Biodiv. Res. Conserv. 19: 93-102, 2010

10.2478/v10119-010-0025-z

BRC
www.brc.amu.edu.pl

Grasses in Poland: invincible, but threatened

Ludwik Frey

Department of Systematics of Vascular Plants, W. Szafer Institute of Botany, Polish Academy of Sciences, Lubicz 46, 31-512 Kraków, Poland, e-mail: L.Frey@botany.pl

Abstract: The paper presents problems connected with expansiveness and threats of grasses in Poland. Some subjectively selected grass species are given. They have conventionally been divided into two opposite groups: (*i*) expansive or even invasive grasses, referred to here as "invincible", and (*ii*) grasses that are threatened for a variety of reasons, and deserving protection.

Key words: grasses, Poaceae, expansion, invasion, threat, protection, Poland

1. Introduction

Cosmopolitan grasses are among the most important families in the kingdom of flowering plants. In terms of the number of species (ca. 10 thousand) they rank fourth behind Asteraceae, Fabaceae and Orchidaceae. Areas where grasses form the dominating form of vegetation, e.g. steppes, savannas, prairies or pampas, cover nearly one-third of the world landmass. In terms of production these areas are second only to forests (Clayton & Renvoize 1986; Weiner 1999; Frey 2000).

The author of the Latin diagnosis of the family Gramineae (called order – Genera plantarum 1789) was A. L. de Jussieu. An alternative name – Poaceae – was introduced by an American botanist, J. H. Barnhart (Barnh. 1895, Bull. Torrey Bot. Club 22:7). Both these names are deemed legitimate.

Against the background of subjectively selected examples of grass species, this paper discusses briefly, on the one hand, issues associated with their expansiveness or even invasiveness and, on the other, the pressing need to protect them. Poaceae have conventionally been divided into two opposite groups: expansive grasses, that extend their distribution areas even by means of invasions, referred to here as „invincible", and other grasses that are threatened for a variety of reasons, some of them even deserving protection.

2. Invincible grasses

Grasses have a characteristic external structure and show distinctive embryological and physiological features. Owing to these characteristics they can manifest extraordinary adaptation abilities and are able to live under disadvantageous conditions, either natural or modified by Man. Grasses can grow under considerably diverse ecological conditions, from very wet to extremely dry, and from hot to Arctic cold. They occur in almost all types of habitats, from sea coasts to high mountains, and from the Equator to the Polar regions (Frey 2000). Under favourable conditions, grasses become expansive or even invasive plants.

In Poland it is difficult to find native grass species showing evident expansive tendencies. These are not shown even by those grass species regarded as invasive in some other regions, such as *Aira caryophyllea* in Australia, New Zealand, and the Americas, where it colonizes coastal areas upon sea and water bodies, as well as forests and meadows, *Leersia oryzoides* that spreads along river banks and on grasslands of Australia (in Poland, both these species are among those disappearing or classed as endangered species), *Ammophila arenaria* that threatens coastal dunes in Australia, New Zealand, and North America, *Elymus repens* – a species dangerous to farmlands as well as grass communities (prairies, meadowlands) in both of the Americas and in

Australia, and *Phragmites australis*, which colonizes similar habitats in North America and Australia. Only several native species, such as *Elymus repens* or *Calamagrostis epigejos*, implement the model of ecological expansion in Poland (Jackowiak 1999), and display an extraordinary ability to colonize new habitats, often on very contaminated soils (Tokarska-Guzik 2007).

Man contributed to the spread of some native species of grasses such as *Ammophila arenaria* and *Leymus arenarius*. Their natural distribution is restricted to the coastal dune belt. Maps of their distribution in Poland show, however, many locations further inland (more numerous of *L. arenarius*, fewer – of *A. arenaria*) that are not of natural character (Zając & Zając 2001). As both species are important as anti-erosion grasses, they have been introduced (particularly *L. arenarius*) on inland sites either as sand stabilizers or decorative plants. For example, information on cultivation of *L. arenarius* on a location situated far inland, in the Lublin area near Kock was reported as early as 1829 (Waga 1847; Korniak & Urbisz 2007).

The other type of expansion in the meaning applied by Jackowiak (1999), i.e. chorological (territorial) expansion, which consists in a species penetrating outside its natural distribution area, is shown chiefly by archaeophytes. The species which may be included in this group are e.g. *Apera spica-venti* and *Avena strigosa*, grasses which reach their optimum in segetal habitats (in Bohemia, *A. spica-venti* is regarded as an invasive species – Pyšek *et al*. 2002), *Avena fatua, Echinochloa crus-galli*, *Hordeum murinum*, *Setaria viridis* and *Alopecurus myosuroides*.

In recent times, three of the aforementioned species have evidently been increasing the number of their locations in Poland.

Hordeum murinum occurs in Europe, from Spain to the Ukraine; its northern limit extends through the British Isles, the Jutland Peninsula to the southern tip of the Scandinavian Peninsula (Mizianty 2006). In Poland a typical subspecies (subsp. *murinum*) is found. This archaeophyte, naturalised in our flora, has distinctly low habitat requirements. It grows in synanthropic locations, devoid of natural vegetation (rubble heaps, embankments, walls) and it is regarded as a pioneer species. Its distribution area extends mainly as a result of human activity. Until recently, it has been recorded throughout Poland, except for the north-eastern part (Zając & Zając 2001), where its spread has been very rapid nowadays. Nonetheless, as of now, it still occurs there much less frequently than in the other areas of Poland (Mizianty 2006). This taxon owns its expansiveness, particularly in urban situations, to rapid ripening and self-pollination, as well as the production of huge numbers of seeds with awns having hooked hairs, facilitating their transport by humans and animals (Bieniek 2010).

