INSPECTION OF ENVIRONMENTAL PROTECTION

Methodology of nature monitoring

Methodological guide for:

Plant species:
4066 Ladder spleenwort *Asplenium adulterinum* Milde
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4066 **Ladder spleenwort** *Asplenium adulterinum* Milde

Photo 1 A ladder spleenwort at a site on the Kiełczyńskie Hills (© L. Żołnierz)

I. INFORMATION CONCERNING THE SPECIES

1. Systematic position

Family: spleenworts *Aspleniaceae*

2. Status

International law

Habitats Directive - Annex II

National law

Protection of the species - strict protection since 2004

Zonal protection – requires establishment of a protection zone within the radius of 30 m from the boundaries of the site.

Threat category

IUCN Red List – not taken into account
Polish Red Book of Plants (2001) – EN
Endangered vascular plant of the Sudetes (2002) – EN
Red List of Lower Silesia (2003) – CR
Red List of vascular plants in Poland (2016) – EN
Red Book of the Czech Republic and Slovakia (1999) – CR

3. Description of the species

The ladder spleenwort is an allotetraploid (2n = 144) derived from a combination of sets of chromosomes derived from two different ancestral species of diploid spleenworts (2n = 72): maidenhair spleenwort *Asplenium trichomanes* and green spleenwort *A. viride* (Lovis and Reichstein 1968).

Clusters of ladder spleenwort usually consist of between a few and a dozen or so or sometimes twenty odd fronds growing from the top of a short rhizome. Sporadically, one can encounter overgrown clusters of old specimens consisting of as many as over fifty fronds. 1-pinnate fronds reach the length of between several and twenty (25) cm and contain up to 20-30 (40) pairs of pinnae. These leaflets are ovate to rhombic to ovate-oblong, slightly convex, with shallowly crenate margins. Their tapered base narrows into a short petiole. On the underside, elongated sori are placed along the end sections of veins. The numbers of sori are as follows: (3) – 6-8 (-9). They are protected by light brown indusia with somewhat frayed edges. Bean-shaped spores are covered by narrow exosporia. The petiole, which is shorter than the pinna blade, and the basal section of the frond are of chestnut brown colour.

The main feature which makes it possible to distinguish the ladder spleenwort from its ancestral species is the green colour of the top of the basal section between 1/10 and sometimes even (approximately) the middle of the length of the frond. The species are easily confused with one of hybrid forms of maidenhair spleenwort *Asplenium trichomanes*, in which the ends of basal sections are green shortly after fronds appear and they only become brown some time later. There is also a hybrid species with features closely resembling *A. viride* (Křisa 1997), whose entire fronds are green. It probably comes from the territory of the Czech Republic.

4. Biology of the species

The species is a hemicryptophyte. It multiplies through spores, which ripen from July to August. Its small prothallia reach a width of up to 7 mm. Their development lasts approximately three months, culminating with the production of the archegonium (Karpowicz 1963).

In 2010, Bucharová and other researchers carried out studies of demographic populations of *Asplenium adulterinum* using stochastic matrix models. They came to the conclusion that even very small populations consisting of up to ten specimens are very unlikely to become extinct over the period of 50 years. According to the authors' calculations, the average lifespan of one specimen is 34 years.

5. Environmental requirements

Most ladder spleenworts grow in rock crevices, but they can also be found on rubble deposits on rock shelves. The species prefers semi-shade, avoiding both too shady and sunlit places. It grows well in the latter only in sufficiently humid conditions.

The ecological indicator values are as follows:

Indicator	According to Zarzycki et al. (2002)	According to Ellenberg et al. (1992)
light L	4	5
thermal T	4-3	4
of continentalism C	2	4
soil moisture M (F)	3	5
of trophism Tr (N)	2	1
of soil acidity R	4	6

The ladder spleenwort *Asplenium adulterinum* grows almost exclusively on serpentine rocks or on peridotites, dunites, magnesites and other rocks that are closely related to serpentine rocks in terms of their genesis and properties. Serpentinite habitats are characterised by shallow, poorly developed soils with a specific composition and specific quantitative relations between elements. As a general rule, these soils contain very few essential nutrients – nitrogen, phosphorus and potassium. In comparison with soils derived from other rocks, they contain high concentrations of magnesium and low concentrations of calcium. In addition, they contain high levels of heavy metals: nickel, chromium and cobalt. The set of these habitat factors, referred to as the “serpentine complex”, forces plants to adapt and determines the uptake and specific proportional representation of elements in their tissues.

