and that the listing of the whole genus appears reasonable on the basis of look-alike issues. However, notes that it is mainly a south Siberian/ eastern Asian issue.No definitive position given.
Tajikistan	
Ukraine	Co-proponent
United Kingdom of Great Britain and Northern Ireland	Co-proponent
United States of America	Co-proponent
Uzbekistan	

Annex 4. A list of commodities, parts and derivatives defined for trade on the national and international level for *R. crenulata* and *R. rosea* (including its synonym *R. sachalinensis*). While some of the entries in the table are similar in name and definition, each is a distinctly separate commodity with different quality specifications on which buyers and sellers agree on, which has price and availability implications. To illustrate, Rhodiola USPC-grade (containing not-less-than 0.3% of phenylpropenoid glycosides) is a different quality material than Rhodiola PhRus-grade (containing not-less-than 1.0% phenylpropenoid glycosides)[13].

Species	Name(s) of article	Definition	Ref.
***Rhodiola crenulata* (Hook.f. & Thomson) H.Ohba**	Rhodiolae Crenulatae Radix et Rhizoma	The dried root and rhizome of *R. crenulata*; collected in autumn after scape withered, coarse bark removed, then dried under the sun to obtain Rhodiolae Crenulatae Radix et Rhizoma.	HKCMM; PPRC
	Rhodiola Crenulata Root Extract	An extract of the roots *R. crenulata*; used for emollient function.	COSING
	Rhodiola Crenulata Root Extract Ferment Filtrate	Filtrate of the product obtained by the fermentation of Rhodiola Crenulata Root Extract by the microorganism *Saccharomyces*; used for skin-conditioning function.	COSING
	Rhodiola crenulata Root and Rhizome	Dried root and rhizome collected after the scape withers in autumn, containing not-less-than 1.0% of total phenylethanoids calculated as the sum of salidroside and tyrosol, and not-less-than 0.6% of salidroside on the dried basis.	USPC
	Rhodiola crenulata Root and Rhizome Powder	Dried root and rhizome reduced to a powder, containing not-less-than 1.0% of total phenylethanoids calculated as the sum of salidroside and tyrosol, and not-less-than 0.6% of salidroside on the dried basis.	USPC
	Rhodiola crenulata Root and Rhizome Dry Extract	Prepared from Rhodiola crenulata Root and Rhizome USP by extraction with alcohol or hydroalcoholic mixtures, containing not-less-than NLT 2.0% of salidroside. It may contain suitable excipient materials as carriers.	USPC
***Rhodiola rosea* L.**	Arctic Rhizome and Root Dry Extract	Prepared from *R. rosea* rhizome and root by extraction (Extraction solvent: ethanol 67–70% v/v) with a drug-to-extract ratio (DER) range of between 1.5:1 and 5:1 (w/w). A narrow range of the DER and a fixed strength of the ethanol used for extraction must be specified on product labelling; used as an active ingredient of registered Traditional Herbal Medicinal Products (THMPs) for temporary relief of symptoms of stress, such as fatigue and sensation of weakness.	EMA

13 *Brinckmann, J. A., Cunningham, A. B., & Harter, D. E. V. (2021). Running out of time to smell the roseroots: Reviewing threats and trade in wild* Rhodiola rosea L. Journal of Ethnopharmacology, 269, *113710.* https://doi.org/10.1016/j.jep.2020.113710