Alopecurus myosuroides is also an expansive grass species, and most recently – perhaps even invasive. The area of its natural range includes the southern and western regions of Europe. In both Central Europe and Poland this species is recorded, first of all, in segetal associations. In Poland it spreads chiefly in lowlands and in the upland belt, where it reaches the northern limit of its European range. This grass can adversely affect the yield of cereals, especially in places where it occurs in high densities per square metre. It is resistant to frost and herbicides, produces great numbers of seeds and is capable of growing new inflorescences after the crop is mown (Korniak 2003; Tokarska-Guzik 2007; Dajdok & Szczęśniak 2009).

Avena strigosa originated from the Mediterranean region. Presumably, the Iberian Peninsula was the centre of its origin and differentiation. As late as in the second half of the 20th century it was found as a grain cultivar or weed in many European countries, for example in Poland, and particularly in its southern and central parts. After its cultivation had been discontinued, it seemed to head into complete disappearance from the area of Poland (Frey 1991a, 1991b). In recent years, however, this grass has embarked on a new period of expansion, especially in the north-eastern part of the country. It is all the more interesting, because the data on its occurrence in this region have been lacking until recently. The species grows chiefly in segetal habitats, and rarely in ruderal ones (Frey 1991a; Korniak 1997; Korniak & Urbisz 2007).

In Poland the truly expansive grasses are those of alien origin, largely kenophytes. They constitute a sizeable percentage of Polish flora and their share has grown in recent decades. Hence, the first preliminary list of kenophytes (Kornaś 1968) included only 4 grass species, and according to Zając *et al*. (1998) among the 251 species representing new arrivals in the flora of Poland 13 were grasses.

The status of some species of grasses in the Polish flora has also changed. In the list of ephemerophytes compiled by Rostański & Sowa (1986-1987), which contains 662 species, 92 species were grasses, 5 of which are species now regarded as fully or locally naturalised plants.

As far back as 25 years ago, *Bromus carinatus* and *Eragrostis albensis* were listed as ephemerophytes, while now they are regarded as kenophytes, that are presently extending their secondary ranges.

Bromus carinatus occurs naturally in the western part of North America and in the south reaches of the Andes in Colombia. In Europe, the first locations were found at the beginning of the 20th century in Sweden, Belgium, the Netherlands, and Germany (Sutkowska & Pasierbiński 2009). In Poland it was first recorded in the Wielkopolska region in 1911 (Tokarska-Guzik

2005). Under the criteria proposed by some authors (e.g. Pyšek *et al*. 2004) it could be regarded as an invasive species. This grass was first introduced into Poland as a cultivated plant in the first half of the 20th century, under the name of *Bromus unioloides* Humb. & Kunth. From cultivation this grass spread onto anthropogenic habitats, and particularly ruderal ones. Outside urbanized areas it is increasingly often recorded in semi-natural habitats and therefore *B. carinatus* may be regarded as an agriophyte. The expansion of this species is helped by its resistance to low temperatures, with rapid growth stimulated by mowing and rapid ripening, as well as the possibility of reproducing both vegetatively and generatively (Tokarska-Guzik *et al*. 2006; Sutkowska & Pasierbiński 2009).

Eragrostis albensis (earlier described as *E. pilosa*) has rapidly increased the number of its locations in Poland, particularly in its south-eastern part, in anthropogenic habitats (Michalewska & Nobis 2005; Tokarska-Guzik 2007). The issue of the origin of this species has not yet been solved. Scholz (1996) regards it as a Central-European neoendemite, whereas Špryňar & Kubát (2004) are of the opinion that it is a neophyte, which probably originated from eastern Eurasia. It is not known how *E. albensis* arrived in Poland, although migration along river valleys is the most likely route. However, one cannot exclude the possibility that road and rail transport have also contributed to this spread (Michalewska & Nobis 2005).

For some time reports have been made of the spread of another kenophyte, *Beckmannia eruciformis*, which was introduced to Poland in the 19th century and was actively cultivated until the beginning of the last century. After its cultivation was discontinued, this grass stayed on, above all in the north-east of the country, where it grows on river banks and lake shores, and, sporadically, in segetal and ruderal habitats. The species has been classified as an agriophyte (Frey & Paszko 2000; Korniak & Urbisz 2007).

Grasses regarded as kenophytes, which are in the process of evident expansion in Poland (as well as other regions of Europe and the world) include, *inter alia, Anthoxanthum aristatum*, a species spreading as a weed accompanying crops, and also *Eragrostis minor* – a species associated primarily with urban habitats.

Anthoxanthum aristatum (= *A. puelli*) came from the Atlantic part of Western Europe. Its distribution range was presented by Meusel *et al*. (1965). In Central Europe, beginning in the early 19th century, it spread in various directions, albeit exclusively in ruderal and segetal locations. This grass was accidentally brought into Poland, into the regions of Pomerania and Wielkopolska, most probably in the early 19th century, and the main migration route of this species from the German Lusatian region was presumably the Central-Polish Lowlands (Kuźniewski 1996; Tokarska-Guzik 2005; Korniak & Urbisz 2007). As these accidental introductions were of an ephemeral nature, they were not noted. The first official records (from the Pomeranian and Silesian provinces) date back to the second half of the 19th century. It is interesting to note that until the year 1960 the species was not recorded in Central Poland. Later, increasingly numerous records appeared, detailing its presence in various regions of Poland (Warcholińska & Siciński 1976, 1996). *Anthoxanthum aristatum* grows primarily in fields of cereal crops, less frequently root crops, as well as sandy abandoned farmlands. It is also reported from railway sites and industrial waste heaps (Tokarska-Guzik 2005). The expansion of this species is facilitated by favourable edaphic and climatic conditions, as well as land management and land use regimes. As this grass eliminates other species, there are even suggestions that it should be controlled with herbicides (Warcholińska & Siciński 1976; Kuźniewski 1996).