The ladder spleenwort belongs to rock fissure communities from the *Asplenietea trichomanis* class and is a characteristic species of the *Androsacetalia vandellii* order. Together with the serpentine spleenwort *Asplenium cuneifolium* and the black spleenwort *A. adiantum-nigrum*, which can only be found on serpentinites in Poland now, the ladder spleenwort is a representative species of habitat 8220-1 “Rock fissure communities of serpentine ferns” (Świerkosz et al 2004).

At some sites, ladder spleenworts faces strong competition from co-existing expansive species, such as the bushgrass, blackberries, raspberries and other species. It seems that this phenomenon is on the increase, as habitats are becoming more fertile because of atmospheric precipitation polluted with nitrogen compounds.

Photo 2 A ladder spleenwort at a site near Janowice Wielkie (© L. Żołnierz)

6. Distribution in Poland

In Poland, the ladder spleenwort grows exclusively on serpentinites, hence its sites are limited to the only region in the country where these rocks occur, i.e. in the Sudetes and the tectonic foreland of the Sudetes, in the mountain ranges of Ślęża and Grochowa. At present, there are twelve known sites of this species. The westernmost site is situated on the Popiel Hill near Janowice Wielkie. Seven sites are located on the Kiełczyńskie Hills in the western part of the mountain range of Ślęża. Two sites are situated in the Owl Mountains – in Kamionki and near Przygórze – and one on the Żmijowiec Mountain in the mountain range of Śnieżnik. Recently (2011, Żołnierz, unpublished data), another site has been discovered in the mountain range of Grochowa. It consists of 19 specimens. The site was known from historical records (Fiek 1881, Schube 1903), but its existence in the post-war period has not been confirmed before. The site on the Żmijowiec Mountain has the highest altitude (1150 m above sea level), whereas the altitudes of the other sites range between 300 (Kiełczyńskie Hills) and 540 m above sea level (Przygórze). During the observations conducted in 2009 at all sites, with the exception of the above-mentioned site in the mountain range of Grochowa, it was found that the number of specimens (clusters) of *Asplenium adulterinum* totalled 640, including 510 (80%) clusters growing on the Kiełczyńskie Hills. The populations inhabiting the Kiełczyńskie Hills include two populations that are the most numerous, one with 250 specimens and the other with 104 specimens. Based on the comparison of the monitoring results with data from previous observations, it can be seen that the number of specimens in most populations has risen in the last decade.

There are historical records suggesting that ladder spleenworts used to grow on walls in Witoszów and on the ruins of a fortress in Świdnica; however, their existence there has not been confirmed in the post-war period. In the 1960s, ladder spleenworts were still present on the Radunia Mountain in the mountain range of Ślęża (J. Fabiszewski, oral information). In 2004, the author (Żołnierz) reported

that ladder spleenworts had been found there again. Unfortunately, it was a mistake. The discovered specimens proved to be a hybrid form of the maidenhair spleenwort *Asplenium trichomanes*, which is very similar to A. adulterinum in spring just after the leaves appear. Maidenhair spleenworts can also be encountered on the ruins of a fortress in Świdnica. Therefore, the historical reports of the presence of ladder spleenworts there were presumably erroneous too.

