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Schoenus ferrugineus (Cyperaceae) in Murmansk Region (Russia)

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Schoenus ferrugineus L. is one of the diagnostic species of calcareous fens, which are floristically rich and scattered locally in Europe. 25 new occurrences, most of them recent ones, have been found in Russia, mostly from the eastern border areas of the species. The new locality in Murmansk Region, reported here, corresponds to the northern limit of this species in Europe, and is situated about 60 km north of the Arctic Circle. The new site is described and the distribution and ecology of the species in Murmansk Region are discussed. It is proposed to change the status of this species in the Regional Red Data Book to 'Critically Endangered'.

Introduction

In the 1800s and at the beginning of the twentieth century Finnish botanists made several expeditions to the Kola Peninsula (see Uotila 2013). In the early 1900s the first locality for *Schoenus ferrugineus* on the peninsula was discovered, and at that time it was the northernmost known site for the species (Lindberg 1914).

A century later, in 2012, a new site for *Schoenus ferrugineus* was found 60 kilometers north of the old locality, in the vicinity of the town Apatity, in the course of field studies by the Laboratory of Plant Population Biology of the Polar-Alpine Botanical Garden-Institute. Recently also many new localities were found in other parts of European Russia.

S. ferrugineus is one of several sedges included in the Red Data Book of Murmansk Region (2003) as well as in Red Data Books of neighboring territories. The main reason for its rarity in Fennoscandia is the very restricted occurrence of base-rich fens, which are the typical habitats for the species in Europe.

Methods

Specimens of *Schoenus ferrugineus* from the following herbaria were examined: H, KPABG, LE, MW.

Ecological measurements of the new population. Vegetation cover was estimated using the Braun-Blanquet cover-abundance scale (Barkman & al. 1964). The following were also measured: pH of the surface water, directly in the field using a PH-009 (Kelilong Instruments) pen with a 0.0–14.0 scale divided into units of 0.1; soil salinity, using a TDS 5 (HM Digital) pen with a 0–9990 mg/l scale divided into units of 1 mg/l;

and illuminance in the habitat, using a Smart Sensor Digital Lux Meter AR813A (1–100.000 Lx) divided into units of 1 Lx.

Results and discussion

Early finds from the Kola Peninsula

Harald Lindberg, Keeper of the Botanical Museum in Helsinki, made an expedition in 1913 to the Kola Peninsula together with his student Henrik Aschan (Uotila 2013). Lindberg found *Schoenus ferrugineus* to be ”fairly abundant from a peculiar mire near the coast between Kandalaksha and Kolvitsa villages”, and believed that the species was new for the Kola Peninsula and that this was the northernmost site for it in the whole of Europe (Lindberg 1914). He mentioned *Phragmites australis*, *Eriophorum latifolium*, *Carex oederi* (= *Carex viridula* var. *bergrothii*) and *Salix arbuscula* from the same habitat, and at least his specimens (in H) of the following species have been provided with similar locality description (*In palude infra alpem inter Kandalakscha & Kolvitsa*, *28.7.1913*): *Carex livida*, *Dactylorhiza incarnata*, *Eleocharis quinqueflora* and *Juncus stygius*. Lindberg collected from *S. ferrugineus* a herbarium specimen (H) with many duplicates for his *Plantae Finlandiae Exsiccatae.* The specimen of *Schoenus* was distributed with the number 491, but the date on the printed label (1912) and in *Schedae* (Lindberg 1916) is erroneous – he visited the locality only in 1913.

In 1911 the students Väinö Krohn and Thord Brenner travelled as assistants to the geologist Wilhelm Ramsay on the Kola Peninsula. The group made excursions in Ponoj and along the south coast to the Kandalaksha area and north to Kola (Uotila 2013). Krohn collected quite a few specimens during the expedition, and many of them were notable finds. One of them is a poor specimen of *Schoenus ferrugineus*, which, according to the label, is collected from ”*Lapponia Imandrae*, Kannanlahti [Kandalaksha] on July 11, 1911” (H). In general, his specimens lack detailed locality information, and Kandalaksha here most probably does not mean the village of Kandalaksha but a wider area especially along the coast; at that time this territory was well populated owing to the establishment of sawmills on several offshore islands.

It appears that Krohn kept the collected specimens in his possession and donated to H merely a specimen of *Paeonia anomala* from Turij. H received the other specimens by bequest in 1970. However, some labeling mistakes occur in Krohn’s specimens, and there is a risk that his specimen of *Schoenus* is actually a fragment of Lindberg’s rich collection. Odd enough Lindberg was not aware of Krohn’s findings.