Expansive or invasive abilities of grasses are sometimes manifested by ephemerophytes, i.e. species alien to the native flora, not yet naturalised, nor cultivated, and mostly brought in accidentally, often over great distances. Some 80 species of grasses, appearing most commonly in habitats heavily disturbed by human activity, are regarded as ephemerophytes (Korniak & Urbisz 2007; Urbisz 2007).

Some of these species were first introduced accidentally into Poland in the 19th century or in the first decade of the 20th century, and some in the 1920s. In the first group only two were observed over a longer period of time, including the end of the 20th century. These are *Cynodon dactylon* and *Phalaris canariensis*. Of the second group, only two species have survived till the present day: *Eragrostis cilianensis* and *Sorghum halepense* (Urbisz 2007). These can hardly be regarded as expansive species in our country, where they face climatic and biotic barriers.

In recent years several exotic plant species were noted for their "attempts" to establish themselves in Poland, including such species as *Cenchrus ciliaris*, found only in a few locations, which requires a warm climate for its development (Frey & Urbisz 2001), *Eleusine indica*, occurring naturally in tropical and subtropical regions which, when introduced in North America, has become an invasive species, but in Europe is confined mainly to the Mediterranean basin (Urbisz & Urbisz 2003), and *Tragus racemosus*, which occurs in the tropical and subtropical regions of Africa and Asia, from where it was accidentally introduced into Central Europe and North America to ruderal habitats (Urbisz & Węgrzynek 2007). It turned out that under climatic conditions prevailing in Poland these "attempts" were unsuccessful and the species were only recorded

in a single location, from which they rapidly disappeared.

On the other hand, the aforementioned *Cynodon dactylon* is an example of a species which is moderately expansive in Poland and, although still listed as an ephemerophyte, has a chance to stabilise permanently in synanthropic habitats associated with various methods of transport. Locations for this species were reported by several authors in the 1970s, 80s and 90s in warmer regions of Poland (Górski 1999). This would therefore represent an example of a situation, where climatic and biotic barriers have been overcome and of a permanent establishment of an ephemerophyte, which turns into an epecophyte or agriophyte. Among the species which attained this kind of success, the following examples might be mentioned: *Agropyron cristatum*, *Bromus japonicus* and *Hordeum jubatum* (Korniak & Urbisz 2007), which cannot be, however, regarded as expansive, let alone an invasive species.

The main underlying reason of the unusual adaptive and expansive abilities of Poaceae probably derives from the history of their emergence and development, and in particular in the frequent changes (both in time and space) of habitats they inhabit. Contacts between genetically diversified diploid populations provided opportunities for the emergence of hybrid forms (interspecific – more than 2000, and intergeneric – 800), as well as polyploids (ca. 70% of species). If the hybrids were infertile, they could stabilise their genotype through polyploidisation and acquire the ability to reproduce sexually. Grasses should therefore be regarded as plants which attained evolutionary success, because they retained the ability to develop further (Mizianty 1995; Frey 2000).

3. Threatened grasses

Despite the fact that grasses possess adaptive abilities, which can justify their being called "invincible", in the present era of "great extermination" they face many different, direct or indirect, threats. Usually protection is extended to a limited number of threatened species, mostly those which are of a distinctive size, beauty or attractiveness to the media (Wilson 2003). One can hardly apply these criteria to grasses as they are not regarded as attractive, chiefly because of their seemingly inconspicuous appearance. For this reason, even botanists do not perceive them as threatened and, by implication, as deserving of diverse methods of protection. Fortunately, plants of practical significance are also protected, and to a great extent this pertains also to grasses.

The causes of threats and the effects of the disappearance of certain grasses are also often overlooked or underestimated. However, their participation in many plant communities, their diagnostic importance for many syntaxa, as well as their role in the dynamics of phytocoenoses, are of huge significance. In Poland, ca. 150 species of grasses are of diagnostic value to the classification and systematics of plant communities. The diagnoses of close associations and other units of similar rank are based on grasses as character species. There are nearly 120 communities of evidently graminaceous character in Poland. It is difficult to point at a plant association not having grasses in their floristic compositions. Many names of syntaxa are derived from the Latin names of grasses (Balcerkiewicz 2007).

Grasses are also of great importance in creating landscape, because of their appearance and colour. They constitute elements of various types of landscape, especially agricultural, but also play a significant role in non-agricultural landscapes, such as mountain or coastal ones, and albeit to a lesser extent – forest and park landscapes (Kozłowski 2007). A number of species and varieties of grasses are used for special purposes in the so-called difficult habitats, e.g. on grounds destitute of soil formed from mine waste, on which they perform pioneering and soil-forming roles (Patrzałek 2007).

Threats to grasses may be considered either in relation to particular species or to the entire range of grassland associations. This paper concentrates mainly on threats to particular species of grasses. Threats to grassland associations and their protection was thoroughly presented and supported by examples given by Załuski (2007).