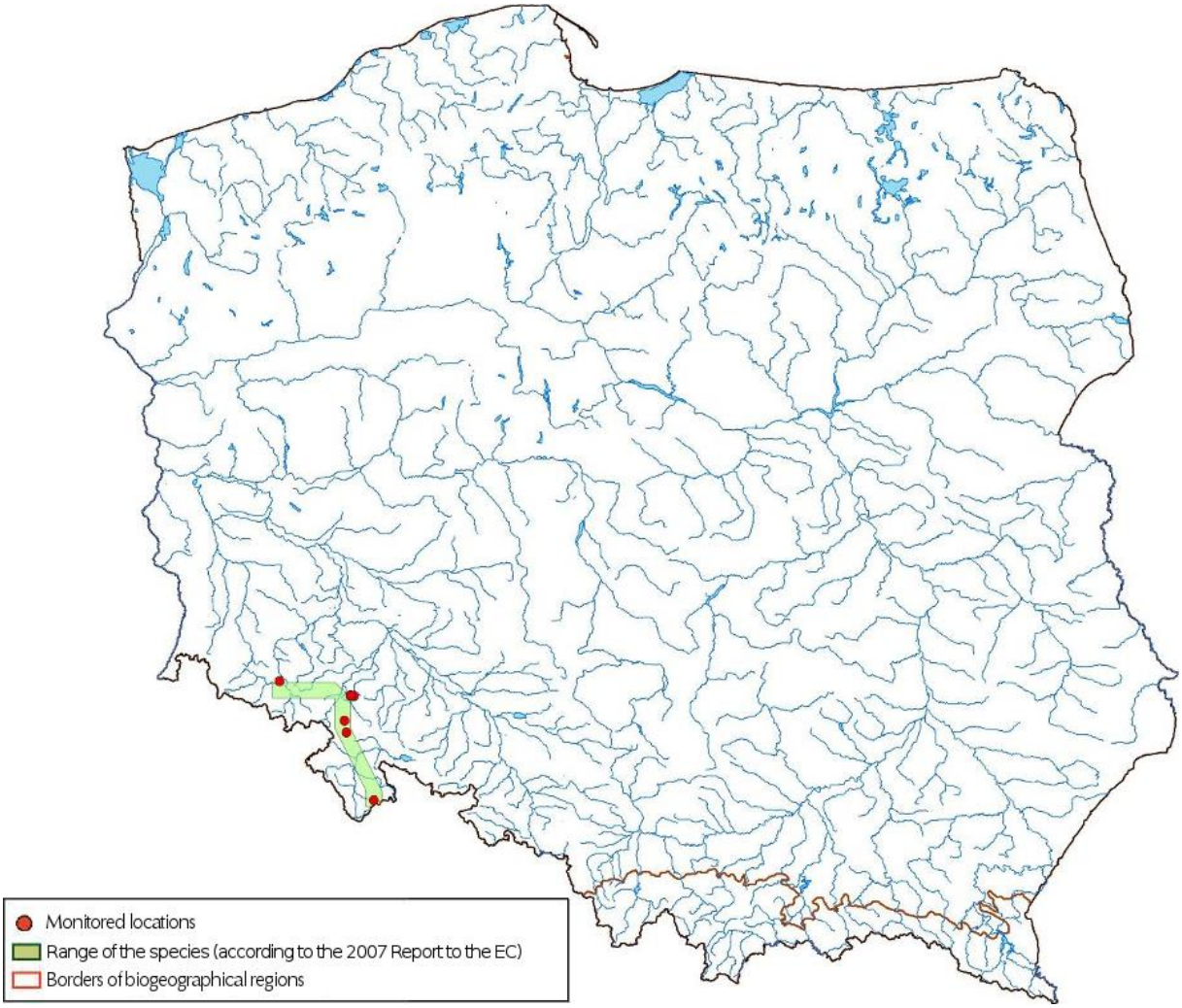

Fig. 1 The distribution of the monitoring locations compared with the geographical range of the species

II METHODOLOGY

1. Description of monitoring studies

Selection of monitoring locations

It is suggested that all the known twelve sites of this species should be covered by regular monitoring due to its high natural value at the European level and its significance for the specific flora composition of Lower Silesia, all the more so because the species is highly endangered and most of its populations have been declining in the last twenty years.

The site here is understood as a separate area with exposed serpentinite rocks or a group of serpentine rocks and clusters of ladder spleenworts, separated from other areas of the same type by a space of at least 50 m.

The area of the habitat at the site is the area of a polygon whose vertices are formed by the outermost specimens of the population. The area covered by the population: the total area (projection onto the horizontal plane) covered by clusters of ladder spleenworts at the site.

Time and frequency of studies

The best time for carrying out studies is mid-September, i.e. after most spores have been dispersed and before fronds dry out naturally. At that time, it is possible to carry out precise measurements of the sporulation performance and to minimize the risk of damage to plants as a result of any of the fronds having been torn off during counting or measurements. At sites with thinned-out tree stands, overexposed to sunlight, such an observation period also makes it possible to notice any signs of premature drying of fronds before the end of the growing season.