Anyway, most probably the possible find by Krohn is from more or less the same locality as Lindberg’s. The only site closely fitting the description of the locality by Lindberg, as well as with the calcareous bedrock, is the mire at the foot of Mt. Malaya Kurtyazhnaya between Mt. Volosyanaya and Mt. Luvengskie. The mire must have been visible from the coastal road of that time.

The mire was studied in 2013 by I. Blinova. The locality matched well Lindberg’s description of his locality, e.g., reed and *Eriophorum latifolium, Dactylorhiza incarnata* and *Juncus stygius* grew there, but *S. ferrugineus* was not found. Instead a new population of *Dactylorhiza traunsteineri* was detected, the third in the Kola Peninsula (see Blinova & Uotila 2012). However, the mire complex is quite large and the summer was exceptionally dry and unfavorable for detecting *Schoenus*, and further searches are needed.

Schoenus ferrugineus was found in 1958 by E. Kurchenko on Veliky Island, which is in the White Sea and in Kandalaksha Nature Reserve. No information on the exact locality is given with this specimen. In 1963 N. Bogdanova and V. Vekhov collected another specimen from the island, from square no. 85. Five years later, in 1968, V. Vekhov found another locality of *S. ferrugineus* from Veliky Island, from square no. 29.

All specimens from Veliky Island have been kept in Moscow (MW) since the earliest find. These two localities were discovered after the publication of Cyperaceae in the Flora of Murmansk Region, in which only the find from Kandalaksha is mentioned (Czernov 1954). However, for unknown reasons the records from Veliky Island are left out of the more recently published ”Flora partis Europaeae URSS” (Egorova 1976), ”Atlas of North European vascular plants north of the Tropic of Cancer” (Hultén & Fries 1986) and

”Red Data Book of East Fennoscandia” (Kotiranta & al. 1998).

The new locality

Studies on rich fens near Apatity began in 2001 (Blinova 2002, Blinova & al. 2002a, b). Many new records of orchids (*Dactylorhiza incarnata, Hammarbya paludosa, Listera ovata, Gymnadenia conopsea*) and rare sedges (*Carex hostiana, C. echinata*) have been made. The work was extended to several closely situated mires in 2011–2013 as part of the scientific program ”Demography of populations of some vascular plants in rich mires of Murmansk Region” by the Laboratory of Plant Population Biology of the Polar-Alpine Botanical Garden-Institute. A new population of *D. traunsteineri* was found in 2011 (see Blinova & Uotila 2012). Highly calcareous habitats still produce interesting finds almost every year. Some single plants of inconspicuous species in the Cyperaceae, Juncaceae and Onagraceae have been occasionally encountered during field work but not all of them were collected or identified because the main aim of the studies was work on certain target plant species. Such an instance occurred on 13 July 2012 when S. Asming presented just one spikelet she had picked for identification, but could not find the place where it was collected. I. Blinova identified the fragment in the Laboratory as *Schoenus ferrugineus* and on the same day returned to the place with Yu. Bobrov in order to find the site and describe the population and vegetation cover. *Schoenus* was found and a specimen was collected for the herbarium KPABG. The locality is to the east – south-east of Apatity, about 4 km from the present center of the town, 67°32´N 33°28´E at an altitude of 171 m.

Range

Schoenus ferrugineus is a European species with a relatively restricted and discontinuous range (Webb 1980). Apart from the Alpine region of Central Europe and some areas close to the Baltic Sea, the species is rare in most of Europe (Meusel & al. 1965, Hultén & Fries 1986, Tabaka & al. 2003). It is absent from the Iberian Peninsula (Castroviejo 2008). The northern and partly eastern limits of its area are in East Fennoscandia. However, most of the eastern occurrences known at present in Russia have been found only recently and are missing from the maps by Meusel & al. (1965) and Hultén & Fries (1986). In the southern Urals there are about 20 localities (Kulikov & Filippov 1997, Muldashev 2011, Ivchenko 2012). One site was discovered in Novgorod Region (Smagin 2011, Konechnaya & al. 2012). Three new occurrences have been found in Vologda and Arkhangelsk Regions (Boch 1985, Smagin & Denisenkov 2013, and Smagin, unpublished data of 2013).