In Poland, legal protection covers only 10 species of grasses, including 8 that are under strict protection (Regulation by the Minister of the Environment of 9 July 2004). The consecutive Polish national "Red Lists" (Zarzycki 1986; Zarzycki & Szeląg 1992, 2006) contained 16, 24, and 30 species, respectively, whereas the Polish national "Red Books" (Zarzycki & Kaźmierczakowa 1993; Kaźmierczakowa & Zarzycki 2001), listed 13 and 16 species, respectively (Table 1).

The species of grasses enumerated in Table 1 were placed on the list of endangered species for a wide variety of reasons. In the opinion of the Author, several of them deserve special attention and will therefore be discussed in greater detail.

Coleanthus subtilis (Tratt.) Seidl. occurs in several European countries, but not all reported locations exist at the present time (e.g. in Norway and Italy), while others have not been confirmed of late (Slovakia). On the other hand, in some countries (e.g. in Austria) a species, recently considered extinct, has been found again. The highest numbers of existing locations were recorded in north-western France, south-eastern Germany and in the south of the Czech Republic (Dajdok 2009). In Poland *C. subtilis* is recognised as a protected species, but to date it has not been included either in the Polish „Red List" or in the „Red Book". However, it

Table 1. Grass species in the Polish red lists, red books and in Regulation of the Minister of Environment of 09 July 2004

Category of threat/ species	Red List 1986	Red List 1992	Red List 2006	Red Book 1993	Red Book 2001	Protected by law
Avenula planiculmis (Schrad.) W. Sauer & Chmelitschek	R	-	R	-	VU	-
Bellardiochloa (*Poa*) *violacea* (Bellardi) Chiov.	R	R	R	V	EN	-
Bromus arvensis L.	-	-	E	-	-	-
Bromus racemosus L.	V	V	V	-	-	-
Bromus secalinus L.	-	-	V	-	-	-
Coleanthus subtilis (Tratt.) Seidl.	-	-	-	-	-	SP
Deschampsia setacea (Huds.) Hack.	Ex	Ex	Ex	Ex	Ex	-
Elymus farctus (Viv.) Runemark ex Melderis	V	E	E	E	CR	-
Elymus hispidus (Opiz) Melderis	-	-	R	-	-	-
Festuca amethystina L.	I	V	-	V	VU	SP
Festuca makutrensis Zapał.	-	R	-	R	VU	-
Festuca pallens Host	-	-	[V]	-	-	-
Festuca pseudodalmatica Krajina ex Domin	-	R	-	R	-	-
Festuca pseudovina Hack. ex Wiesb.	-	R	-	R	VU	-
Festuca valesiaca Schleich. ex Gaudin	-	-	V	-	-	-
Hierochloë australis (Schrad.) Roem. & Schult.	-	R	V	-	-	(PP)
Hierochloë odorata (L.) P. Beauv.	-	R	V	-	-	(PP)
Koeleria pyramidata (Lam.) P. Beauv.	-	-	R	-	-	-
Lolium remotum Schrank	-	E	E	-	-	-
Lolium temulentum L.	-	-	V	-	-	-
Melica ciliata L.	I	I	E	-	CR	-
Melica picta K. Koch.	-	-	R	-	-	-
Melica transsilvanica Schur	-	-	R	-	-	SP
Poa glauca Vahl	I	I	R	-	-	-
Poa granitica Braun-Blanq.	-	-	-	-	LR	SP
Poa nobilis Skalińska	-	R	R	I	DD	-
Puccinellia capillaris (Lilj.) Jansen	-	-	R	-	-	-
Puccinellia maritima (Huds.) Parl.	V	E	E	E	CR	-
Sclerochloa dura (L.) P. Beauv.	R	R	R	-	-	-
Scolochloa festucacea (Willd.) Link	R	R	-	-	-	-
Sesleria bielzii Schur	R	E	R	R	VU	-
Sesleria uliginosa Opiz	-	V	V	-	-	-
Stipa borysthenica Klokov	-	V	V	V	CR	SP
Stipa capillata L.	-	-	V	-	-	SP
Stipa joannis Čelak s. str.	R	V	V	V	VU	SP
Stipa pulcherrima K. Koch.	R	V	V	V	VU	SP
Trisetum fuscum (Kit. ex Schult.) Roem. & Schult.	R	R	-	-	-	-
Trisetum sibiricum Rupr.	R	R	-	-	LR	-
Vulpia myuros (L.) C. C. Gmel.	-	-	V	-	-	-

Explanations: Ex – extinct and missing; CR – critically threatened; E, EN – endangered; V, VU – vulnerable; [V] – vulnerable at isolated localities, situated beyond the main area of occurrence; LR – species of lower risk; R – rare; I/DD – species of indeterminate threat, data deficient; SP – species strictly protected; (PP) – species under partial protection

was included as critically endangered (CR) in the "Red List" of vascular plants of the Lower Silesia region (Kącki *et al*. 2003). Perhaps the reason was that the species has recently been noted in only a single locality from the surroundings of Borowa Oleśnicka in the Lower Silesia (Fabiszewski & Cebrat 2003). This population has survived till now and has even increased in numbers. In 2008 a new location was found near Ruda Milicka, some 40 km north of the first location. It is possible that aquatic birds acted as vectors in transporting diaspores. Periodic denudation of the bottom of some of the banks of water bodies and protecting them from pollution is advantageous for the survival of this species (Dajdok 2009). It is beyond doubt that this species should be included in the new editions of the Polish "Red List" and "Red Book" of plants.