It is also advisable to carry out annual inspections of the most endangered sites, as well as periodic monitoring activities with measurements of all indicators, at intervals of three to five years.

Equipment used in studies

A GPS device will be helpful in establishing the location of sites. Other useful items include a measuring tape and metal rods ("pins") for delineating baselines (grids) during measurements of the area of sites performed with a laser target marker. A folding carpenter's ruler with a zero point placed at the edge is used for measuring the length of fronds and rock crevices. A digital camera will make it possible to document the condition of habitats and specimens or their assemblages. A camera with wide-angle lens will help to estimate the density of crowns of trees.

Table 1 The method of measuring the indicators used for assessing the condition of the population and the habitat

Index	Unit	Measurement method
Population		
Quantity	Number of specimens (pcs)	Calculation of clusters
Percentage of juvenile specimens	The number (pcs) % in the population	Counting; value as compared with the overall size of the population (%; a juvenile specimen is understood as a sporophyte with one, sometimes two fronds with a length of up to approximately 3 cm, with no remnants of petioles from the previous season
Health condition	Percentage of damaged specimens	Estimation of the percentage of damaged specimens (%) – observation and supplementation of the description of symptoms such as chloroses, death of clusters, poor sporulation performance, premature drying of leaves before the end of the growing season, bite marks left by herbivores, etc.
The number of fronds in the cluster	The average number of fronds per specimen	Counted for 20-30 randomly selected specimens or for all specimens in the case of less numerous populations.
The length of 5 longest fronds in the cluster	The average length of fronds	Measurements for 20-30 randomly selected specimens or for all specimens in the case of less numerous populations.

Index	Unit	Measurement method
Habitat		
Habitat area at the site	Area (m^2)	Measurement of the polygon comprising the outermost sites where particular specimens occur, using a laser target marker, with coordinates of contour points of the site in relation to the established baseline.
Area occupied by the population	Area (m^2)	Measurement (or estimation in inaccessible places) of the area covered by clusters of ladder spleenworts at the site.
Potential habitat area	Area (m^2)	Measurement (or estimation in inaccessible places) of the area of the site with microhabitats which would be suitable for ladder spleenworts to grow.
Overshadowing by trees and bushes	Estimation (%) of the density of crowns of trees and bushes.	It relates to the entire patch of the habitat where the species may potentially occur; Identify tree species occurring at the site (Polish and Latin names). Specify the average density on the basis of observations or on the basis of an analysis of photographs of the forest canopy taken in different parts of the site.
Intensity of competition	In a 3-step scale	In the microhabitat where the ladder spleenwort occurs, identify species competing with it (Polish and Latin names). Evaluate the intensity of competition using a three-step scale: no competition or competition of low intensity - 0, competition of medium intensity - 1, competition of high intensity - 2)
Invasive species	In a 3-step scale	In the patch where the ladder spleenwort occurs, identify present alien species (Polish and Latin names). Evaluate their impact using a 3-step scale: non-existent -0, medium - 1, strong - 2

2. Assessment of population and habitat condition indicators

The usefulness of pre-assessed indicators presented in this paper will be verified after the next monitoring period.

Table 2 Assessment of population and habitat condition indicators

Index	FV favourable	U1 unsatisfactory	U2 bad
Population			
Quantity	At least the same as in the previous monitoring period or >50 specimens.	Up to 10% smaller than in the previous monitoring period or 25-50 specimens	More than 10% smaller than in the previous monitoring period or <25 specimens
Percentage of juvenile specimens	>5%	1-5%	<1%
Health condition	<5%	5-20%	>20%
The average number of fronds in the cluster	No statistically significant differences or an increase	A statistically significant decrease of up to 20%	A statistically significant decrease of >20%
The average length of 5 longest fronds in the cluster	No statistically significant differences or an increase	A statistically significant decrease of up to 20%	A statistically significant decrease of >20%
Habitat			
Habitat area at the site	The same or larger in the next monitoring period	Smaller by up to 10% in the next monitoring period	Smaller by >10% in the next monitoring period
Area occupied by the population	The same or larger in the next monitoring period	Smaller by up to 10% in the next monitoring period	Smaller by >10% in the next monitoring period
Potential habitat area	The same or larger in the next monitoring period	Smaller by up to 10% in the next monitoring period	Smaller by >10% in the next monitoring period
Overshadowing by trees and bushes	50-90%	40-49% or 90-95%	<40% or >95%
Intensity of competition	0	1	2
Invasive species	0	1	2