In Murmansk Region *S. ferrugineus* occurs at four sites documented by herbarium specimens (Fig. 1). The two southernmost localities for the Region, from Velikij Island, are very close to the nearest sites on the Karelian coast of the White Sea on Cape Kindo and Cape Krasnij (Sokoloff & Filin 1996; MW), and on the same parallel of latitude as the localities in the west, in Loukhi District, Lake Paanajärvi area (Kuznetsov 2007), and in Finland, Kuusamo (Ranta 2012).

The two other localities in Murmansk Region are more isolated. The site on the northern shore of the Gulf of Kandalaksha is about 70 kilometres NW of Velikij Island and the northernmost, recently found site is located 60 km further NE, near Apatity and south of the Khibiny Mts.

Ecology and phytocoenology

According to the European Nature Information System (EUNIS, www.eunis.eea.europa.eu), mires with certain key species like *Schoenus ferrugineus* are classified as ’base-rich fens and calcareous spring mires’ (Davies & al. 2004). ’Calcareous fens’ and ’alkaline fens’ are their synonyms in the EU Habitat Directive (Hájek & al. 2006; Šefferová Stanová & al. 2008; European Commission 2013). These plant communities are floristically very rich and syntaxonomically they often correspond to the order *Caricetalia davallianae* (Dierssen & Dierssen 2001, Ellenberg & Leuschner 2010). However, floristic composition can vary geographically and towards the north more species of the order *Scheuchzerietalia* may be integrated in plant communities (Tyler 1979,

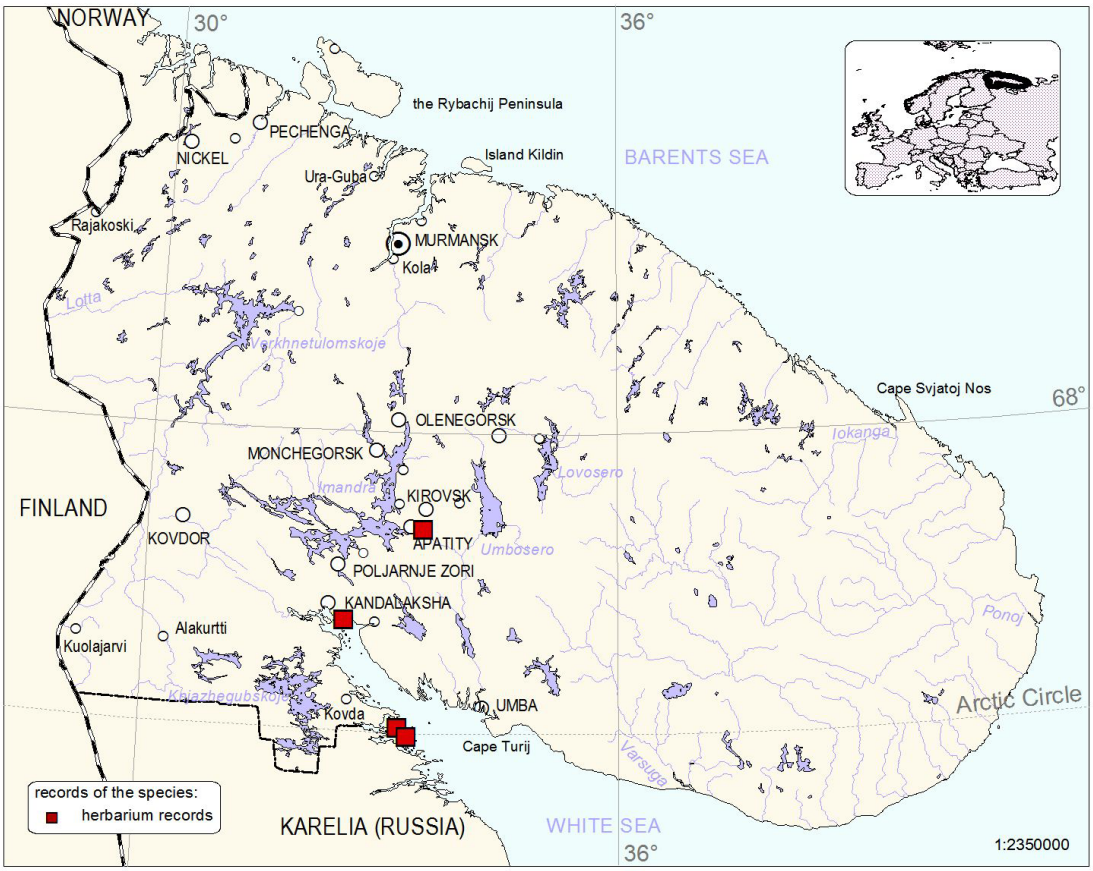

Fig. 1. The localities of *Schoenus ferrugineus* in Murmansk Region, Russia.