Elymus farctus grows along European coasts, from Portugal to Finland. In Poland it is represented by subsp. *boreoatlanticus* and is a very rare taxon occurring most often on fore dunes, rarely on white dunes. For this reason it was included in all the three Polish "Red Lists" and in the two "Red Books" of plants published to date, in categories V, E and CR (Zarzycki 1986; Zarzycki & Szeląg 1992, 2006; Stasiak 1993; Frey 2001b), and in category E – on local lists for the Western Pomerania (Żukowski & Jackowiak 1995) and the Gdańsk Pomerania (Markowski & Buliński 2004) regions. Of 20 reported localities only several have survived to this day: on the islands of Uznam and Wolin, upon the Puck Bay and in the town Unieście, north of Koszalin (Frey 1999; Frey 2001a; Frey & Szczepaniak 2001). It should be feared that the number of localities will decrease primarily

because of the destruction of habitats and as such this taxon could become regarded as extinct, similarly to *Deschampsia setacea* (Frey 2001b). Natural threats are primarily storms and aeolian abrasion, whereas anthropogenic threats include the destruction of localities by tourists and the levelling of dunes (Frey & Szczepaniak 2001). Placing *E. farctus* subsp. *boreoatlanticus* on Polish "Red Lists" and in the "Red Books" or monitoring their populations will not stop it from vanishing, and although placing it under a strict protection regime seems advisable, it is not very realistic because the whole biotopes should be protected, perhaps as natural reserves. Potential protection *ex situ* would be very difficult because of the narrow environmental amplitude of this taxon and its specific habitat requirements.

Lolium remotum is a specialised weed living in flax fields. It is an archaeophyte occurring in Central and Eastern Europe. In Poland it has been present ever since the 1950s and 60s (Szafer 1919; Szafer *et al*. 1986; Kucharczyk 2005). As a result of herbicide application and adopted advanced methods of cleaning seed lots, coupled with the reduction of areas under flax cultivation, this species has became rare and also – a species endangered throughout the country. In the Polish "Red Lists" it is included in category E (Zarzycki & Szeląg 1992, 2006) and in many regions of Poland it has become extinct – a fact reflected in the local "Red Lists" (vide – Piękoś-Mirkowa & Mirek 2007). On the distribution map for this species its localities are shown as "unconfirmed", "uncertain" and "extinct" (Zając & Zając 2001). The sparse data on its occurrence in untypical habitats pertain mainly to towns (Gdańsk and Zgierz), where it has appeared from time to time, after being accidentally introduced (Misiewicz 2001; Bomanowska & Witosławski 2009). Although in the years 2003-2004 a total of 13 locations were found on the Lublin upland and the Roztocze region (Kucharczyk 2005), this does not alter the fact that *L. remotum* is still a critically endangered species. Its occurrence is only possible in areas where flax is cultivated by traditional methods and the application of herbicides is limited.

Scolochloa festucacea is distributed in the temperate region of the northern hemisphere. One of the newer distribution maps was presented by Conert *et al*. (1998). In Poland it reaches the local southern limit of its distribution. Prior to 1950, little more than 30 locations were recorded in Poland, but many of these have not been confirmed recently. In the second half of the 20th century the number of locations of this species decreased markedly, and in the 1990s a mere 15 were reported (Frey 2005). As it is a species of wet and moist habitats (a component of the *Phragmition* alliance, but sometimes treated as a character species of *Scolochloetum festuceae* Rejewski 1977), any adverse alterations in the water regime represent the most important threat to the species, including primarily incorrect farm or forest management. Much more rarely the species is being threatened by direct destruction (Frey 2001a, 2005, 2009). The threat faced by *S. festucacea* in Poland is not assessed explicitly. The species appeared twice as "rare" in the Polish "Red Lists" and it was not included in the most recent "Red List". In several local "Red Lists" it was included in the category of vulnerable (VU), or even endangered species (EN) (vide – Piękoś-Mirkowa & Mirek 2007). It seems that according to the IUCN (2001) criteria this species should again be entered in the Polish "Red List" in the VU category.

Trisetum sibiricum is widely distributed in Asia, reaching the Far East. Its distribution in Europe is limited to the eastern part of the continent (principally Russia and Poland). Poland is crossed by a fragment of the western border of this taxon's range, which until very recently was confined to north-eastern part of the country. In the last two decades of the 20th century some localities were recorded outside its natural range (Ceynowa-Giełdon 1988; Frey 1992; Frey *et al*. 2001; Gawenda & Załuski 2001). The number of localities within the range occupied to date is also increasing. Perhaps the species is extending its range, or it is now being distinguished better from the similar *T. flavescens* (Frey 1992). As a consequence, this could be the reason behind the absence of *T. sibiricum* from the 2006 "Red List", even though it was included in the national "Red Lists" in 1986 and 1992 (Zarzycki 1986; Zarzycki & Szeląg 1992, 2006). However, it was included in the second issue of the "Red Book" in the lower risk category (LR). In two regional "Red Lists" – in the Kujawy-Pomerania region and the Podlasie province – it was entered as vulnerable (VU) and near threatened (NT) (vide Piękoś-Mirkowa & Mirek 2007). It seems justified that this species should be left on a list of plants threatened to some degree, despite the growing number of confirmed locations and a fairly numerous population. However, being a glacial relict, it is still a rare species and as a typical resident for natural fens is still potentially threatened. This fact is associated with the draining of peat bogs and their conversion into permanent grasslands. For this reason, the protection of species should be primarily associated with the protection of habitats and above all, those focusing on the preservation of existing water regimes (Frey *et al*. 2001).