Cardinal indicators

- Number
- Overshadowing by trees and bushes
- Intensity of competition

3. An example of a filled-in species observation sheet for a monitored location

Template of a filled-in species observation sheet for a monitored location with instructions for filling in particular fields

A species observation sheet for a monitored location	
Code of the species	4066 Asplenium adulterinum (ladder spleenwort)
Code and name of the area	Name of the monitored Natura 2000 site PLH020037 Góry i Pogórze Kaczawskie
Other forms of protection of the area within which the site is situated	Nature reserves, national and landscape parks, sites of ecological interest, documentation sites, etc. Rudawski Park Krajobrazowy
Name of the site	Name of the monitored location Janowice Wielkie
Site type	Reference/research research
Description of the site	Provide a description identifying the site in the area Anthropogenic site. A small rock wall facing south-east in an abandoned stone quarry overshadowed by a cluster of Quercus robur oak-trees and Betula pendula birch-trees. A part of the quarry situated in the direct vicinity of rocks with ferns is a popular location for organizing picnics and fun activities.
Area of the site	Area (in ha, a, m^2) Approximately 10 m^2
Geographical coordinates	Specify the geographical coordinates (GPS) of the site 15°56'...E 50°53'...N
Elevation a.s.l.	elevation of the site a.s.l. – or an elevation range – from... to... 450 m a.s.l.
The characteristics of the species' habitat at the site	general character of the area: e.g. meadow, warm grassland, a fragment of a forest, brushwood natural habitat type (natural habitat code/plant community/plant association) composition and age of tree stand/s (in the case of forest habitats) habitats in the vicinity of the site In the vicinity, there are fragments of thermophilous vegetation with sticky catchfly Viscaria vulgaris and bladder campion Silene vulgaris. Direct competitors of the ladder spleenwort include grasses: reed grass Calamagrostis arundinacea and wavy hair-grass Deschampsia flexuosa. In one of the rock crevices inhabited by the ladder spleenwort, there is also one specimen of the black spleenwort A. adiantum-nigrum. A population of that species overgrows the neighbouring rocks. Natural habitats: 8220 Rock walls and siliceous rocky slopes with vegetation of alliances Androsacion vandelii. 8220-1 Rock fissure communities of serpentine ferns.
Information about the species at the site	Synthetic information about the occurrence of the species at the site, research to date and other essential facts. Results of monitoring activities from previous years Ferns cover several rock crevices densely, some specimens grow on rubble deposits covering the sloping part of the rock. After strong fluctuations in the previous decades, a considerable increase in the size of the population has been observed in the last decade.
Observer	First name and surname of the local expert responsible for the site (as specified in the agreement). Ludwik Żołnierz
Dates of observations	Dates of all observations (as specified in partial forms) 19.08.2009

The description should be based on field observations. A proposal of an expert summary of observations carried out at the site as part of the project in the current year is presented below; the summary can be supplemented with one's own data collected previously at the site under analysis.
Evaluation of particular parameters: satisfactory (FV) / unsatisfactory (U1) / bad (U2) / unknown (XX).