Kuznetsov 2006). This mire type occurs locally in Europe and is rare in Fennoscandia on account of the very restricted occurrence of calcareous rocks (Eurola & al. 1991, Tahvanainen 2004, Eurola & Huttunen 2006).

The new, northernmost population of *Schoenus ferrugineus* is situated at the border of rich fen with dominance by *Triglochin maritimum, Molinia caerulea, Carex lasiocarpa* and brown mosses (*Limprichtia cossonii, L. revolvens, Scorpidium scorpioides*) (Table 1, Fig. 2). Some small alders and pines, as well as shrubs like junipers and willows, occur nearby. A poor-to-rich gradient of mire vegetation has been observed. The plant community with *S. ferrugineus* occupies the less acid part of the mire with higher levels of light, pH, salinity and humidity (Table 2). The floristic composition of the community is similar to that in the South Urals (Kulikov & Filippov 1997).

Seasonal development

As in many Cyperaceae, shoots of *Schoenus ferrugineus* have a biennial growth cycle. New shoots appear in autumn and reach 3–7 cm height (Ganzert & Pfadenhauer 1986, Cowie & Sydes 1994). Such a development represents an adaptive strategy to infertile habitats because it allows a translocation of nutrients (especially nitrogen and phosphorus) from old to new shoots (Ganzert & Pfadenhauer 1986). Flowering is in mid July, including the northernmost population.

Table 1. The description of vegetation cover in the plant community with *Schoenus ferrugineus* in the Apatity locality. Nomenclature according to Czerepanov (1995) and Ignatov & Afonina (1992). Explanation of symbols: "r" = 1–3 individuals; "+" = less than 1%, "1" = 1–5 %, "2a" =5–15%, "2b" = 15–25%, "3" = 25–50%, "4" = 50–75%, "5" = 75–100%.

Total cover (%)	100
Field layer (%)	95
Moss layer (%)	80
Total number of species	60
Vascular plants	47
Mosses	13
Tree layer	
Alnus kolaënsis	+
Betula subarctica	+
Pinus friesiana	+
Shrub layer	
Betula nana	1
Juniperus sibirica	r
Salix sp.	1
Field layer	
Andromeda polifolia	r
Baeothryon alpinum	1
Baeothryon cespitosum	r
Bartsia alpina	+
Calluna vulgaris	+
Carex adelostoma	+
Carex dioica	+
Carex hostiana	1
Carex lasiocarpa	2b
Carex limosa	+
Carex panicea	+
Chamaenerion angustifolium	+
Dactylorhiza incarnata	+
Dactylorhiza maculata	+
Empetrum hermaphroditum	r
Epilobium palustre	+
Eriophorum latifolium	+
Eriophorum vaginatum	+
Festuca rubra	r
Gymnadenia conopsea	+
Listera ovata	r
Menyanthes trifoliata	+
Molinia caerulea	2b
Moneses uniflora	r
Oxyccoccus palustris	+
Parnassia palustris	+
Pedicularis palustris	+
Pinguicula alpina	+
Pinguicula vulgaris	+
Potentilla erecta	1
Rubus chamaemorus	+
Sanguisorba officinalis	+
Saussurea alpina	+
Saxifraga aizoides	+
Schoenus ferrugineus	1
Selaginella selaginoides	r
Solidago lapponica	+
Tofieldia pusilla	+
Triglochin maritimum	2a
Triglochin palustre	r
Vaccinium uliginosum	r
Moss layer	
Aulacomnium palustre	+
Blasia pusilla	r
Campylium protensum	2a
Fissidens adianthoides	r
Hylocomium splendens	+
Limprichtia cossonii	2a
Limprichtia revolvens	+
Rhizomnium pseudopunctatum	+
Rhytidiadelphus triquetrus	+
Saccobasis polita	+
Scapania irrigua	1
Scorpidium scorpioides	+
Sphagnum russowii	2a

Table 2. Ecological data for rich fen including the plant community with *Schoenus ferrugineus* near Apatity. Means (X) of ecological values, their deviations (SD), coefficients of variation (CV, %) and sample set (n) for the growing period. The measurements are given separately for the plant community with *S. ferrugineus* (sch1a) in 2012–2013 and for the whole rich fen biotope (all) in 2012.