Among plants which are endangered in Poland there are four endemic species of grasses, deemed valuable from the botanic viewpoint (Table 1). These are *Festuca amethystina* subsp. *ritschli* – endemic to the Polish lowlands, *Trisetum fuscum* – a Pan-Carpathian endemic species, and *Poa granitica* and *P. nobilis* – two species endemic to the Tatra Mountains.

Festuca amethystina subsp. *ritschli* was included in categories R and VU on several regional "Red Lists", and even regarded as being locally extinct – in the Kujawy-Pomerania region (vide – Piękoś-Mirkowa & Mirek 2007). In the Wielkopolska region it is currently deemed to be vulnerable (Jackowiak *et al*. 2007), while by Żukowski & Jackowiak (1995) it was included in category R. On account of the fact that populations of this grass are few and locations scattered, this shows that it has specific habitat requirements. Additionally, the heliophilous oak forests, in which it grows, are disappearing (Jakubowska-Gabara 2001) and therefore it deserves consideration as an endangered species – category EN.

Poa granitica and *P. nobilis* occur only in the Tatra Mountains (the former appears on the World Conservation IUCN Red List of Endangered Species and is also covered by the Berne convention as a protected species) and of late have been deemed to be LR and DD species, respectively. One of the reasons given was that they are already sufficiently protected as they grow in the Tatra National Park. As regards *P. nobilis*, it was found that possible protection measures may only be determined after gathering precise data on the distribution, population numbers and dynamics (Mirek & Piękoś-Mirkowa 2009). It seems, however, that upgrading threat categories for both species should be considered or, at least, *P. nobilis* should be regarded as a lower risk (LR) species.

Trisetum fuscum was last entered in the "Red List" in 1992 (category R). Recently it has been regarded as not being under threat, although this decision seems premature. In Poland the species occurs only in the Tatra Mountains, with the centre of its distribution in the subalpine and alpine belts. It often grows in inaccessible places and thus it is not at risk of direct destruction, although the details of its biology are not yet sufficiently known. Therefore the dynamic tendencies of the population are unknown. Moreover, some of the several dozen reported locations have not been confirmed recently. For these reasons, it would be worthwhile to place *T. fuscum* on the "Red List", at least as a DD species (Frey 1992; Zarzycki & Szeląg 1992; Piękoś-Mirkowa *et al*. 1996; Piękoś-Mirkowa & Mirek 2007).

From outside the list of species given in Table 1, two are worth mentioning: *Aira caryophyllea* and *A. praecox*. The former of the species occurs principally in Europe, but it is reported, as accidentally introduced, from the Americas, South Africa, and New Zealand, where it enters coastal habitats, woods and heathland, meadows, and disturbed habitats, thereby becoming an invasive plant. In Poland, however, it is a rare native species. *Aira praecox* is a sub-Atlantic species reported mainly from the western and central parts of Europe. The largest concentrations of locations of both species occur in the Lower Silesia and along the western and eastern parts of the Baltic coast. In Poland both species reach the eastern limit of their distribution, which probably does extend beyond the geographical longitude of 21° east (Frey 1994). To date these species have never been included in the Polish national "Red List", only in the regional "Red Lists" (*A. caryophyllea* on 9, *A. praecox* on 5 such lists – vide Piękoś-Mirkowa & Mirek 2007) and categorised as being either vulnerable or endangered. Additionally, these two species are constituents of inland psammophilous swards of the *Koelerio-Corynephoretea canescenstis* class, which are at risk of destruction resulting from either natural or anthropogenic factors. It would be advisable to include both *A. caryophyllea* and *A. praecox* in the Polish national "Red List" (in category R), even though their existence is not immediately under threat.

Grasses (not only those threatened) are still not studied in sufficient detail regarding their biology and ecology. Without such comprehensive studies (often basic research) it is difficult to classify them into appropriate categories of threat and as such to undertake sensible protection measures.

In some cases, allocating species of grasses to particular categories is based on information that is not updated and has not recently been verified in the field. As a result, the true extent of the threat to them in Poland is not known. It seems that some species should be allocated to other categories of threat than those, in which they are currently categorised, whereas some other species should be included in "Red Lists" or entered into the "Red Book".

A list of threatened grass species, verified and based chiefly on field research, should be created, augmented by data on their locations, resources and habitat requirements, as well as indications concerning the dynamic tendencies of these populations. This would allow one to gain insight into the biological diversity of grasses and could create opportunities for preserving, as well as facilitating the development of nature conservation plans.

References

Balcerkiewicz S. 2007. Trawy w zbiorowiskach roślinnych Polski. In: L. Frey (ed.). Księga polskich traw, pp. 229-248. Instytut Botaniki im. W. Szafera, Polska Akademia Nauk, Kraków.

Bieniek W. 2010. Wzorce zmienności *Hordeum murinum* L. jako podstawa analiz taksonomiczno-fitogeograficznych. Ph. D. Thesis, W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków and International Doctoral Studies in Natural Sciences at the Polish Academy of Sciences in Cracow.