Species protection status at the site				
Parameter/ indicators		**Value of the indicator and comments**	**Assess-ment**	
Population	Quantity	the number or density of specimens 53	FV	FV
	Percentage of juvenile specimens	The number of juvenile specimens 9 (17% of the population)	FV	
	Health condition	Health condition <5% of specimens in the population with signs of deterioration of health condition. All other specimens sporulate intensively with the exception of juvenile species.	FV	
	The average number of fronds in the cluster	The number of fronds in the cluster 16.37 ±2.14 A statistically significant (t-Student test, p =0,03) and almost twofold increase in value as compared with the last observation (based on observation results from 2004)	FV	
	The average length of 5 longest fronds in the cluster	The length of 5 longest fronds in the cluster 12.26 ±1.19 No differences as compared to the previous observation. (based on observation results from 2004)	FV	
Habitat	Habitat area at the site	Area (in ha, a, m^2) 3 m^2	FV	FV
	Area occupied by the population	Area (in ha, a, m^2) Approximately 0.5 m^2	FV	
	Potential habitat area	Area (in ha, a, m^2) Approximately 7 m^2	FV	
	Overshadowing by trees and bushes	% or assessment in a 3-step scale in comparison with the patch where the species occurs (acreage occupied by the population) 40-60% Common oak Quercus robur, warty birch Betula pendula, scots pine Pinus sylvestris	FV	
	Intensity of competition	Species (Polish and Latin name) and % coverage in the patch where the species occurs Reed grass Calamagrostis arundinacea, Wavy hair grass Deschampsia flexuosa 1 – 2 from moderate to considerable	U2	
	Invasive species	0 - none	FV	
Conservation prospects		site in the context of the sustainability of the population, availability of an appropriate habitat, existing and potential risks, as well as other information, e.g. own previous data) Species sustainability prospects In the last decade, the size of the population has increased considerably, even though significant fluctuations were observed in the previous decades. The main risk factors for the population are as follows: 1. Unfavourable random events associated with permanent and intensive human activity. 2. Strong competitive pressure from co-occurring species, mostly grasses.	FV	
Active protection measures and their effectiveness		Specify visible signs of protective measures, possibly relying on previous knowledge obtained in the past (protection plans, etc.) In the last 20 or so years, irregular attempts have been made to remove grasses competing with ferns and to remove plant debris from sites where fern spores could germinate. In the last decade, the size of the population has increased considerably, however, there is no evidence that there is a causal relationship between this increase and the performed procedures, as no detailed observations were carried out.		
Overall assessment			**FV**	

The list of the most significant impacts affecting the species and its habitat at the monitored location (including its use). Impacts should be coded in accordance with Appendix E to the Standard Data Form for Natura 2000 sites.

Current impacts				
Code	**Operation**	**Intensity**	**Impact**	**Synthetic description**
690	Other possible impacts of recreational and sports activities	A	-	The area adjacent to the site is a popular location for organizing picnics and fun activities.
971	Competition	A	-	A part of the population is strongly affected by competition from reed grass Calamagrostis arundinacea and wavy hair-grass Deschampsia flexuosa.

A list of factors that may pose a threat to the species and/or its habitat over a longer term (future, anticipated impacts, such as for example planned investments, changes in management and use, urban sprawl pressure). Threats should be coded in accordance with Appendix E to the Standard Data Form for Natura 2000 sites If there is no proper code - only a description should be provided in the table "Other information" in the field "Other comments".

Threats (foreseeable future impacts)				
Code	**Name**	**Intensity**	**Impact**	**Synthetic description**
250	Harvesting / removal of plants - in general	C	-	There is a potential risk that some specimens may be removed by collectors.
690	Other possible impacts of recreational and sports activities	A	-	The area adjacent to the site is a popular location for organizing picnics and fun activities.
950	Biocenotic evolution	B	-	In the course of succession by plants growing on the rubble deposits covering rock crevices, ferns may be forced out from this part of the site.
971	Competition	A	-	Pressure from competitors may become stronger due to contaminated precipitation eutrophying the habitat - the scale of this phenomenon is unknown.

Other information	
Other natural values	Other observed animal and plant species listed in the Annexes to the Habitats and Bird Directives: endangered (Red Book) and rare species/ protected species (their numbers should be classified as follows: abundant, average, rare); other exceptional qualities of the area On the rocks in the vicinity of the population of ladder spleenworts, there is a population of black spleenworts A. adiantum-nigrum, consisting of 34 specimens. It is a species protected by law, included in the Red Book.
Other observations	All information that helps to interpret the results, e.g. weather anomalies None
Methodological remarks	Any other comments associated with performed work. Most of all, information relevant for further planning of monitoring (work methodology, indicators to be used for monitoring purposes, the optimal time for carrying out research in this region, etc.) The area of the potential habitat can be wrongly estimated due the subjectivity of the observer. It seems that estimations should be limited to microhabitats closely resembling (in terms of their properties) the ones used by ladder spleenworts, but occupied by competitive species, rock crevices filled with leaves fallen from trees, etc.

A drawing of the site can be enclosed, containing:

- distribution of the species within the site (assemblages)
- marked locations where phytosociological relevés were taken.

Photographs to be enclosed: (specify the titles/number and authors of all photographs, in an electronic format, attached to the site observation forms – at least 2 photographs per stand – preferably a general view and the structure of the plant community comprising the monitored species.