Ecological values	**Statistical data**	**sch1a, 2012–2013**	**all, 2013**
Light, lx	X± SD (n)	48733±24419 (n=6)	35667±22987 (n=48)
	CV, %	50	64
Soil reaction (pH)	X± SD (n)	7.1±0.2 (n=3)	6.6±0.5 (n=48)
	CV, %	3	7
Salinity, mg/l	X± SD (n)	36±23 (n=2)	33±22 (n=48)
	CV, %	63	67
Temperature, ° C	X± SD (n)	22.4±4.4 (n=6)	21.8±4.2 (n=48)
	CV, %	20	19
Humidity, %	X± SD (n)	56±8 (n=6)	49±8 (n=48)
	CV, %	14	17

NB. The growing period was extremely warm and dry in 2013 which resulted in high mean temperatures.

Fig. 2. A tussock of *Schoenus ferrugineus* with *Molinia caerulea* in the newly described population near Apatity (Murmansk Region, Russia). Photo I. Blinova, 13 July 2012.

Fig. 3. Flowering shoots of *Schoenus ferrugineus* in the newly described population near Apatity (Murmansk Region, Russia). Photo I. Blinova, 13 July 2012.

In 2013 flowering began in the Apatity population two weeks earlier in July because of the exceptionally early and warm summer. During anthesis stamens of hermaphrodite flowers appear earlier than stigmas (Fig. 3, 4). Most shoots of an individual plant are at the same phenological phase while in the population different individuals may be at various phases. This allows the wind-pollinated *S. ferrugineus* to achieve cross-pollination – a strategy which is efficient in large populations. However, it is not efficient in small populations of this species and this is apparently the reason why seeds do not seem to develop well in Murmansk Region. Several spikelets were examined for two subsequent years and were found not to contain any seeds at all.

Population performance

Reproduction and the earliest stages of development in *Schoenus ferrugineus* possibly represent a bottleneck in the life cycle. The rate of fruiting is very low, 10–32% (Wheeler & al. 1983, Schopp-Guth & al. 1994) and seeds, even if developed, remain in the spikelets until the following year (Cowie & Sydes 1994). No germination of *S. ferrugineus* has been observed *in vitro* even though seeds at different stages of ripeness have been sown and various treatments (including low temperature stratification) have been tried (Kļaviņa & al. 2006). However, the germination rate in pot culture may reach 50% with a 10–20% delay up to 2 years (Schopp-Guth & al. 1994). Only single seedlings were observed in natural populations over decades (Wheeler & al. 1983).

The number of flowering shoots varies drastically in *S. ferrugineus* between populations and years (Schopp-Guth & al. 1994). The same was characteristic for the population near Apatity. In 2013 it was almost impossible to find most of the plants observed in 2012. The tussocks with flowering shoots need to be marked for long-term studies. Some demographic parameters for the population of *S. ferrugineus* near Apatity are shown in the Table 3.