Rhodiolae roseae rhizomata et radices	Dried rhizome and root of *R. rosea*, harvested from perennial wild plants during the flowering and fruiting period or from cultivated plants, peeled and cut, containing not-less-than 1% phenylpropenoid glycosides, calculated as rosavin, and not-less-than 0.8% salidroside.	PhRus
Rhodiolae rosae rhizomatum et radicum extractum liquidum	Hydro-alcoholic liquid extract prepared from Rhodiolae roseae rhizomata et radices	PhRus
Rhodiola Rosea Callus	The callus of *R. rosea* grown in culture; used for antioxidant and skin-protecting functions.	COSING
Rhodiola Rosea Callus Extract	The extract of the callus of *R. rosea* grown in culture; used for skin-protecting function.	COSING
Rhodiola Rosea Root and Rhizome	Dried root and rhizome, containing not-less-than 0.3% of phenylpropenoid glycosides calculated as the sum of rosarin, rosavin, and rosin; and not-less-than 0.08% salidroside.	USPC
Rhodiola Rosea Root and Rhizome Powder	Dried root and rhizome reduced to a powder, containing not-less-than 0.3% of phenylpropenoid glycosides calculated as the sum of rosarin, rosavin, and rosin; and not-less-than 0.08% salidroside.	USPC
Rhodiola Rosea Dry Extract	Prepared from Rhodiola Rosea Root and Rhizome by extraction with hydroalcoholic mixtures. The drug-to-extract ratio range is between 1.5:1 to 5:1 (w/w). It may contain suitable excipient materials as carriers.	USPC; EMA
Rhodiola Rosea Standardized Extract	Prepared from Rhodiola Rosea Root and Rhizome, standardized to contain 0.8–3% salidroside and/or 1–6% rosavins. Used as an active ingredient of licensed Natural Health Products.	NNHPD
Rhodiola Rosea Capsules	Contains Rhodiola Rosea Dry Extract	USPC
Rhodiola Rosea Tablets	Contains Rhodiola Rosea Dry Extract	USPC
Rhodiola Rosea Tincture	Prepared from Rhodiola Rosea Root and Rhizome, containing not-less-than 0.06% (w/v) of phenylpropenoid glycosides calculated as the sum of rosarin, rosavin, and rosin; and not-less-than 0.016% salidroside. Used as an active ingredient of licensed Natural Health Products.	USPC; NNHPD
Rhodiola Rosea Root Extract	Extract of the roots of the *R. rosea*; used for emollient and skin-protecting functions.	COSING

	Rhodiola Rosea (whole plant) Extract	Extract of the whole plant of *R. rosea*; used for emollient function.	COSING
	Sedum Rosea Root Extract	Extract of the roots of the Rose Root, *S. rosea* L (syn. *R. rosea* L.); used for antioxidant, astringent, and skin conditioning functions.	COSING
	"rhodiola"	By U.S. law, any item in U.S. commerce with a label bearing the standardized common name "rhodiola" legally refers to any of these three species: *Rhodiola algida* var. *tangutica* (referred to in this proposal as *Rhodiola tangutica*), *Rhodiola kirilowii*, and *Rhodiola rosea.*	DSHEA, Herbs of Commerce
	Rhodiolae Sachalinensis Radix et Rhizoma	Dried rhizome and root of *R. sachalinensis* (synonym of *R. rosea,* according to Ohba (2003)), harvested from perennial wild plants or from cultivated plants.	
	Rhodiola Sachalinensis Callus	The callus of *R. sachalinensis* (synonym of *R. rosea,* according to Ohba (2003)) grown in culture; used for emollient and humectant functions.	COSING
	Rhodiola Sachalinensis Callus Culture Extract	The extract of the callus of *R. sachalinensis* (synonym of *R. rosea,* according to Ohba (2003)) grown in culture; used for skin-conditioning function.	COSING
	Rhodiola Sachalinensis Extract	Extract of the whole plant, *R. sachalinensis* (synonym of *R. rosea,* according to Ohba (2003)); used for hair skin conditioning, hair waving or straightening, and skin conditioning functions.	COSING

References Legend:

COSING - Cosmetic Ingredients & Substances Database (European Commission)

DSHEA - Dietary Supplement Health and Education Act (United States of America)

EMA - European Medicines Agency (European Union)

HKCMMS - Hong Kong Chinese Materia Medica Standards (Hong Kong S.A.R., P.R. China)

NNHPD - Natural and Non-prescription Health Products Directorate (Canada)

PhRus - State Pharmacopoeia of the Russian Federation

PPRC - Pharmacopoeia of the People's Republic of China (P.R. China)

USPC - United States Pharmacopeial Convention (United States of America)