4. Species with similar ecological requirements

The habitats occupied by ladder spleenworts *Asplenium adulterinum* are likewise used by serpentine spleenworts *A. cuneifolium* and black spleenworts *A. adiantum-nigrum*. Apart from "serpentinite spleenworts", other components of the vegetation at the sites of *A. adulterinum* include maidenhair spleenwort *A. trichomanes*, northern spleenwort *A. septentrionale* and the common polypody *Polypodium vulgare*. The proposed methodology can be adopted for the purpose of monitoring the above-mentioned species.

5. Protection of the species

The ladder spleenwort together with other species of the so-called "serpentinite ferns" has been protected as a species since 2004. Under Regulation of the Minister of the Environment, it is required to delineate a protection zone with a width of 30 cm from the edges of its sites. Active protection measures must be undertaken too.

The proposed active protection measures (Żołnierz 1993, 1997, 2001, 2004, Szczęśniak 2006, Świerkosz et al 2007, Żołnierz et al 2008) at sites occupied by *Asplenium adulterinum* include:

- modification of tree stands within sites and in their surroundings in order to ensure optimum shading and other micro-climate parameters;
- removal of expansive competitors (with utmost care to avoid any damage to ferns);
- at some sites, it seems advisable to clean some rock crevices in order to transform them into suitable micro-habitats for ferns;
- securing an ex situ population in the event of adverse events which may jeopardize the survival of the species. The developed method of cultivation and multiplication of *Asplenium adulterinum* (Marszał et al 1999, Kromer et al 2006) makes it possible to secure all populations in the facilities of the Tissue Culture Laboratory of the Botanical Garden of the University of Wrocław.

Up to now, the only procedure out of the ones mentioned above which has been performed, although irregularly, is the removal of competitors at some sites where their pressure was particularly strong. The ex situ cultivation of the species is only conducted on an experimental scale. Promising results have been obtained after experimental cleaning of selected micro-habitats (crevices and soil at the foot of rocks) at one of the sites, where juvenile specimens were discovered in the following year (Żołnierz, unpublished data).

Three out of the eleven sites of the species are protected as sites of ecological interest (Żołnierz 1997). It seems appropriate to establish such a form of protection for other sites too. The site in Kamionki is the only one which is occupied by all the three species of "serpentinite ferns". There, the population of black spleenworts *Asplenium adiantum-nigrum* is the largest in Poland. Therefore, it deserves the status of a flora reserve.

As can be concluded from field observations, it is necessary to provide training for employees of the forest districts where populations of the ladder spleenwort occur, to make sure that they exercise proper care when performing forestry tasks in the vicinity of sites and intervene on an ongoing basis if any adverse phenomena take place.

6. References

Bucharová A., Münzbergerová Z., Tájek P. 2010. Population biology of two rare fern species: long life and long-lasting stability. American Journal of Botany 97 (8): 1260-1271.

Čeřovský J., Klaudisová A. 1999. *Asplenium adulterinum* Milde. – W: Čeřovský J., Feráková V., Holub J., Maglocký S., Procházka F. (red.) Červená kniha ohrozených a vzácných druhom rastlin a živočichov SR a ČR. Vol. 5. Vyššíe rastliny. Príroda a.s., Bratislava., s. 46.

Ellenberg H., Düll R., Wirth V., Werner., Paulißen D. 1992. Zeigerwerte von Pflanzen in Mitteleuropa. Scripta Geobotanica 18, 2 Auflage, Verlag Erich Goltze KG, Göttingen, 248.

Fabiszewski J., Kwiatkowski P. 2002. Threatened vascular plants of the Sudeten Mountains. Acta Soc. Bot. Pol. 71 (4): 339-350.

Fiek E. 1881. Flora von Schlesien. Breslau, 571 pp.

Karpowicz W. 1963. Paprocie na serpentynitach w Polsce. Fragm. Flor. Geobot. 9: 35-57.

Kącki Z., Dajdok E., Szczęśniak E. 2003. Czerwona lista roślin naczyniowych Dolnego Śląska. W: Kącki Z. (red.) Zagrożone gatunki flory naczyniowej Dolnego Śląska. Instytut Biologii Roślin, Uniwersytet Wrocławski, Polskie Towarzystwo Przyjaciół Przyrody "Pro Natura", Wrocław, 9-65.