Bomanowska A. & Witosławski P. 2009. Share and diversity of grasses in synanthropic floras of major towns in Central Poland. In: L. Frey (ed.). Grass research, pp. 81-94. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Ceynowa-Giełdon M. 1988. *Trisetum sibiricum* Rupr. w Oborowie koło Tucholi (woj. bydgoskie). Acta Univ. Nicol. Copernici Biologia 29: 79-83.

Clayton W. D. & Renvoize S. A. 1986. Genera graminum. Grasses of the world. 389 pp. Her Majesty's Stationery Office, London.

Conert H. J., Jäger E. J., Kadereit J. W., Schultze-Motel W., Wagenitz G. & Weber H. E. (eds.). 1998. Gustav Hegi Illustrierte Flora von Mitteleuropa. 1(3). Spermatophyta, Angiospermae, Monocotyledones 1(2): Poaceae. 3 Aufl. Parey Buchverlag, Berlin.

Dajdok Z. 2009. *Coleanthus subtilis* (Poaceae) na terenie Stawów Milickich – nowe stanowisko w Polsce. Fragm. Flor. Geobot. Polonica 16(2): 227-236.

Dajdok Z. & Szczęśniak E. 2009. Występowanie *Alopecurus myosuroides* (Poaceae) na obszarach rolnych okolic Gilowa na Przedgórzu Sudeckim. Fragm. Flor. Geobot. Polonica 16(2): 237-248.

Fabiszewski J. & Cebrat J. 2003. *Coleanthus subtilis* (Tratt.) Seidl – a new species to Polish vascular flora. Acta Soc. Bot. Pol. 72(2): 135-138.

Frey L. 1991a. Rozmieszczenie *Avena strigosa* Schreb. w Polsce. Fragm. Flor. Geobot. 34(1-2): 43-51.

Frey L. 1991b. Distribution of *Avena strigosa* (Poaceae) in Europe. Fragm. Flor. Gebot. 36(2): 281-288.

Frey L. 1992. Taxonomy, karyology and distribution of the selected genera of the tribe Aveneae (Poaceae) in Poland. II. *Trisetum*. Fragm. Flor. Geobot. 37(2): 443-475.

Frey L. 1994. Rozmieszczenie *Aira caryophyllea* i *A. praecox* (Poaceae) w Polsce. Fragm. Flor. Geobot. Ser. Polonica 1: 5-17.

Frey L. 1999. The *Agropyron-Elymus* complex (Poaceae) in Poland: disappearance of *Elymus farctus* subsp. *boreoatlanticus* on the coast of the Baltic sea. Fragm. Flor. Geobot. 44(1): 35-42.

Frey L. 2000. Trawy niezwyciężone (wybrane zagadnienia z historii, taksonomii i biologii Poaceae). Łąkarstwo w Polsce 3: 9-20.

Frey L. 2001a. Zagrożenie i ochrona traw w Polsce. Zesz. Probl. Post. Nauk Roln. 476: 117-123.

Frey L. 2001b. *Elymus farctus*. Perz sitowy. In: R. Kaźmierczakowa & K. Zarzycki (eds.). Polska Czerwona Księga Roślin. Paprotniki i rośliny kwiatowe, pp. 451-453. Instytut Botaniki im. W. Szafera, Instytut Ochrony Przyrody, Polska Akademia Nauk, Kraków.

Frey L. 2005. Distribution of *Scolochloa festucacea* in Poland. In: L. Frey (ed.). Biology of grasses, pp. 37-44. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Frey L. 2009. The need to protect grasses. In: Z. Mirek & A. Nikel (eds.). Rare, relict and endangered plants and fungi in Poland, pp. 203-208. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Frey L. & Paszko B. 2000. Rozmieszczenie *Beckmannia eruciformis* (Poaceae) w Polsce. Fragm. Flor. Geobot. Polonica 7: 73-80.

Frey L. & Szczepaniak M. 2001. Nowe stanowisko perzu sitowego *Elymus farctus* subsp. *boreoatlanticus* na polskim wybrzeżu Bałtyku. Chrońmy Przyr. Ojcz. 57(6): 120-122.

Frey L. & Urbisz A. 2001. *Cenchrus ciliaris* (Poaceae) – new ephemerophyte in Poland. In: L. Frey (ed.). Studies on grasses in Poland, pp. 235-241. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Frey L., Załuski T. & Gawenda D. 2001. *Trisetum sibiricum*. Konietlica syberyjska. In: R. Kaźmierczakowa & K. Zarzycki (eds.). Polska czerwona księga roślin. Paprotniki i rośliny kwiatowe, pp. 455-457. Instytut Botaniki im. W. Szafera, Instytut Ochrony Przyrody, Polska Akademia Nauk, Kraków.

Gawenda D. & Załuski T. 2001. Stanowisko *Trisetum sibiricum* (Poaceae) na Pojezierzu Chełmińsko-Dobrzyńskim. Fragm. Flor. Geobot. Polonica 8: 288-290.

Górski P. 1999. *Cynodon dactylon* (Poaceae) in Poland. Fragm. Flor. Geobot. Suppl. 7: 65-71.

IUCN 2001. Red List Categories and Criteria: version 3.1. IUCN Species Survival Commission. IUCN. Gland. Switzerland and Cambridge, UK.

Jackowiak B. 1999. Modele ekspansji roślin synantropijnych i transgenicznych. Phytocoenosis 11(N.S.) Semin. Geobot. 6: 3-16.

Jackowiak B., Celka Z., Chmiel J., Latowski K. & Żukowski W. 2007. Red list of vascular flora of Wielkopolska (Poland). Biodiv. Res. Conserv. 5-8: 95-127.