Annex 5. Legal protections in place for *R. rosea* and *R. crenulata*

Range State	Legal protection
Afghanistan	
Andorra	
Austria	Legal protection for *R. rosea* is determined at the level of province. The species is partially or fully protected in the five provinces where it occurs (Carinthia, Lower Austria, Salzburg, Styria, and Tyrol); in cases where the species is partially protected, this includes the prohibition of root and rosette collection (CITES MA of Austria *in litt.* to Bundesamt für Naturschutz (BfN), 2020).
Bhutan	*Rhodiola* species are not mentioned specifically in either the Forest and Nature Conservation Act (Royal Government of Bhutan, 1995) or the Forest and Nature Conservation Rules and Regulations (Royal Government of Bhutan, 2017), which include the legal provisions for the collection of medicinal plants. Instead the genus falls under the term "forest produce" as defined by the Forest and Nature Conservation Act, which includes all "wild plants and parts or products of wild plants" as well as medicinal plants. They are collected on a permit basis (Rinzin *et al.*, 2009).
Bosnia and Herzegovina	*Rhodiola rosea* is strictly protected by the Decree on Protected and Strictly Protected Wild Species in Republika Srpska (CITES MA of Bosnia and Herzegovina *in litt.* to Bundesamt für Naturschutz (BfN), 2020).
Bulgaria	*Rhodiola rosea* is listed in Appendix 3 of the Bulgarian Biodiversity Act (Republic of Bulgaria 2002); collection from the wild is prohibited.
Canada	*Rhodiola rosea* is not specifically covered by the Canadian Species at Risk Act and its Annexes (S.C.2002, last amended 2021-04-23) (Ministry of Justice of Canada, 2021).
People's Republic of China	The Regulations of the People's Republic of China on Wild Plants Protection (State Council of the People's Republic of China, 2017) have been in effect since 1997, amended in 2017 and cover all activities concerning the protection, development and utilization of wild plants. The Regulation makes reference to lists of wild plants under special state protection, which are regularly updated by the government. The updated list has been promulgated and is in effect. Ten species of *Rhodiola* are listed under second class protection – this would make a collection permit compulsory (State Forestry and Prairie Administration and Ministry of Agriculture and Rural Affairs, 2021).
Czech Republic	
Croatia	*Rhodiola rosea* was a protected species up until 2017; it was subsequently removed from this list as no application for wild collection was received in the 15 years in which it had been listed as a protected wild plant (CITES SA of Croatia *in litt.* to Bundesamt für Naturschutz (BfN), 2020).

Denmark	
Finland	
France	*Rhodiola rosea* is listed as a protected plant in the Alsace region; according to Inter-ministerial Order of 28 June 1993, “the destruction, cutting, mutilation, uprooting, picking or removal, use, offering for sale, sale or purchase of all or part of wild specimens” is prohibited in Alsace (Republic of France, 2021; CITES SA of France *in litt.* to Bundesamt für Naturschutz (BfN), 2020).
Germany	
Iceland	*Rhodiola rosea* was not reported to be a protected species (P. Wasowicz *in litt.* to Bundesamt für Naturschutz (BfN), 2020).
India	The Indian Forest Act of 1927 (Government of India, 1927) regulates the transit of “forest produce”, which include medicinal plants. The Act empowers State governments to enact rules concerning forest management; regulations therefore differ from state to state (Jain, 2000; Mulliken and Crofton, 2008; Forest Legality Initiative, 2014). The Wildlife Protection Act of 1972 regulates hunting but was extended to plants in a 1991 Amendment. It bans the collection, possession and cultivation of “specified plants” (Government of India, 1991; Jain, 2000). The Act does not specify any plant species that fall under these rules. Forest management provisions of the State of Sikkim are consolidated in the Sikkim Forests and Water Courses (Preservation and Protection) Act of 2007 (State Government of Sikkim, 2007), which does not make provisions for a list of protected species or for *Rhodiola* species in particular.
Iran	
Ireland	
Italy	No protections are thought to be in place for *R. rosea* (CITES SA of Italy *in litt.* to Bundesamt für Naturschutz (BfN), 2020).
Japan	
Kazakhstan	Ministerial Decree No. 223 validated a harvest quota of 2500 kg for *Rhodiola rosea* in certain areas in E Kazakhstan for the period of 2016 (Government of the Republic of Kazakhstan, 2016). More recent annual harvest quota validations could not be located.
Democratic People’s Republic of Korea	
Kyrgyzstan	G.A. Lazkov *in litt.* to Bundesamt für Naturschutz (BfN) (2020) did not consider *R. rosea* to be present in Kyrgyzstan; however, according to a 2008 report prepared for the German Technical Cooperation in Kyrgyzstan (GTZ), harvest of *R. rosea* was reported to be restricted due to its classification in the Red Book of the Kyrgyz Republic (iCAP Investment, 2008). No information regarding legal protections for other *Rhodiola* species could be located.