Kromer K., Marszał-Jagacka J., Kępińska K., Nowak T., Żołnierz L., Poturała D., Świerkosz K. 2006. *In vitro* propagation and *ex situ* preservation of endangered Ferns from Lower Silesia. Botanical Guidebooks 29: 303-312.

Křisa B. 1997. *Asplenium* L. sleziník. W: Hejný S., Slavík B. 1997. Květena České Republiky 1. Akademia, Praha, 242-248.

Lovis J. D., Reichstein T. 1968. Über das spontane Entstehen von *Asplenium adulterinum* aus einem natürlichen Bastard. Naturwissenschaften 55 (3): 117-120.

Marszał J., Kromer K., Nowak T. 1999. Ochrona paproci serpentynitowych z Masywu Ślęży i możliwości ich rozmnażania in vitro. Prace Ogrodu Bot. Uniw. Wroc. 5 (1): 415-422.

Reichstein T. 1984. *Aspleniaceae*. W: Hegi G. Illustrierte Flora von Mitteleuropa. 3 Aufl. Bd 1.1: 211-275.

Schube T. 1903. Die Verbreitung der Gefäßpflanzen in Schlesien preußischen und österreichischen Anteils. Nieschkowsky, Breslau, 361 pp.

Szczęśniak E. 2006. *Asplenium* Serpentine Ferns in Poland – Threats and Conservation Imperatives. Botanical Guidebooks 29: 89-97.

Świerkosz K., Perzanowska J., Mróz W. 2004. Ściany skalne i urwiska krzemianowe ze zbiorowiskami z Androsacetalia vandellii. W: Herbich J. (red.): Murawy, łąki, ziołorośla, wrzosowiska, zarośla. Poradniki ochrony siedlisk i gatunków Natura 2000 – podręcznik metodyczny. Ministerstwo Środowiska, Warszawa. T. 3: 57-72.

Świerkosz K., Szczęśniak E. 2003. Stan populacji i zagrożenia wybranych gatunków naskalnych na Dolnym Śląsku. – W: Kącki Z. (red.) Zagrożone gatunki flory naczyniowej Dolnego Śląska. Instytut Biologii Roślin, Uniwersytet Wrocławski, Polskie Towarzystwo Przyjaciół Przyrody "Pro Natura", Wrocław, 69-83.

Świerkosz K., Żołnierz L., Kromer K. i inni. 2007. Krajowy plan zarządzania gatunkiem: zanokcica serpentynowa – Corrupt spleenworth (*Asplenium adulterinum*). Ministerstwo Środowiska, Warszawa 2007 (PL2004/IB/EN-03).

Żołnierz L. 1993. Paprocie serpentynitowe w Masywie Ślęży. Annales Silesiae 23: 77-91.

Żołnierz L. 1997. Dokumentacja przyrodnicza projektowanych użytków ekologicznych na stanowiskach paproci serpentynitowych w Ślężańskim Parku Krajobrazowym. Dep.: Dolnośląski Urząd Wojewódzki we Wrocławiu (mscr).

Żołnierz L. 2001. *Asplenium adulterinum* Milde – Zanokcica serpentynowa. – W: Polska Czerwona Księga Roślin. Paprotniki i Rośliny kwiatowe R. Kaźmierczakowa K., Zarzycki (red.), Instytut Botaniki im. W. Szafera PAN, Instytut Ochrony Przyrody PAN, Kraków, pp.: 49-51.

Żołnierz L. 2004. Zanokcica serpentynowa *Asplenium adulterinum*. – W: Sudnik-Wójcikowska B., Werblan-Jakubiec H. (red.). Podręcznik ochrony siedlisk i gatunków Natura 2000. Tom 9. Gatunki roślin. Ministerstwo Środowiska, Warszawa, 47-51.

Żołnierz L., Kromer K., Świerkosz K. 2008. Ladder spleenwort (*Asplenium adulterinum* Milde) in Poland - distribution, population state and conservation plan framework - W: E. Szczęśniak, E.

Gola (red.). Club mosses, horsetails and ferns in Poland - resources and protection. Institute of Plant Biology University of Wrocław, Wrocław, p. 29-46, ISBN 978-83-61764-00-7.

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