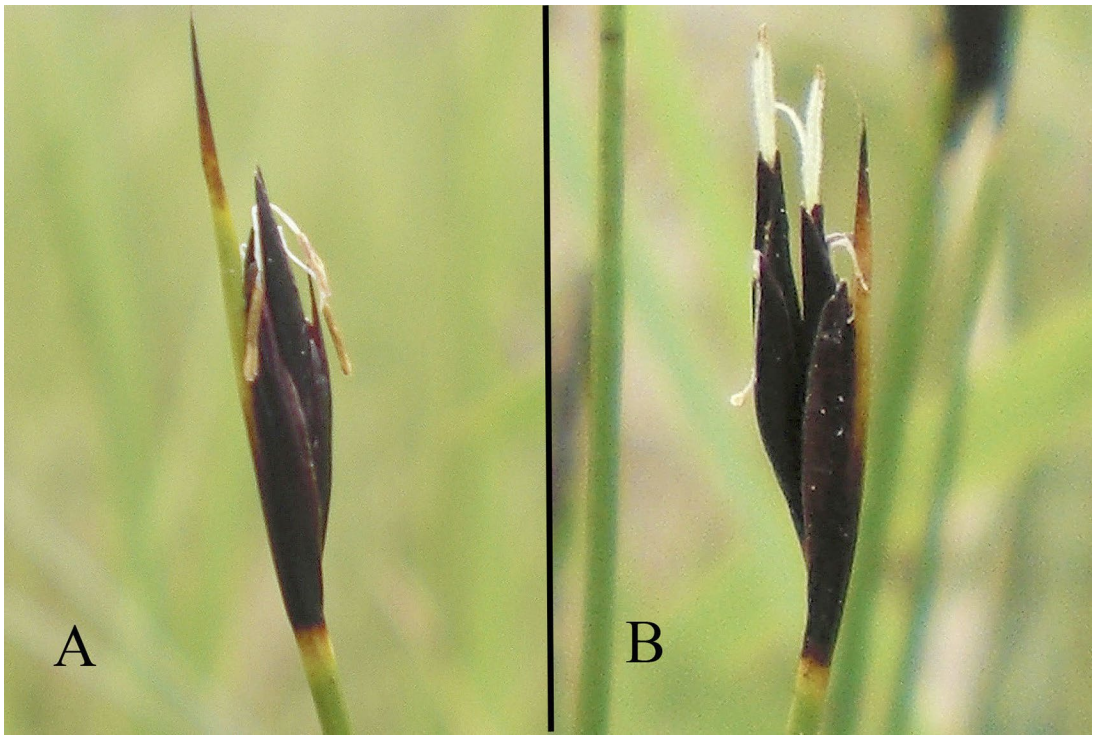

Fig. 4. Anthesis of hermaphrodite flowers of *Schoenus ferrugineus*: A – first phase, anthers visible, B – second phase, stigmas visible. Shoots of one individual plant are mostly in the same phase on any given date. Photo I. Blinova, 13 July 2012.

Table 3. Demographic data for the population of *Schoenus ferrugineus* in a rich fen nearApatity, 2013.

Area of biotope, m^2	20243
Area of population, m^2	74
Cover in biotope, %	0.4
Population size measured as number of individuals	<10
Population size measured as number of shoots	148
Shoot density on 1 m^2	2
Shoot density in biotope (ecological density) on 1 m^2	0.007

Vulnerability and protection

Schoenus ferrugineus is considered to be a soil relic (Faegri 1944) or glacial relic (Wheeler & al. 1983). However, the species is not included in the European Red List of species (Bilz & al. 2011). In Finland a re-estimation of Red-List status took place in 2010 and at present the species has status ”EN” according to the following criteria B2ab (ii,iii,iv,v) (Rassi & al. 2010). Threats include peatland drainage for forestry and peat harvesting (excluding clearing of streams), construction relating to housing, business, recreation and roads. The species is included in the Norwegian Red List with the status NT (Kålås & al. 2010).

S. ferrugineus is not included in the Red Data Book of the Russian Federation (Bardunov & Novikov 2008). In the Red Data Book of Murmansk Region (Konstantinova 2003) it has the status 3 (rare species). However, according to the IUCN criteria (B2ac(iv), C2a(i)) the species should be classified as ”CR”. Four regional populations known in Murmansk Region are isolated from the main distribution area and from each other. *S. ferrugineus* was indicated as fairly abundant only in the Kandalaksha population (Lindberg 1914). However, it is a record from a single and perhaps unusually favorable year, and the site has not been confirmed recently. The other three populations seem to be very small and with highly fluctuating numbers of flowering shoots. For example the population on Velikij Island found in 1963 by N. Bogdanova and V. Vekhov, who added to the mire description on the herbarium label a note ”on the edge of a hummock”, was very likely of small size. In the 1990s some annual searches were undertaken to rediscover this species, there and on the adjacent Cape Kindo but without success. Only in 1999 was the species at last found once more on Velikij Island (MW), but it was not found on Cape Kindo where only isolated individuals had occurred in the mire in the 1960s and 1970s (Sokoloff & Filin 2008).

Of the four populations in Murmansk Region, the two southernmost ones are under protection in the Kandalaksha Nature Reserve. The establishment of nature monuments is required for two other populations. In the Karelian Republic sites with *S. ferrugineus* are protected only in the National Park ”Paanajarvi” (Kuznetsov 2007).

The territory of rich fen with *S. ferrugineus* near Apatity is included in the planned nature monument ”Mochazhinnoje boloto”. However, unfortunately its position is indicated incorrectly in the literature and in some official documents (Kobyakov 2011, Koroleva & Kostina 2011–2013). There is a Directive of the Regional Committee to organize a local monument by the year 2038. However, it is very likely that the territory will be covered by buildings as Apatity expands. Even now house construction is rapid. The local municipality prioritizes urban development over nature protection.

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