Mongolia	
Myanmar	
Nepal	Collection of plant material and domestic trade controls are implemented through the Forest Act of 1993 (Government of Nepal, 1999) and the National Parks and Wildlife Conservation Act of 1973 (Government of Nepal, 1973). These Acts include regulations pertaining to the collection of forest products (Heinen and Kattel, 1992) which is authorized via licences issued by District Forest Officers (Mulliken and Crofton, 2008). However, several studies have found that implementation of these licensing provisions was low in government forests based on lack of resource management rights among the local population and low government enforcement capacity (Pandit and Thapa, 2004; Subedi *et al.*, 2014). There are no specific provisions in place for *Rhodiola* species.
Norway	Several populations on Bjørnøya and Prins Karls Forland in the Svalbard archipelago are protected (Engelskjøn *et al.*, 2003).
Pakistan	
Poland	
Romania	Harvesting, possessing or trading of plant and animal species is regulated by Ordinul nr. 410/2008 (Ministry of Environment and Sustainable Development Romania, 2008). It has no special provisions for *R. rosea* (Kathe *et al.*, 2003; Popa, H., *in litt.* to J. Brinkmann, 2019)
Russian Federation	Article 8.35 of the *Code of Administrative Offenses of the Russian Federation* 195 of 2001 (Government of the Russian Federation, 2001) regulates the collection and possession of rare and endangered animal and plant species listed in the Red Book of the Russian Federation. *Rhodiola rosea* is in Category 3 (Rare) (Ministry of Natural Resources of the Russian Federation, 2005), and restricted for transport across the customs border for export. However, materials harvested from populations in the Tuva Republic (southern Siberia), Altai Territory (western Siberia; bordering Republic of Altai and Kazakhstan), Krasnoyarsk Krai (Siberia), and Magadan Oblast (Far East Region) are specifically excluded (Lyapustin *et al.*, 2013). In the Kuznetsky Alatau mountain range, Nekratova and Shurupova (2014) reported *R. rosea* to be strictly protected, with only limited amounts (1–2 individuals) permitted to be used for personal purposes.
Slovakia	
Spain	
Sweden	Wild harvest of *R. rosea* is prohibited in several counties in southern Sweden (Bohuslän, Göteborg and Västra Götaland) (Cuerrier *et al.*, 2014).
Switzerland	*Rhodiola rosea* is not a protected species.

Tajikistan	
Ukraine	*Rhodiola rosea* is included in Ukraine's Red data book. Collection. Species listed in the Red Book of Ukraine and species under regional protection is prohibited unless a special permit is issued, which is subject to limitations on amount (Minarchenko, 2011).
United Kingdom of Great Britain and Northern Ireland	
United States of America	*Rhodiola rosea* is not protected under the federal Endangered Species Act (ESA) of 1973; but is protected under the Environmental Conservation Law in the state of New York and under Vermont's Endangered Species Law (Cuerrier *et al.*, 2014). It is also protected in the state of North Carolina (Cuerrier *et al.*, 2014). Quota-based wild *R. rosea* harvest is allowed in Alaska (State of Alaska Department of Natural Resources, Division of Mining Land and Water, 2008), where a permit for commercial harvesting of *R. rosea* roots on any general state land must be obtained from the Division of Mining, Land and Water (DMLW). The harvest quantity is limited to 50 lbs (=22.7 kg) carried out according to prescribed harvest protocols, which stipulate that (1) only the most minimal ground disturbance is allowed, (2) all holes dug must be refilled, (3) harvest must occur at a minimum distance of 50 feet from any waterbody, (4) no more than 33% of the plants may be selected for harvest in any given area (5) harvesters must not dig unless there is another plant of the same species to be left within 3 feet of the one they are taking; (6) harvest in a given area is to occur only every other year; (7) no harvesting should occur on slopes greater than 15 degrees; and (8) a portion of the rootstock of each plant must be left in the ground (State of Alaska, 2008).
Uzbekistan	

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