Jakubowska-Gabara J. 2001. *Festuca amethystina* L. Kostrzewa ametystowa. In: R. Kaźmierczakowa & K. Zarzycki (eds). Polska Czerwona Księga Roślin. Paprotniki i rośliny zarodnikowe, pp. 436-438. Instytut Botaniki im. W. Szafera, Instytut Ochrony Przyrody, Polska Akademia Nauk, Kraków.

Kaźmierczakowa R. & Zarzycki K. (eds.). 2001. Polska czerwona ksiega roslin. Paprotniki i rosliny kwiatowe, wyd. 2, 664 pp. PAN, Instytut Botaniki im. W. Szafera, Instytut Ochrony Przyrody, Kraków.

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

Kornaś J. 1968. Prowizoryczna lista nowszych przybyszów synantropijnych (kenofitów) zadomowionych w Polsce. Mater. Zakł. Fitosoc. Stos. UW 25: 43-53.

Korniak T. 1997. *Avena strigosa* (Poaceae) in north-eastern Poland. Fragm. Flor. Geobot. 42(2): 201-206.

Korniak T. 2003. Synanthropic grass species in Poland. In: L. Frey (ed.). Problems of grass biology, pp. 189-200. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Korniak T. & Urbisz A. 2007. Trawy synantropijne. In: L. Frey (ed.). Księga polskich traw, pp. 317-342. Instytut Botaniki im. W. Szafera, Polska Akademia Nauk, Kraków.

Kozłowski S. 2007. Trawy w polskim krajobrazie. In: L. Frey (ed.). Księga polskich traw, pp. 389-411. Instytut Botaniki im. W. Szafera, Polska Akademia Nauk, Kraków.

Kucharczyk M. 2005. New localities of *Lolium remotum* in Poland. In: L. Frey (ed.). Biology of grasses, pp. 67-72. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Kuźniewski E. 1996. *Anthoxanthum aristatum* Boiss. na Śląsku Opolskim. Zesz. Przyr. Op. Tow. Przyj. Nauk 31: 17-20.

Markowski R. & Buliński M. 2004. Ginące i zagrożone rośliny naczyniowe Pomorza Gdańskiego. Acta Bot. Cassub. Monogr. 1: 1-75.

Meusel H., Jäger E. & Weinert E. 1965. Vergleichende Chorologie der zentraleuropäischen Flora. I. (Karten). 258 pp. VEB G. Fischer Verlag, Jena.

Michalewska A. & Nobis M. 2005. Ekspansja *Eragrostis albensis* (Poaceae) na antropogenicznych siedliskach w południowo-wschodniej Polsce. Fragm. Flor. Geobot. Polonica 12(1): 45-55.

Mirek Z. & Piękoś-Mirkowa 2009. Fitogeograficzne aspekty endemizmu w Polsce. Wiad. Bot. 53(3-4): 7-30.

Misiewicz J. 2001. Adventive grass species in the synathropic flora of the Polish seaports. In: L. Frey (ed.). Studies on grasses in Poland, pp. 251-256. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Mizianty M. 1995. Trawy – grupa roślin, które odniosły ewolucyjny sukces. Wiad. Bot. 39(1-2): 59-70.

Mizianty M. 2006. Stanowiska *Hordeum murinum* (Poaceae) w Polsce północno-wschodniej. Fragm. Flor. Geobot. Polonica 13(2): 261-266.

Patrzałek A. 2007. Trawy do celów specjalnych. In: L. Frey (ed.). Księga polskich traw, pp. 343-359. Instytut Botaniki im. W. Szafera, Polska Akademia Nauk, Kraków.

Piękoś-Mirkowa H. & Mirek Z. 2007. Zagrożenie i ochrona traw w Polsce. In: L. Frey (ed.). Księga polskich traw, pp. 249-282. Instytut Botaniki im. W. Szafera, Polska Akademia Nauk, Kraków.

Piękoś-Mirkowa H., Mirek Z. & Miechówka A. 1996. Endemic vascular plants in the Polish Tatra Mts. Distribution and ecology. Polish Botanical Studies 12: 1-107.

Pyšek P., Sádlo J. & Mandák B. 2002. Catalogue of alien plants of the Czech Republic. Preslia 74: 97-186.

Pyšek P., Richardson D. M., Rejmánek M., Webster G. L., Williamson M. & Kirschner J. 2004. Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. Taxon 53(1): 131-143.

Regulation 2004. Regulation of the Minister of Environment of 09 July 2004 on wild species of plants under protection. Journal of Laws No 168 (2004), item 1764.

Rostański K. & Sowa R. 1986-1987. Alfabetyczny wykaz efemerofitów Polski. Fragm. Flor. Geobot. 31-32(1-2): 151-205.

Scholz H. 1996. *Eragrostis albensis* (Gramineae), das Elb-Laibesgras – ein neuer Neo-Endemit Mitteleuropas. Verh. Bot. Ver. Berlin Brandenburg 128(1995): 73-82.

Špryňar P. & Kubát K. 2004. *Eragrostis albensis* a *E. pectinacea*, dva nové cizi druhy trav pro květenu České republiky (Poaceae). Zprávy Čes. Bot. Společ. 39: 1-24.

Stasiak J. 1993. *Agropyron junceum*. Perz sitowy. In: K. Zarzycki & R. Kaźmierczakowa (eds.). Polska Czerwona Księga Roślin. Paprotniki i rośliny kwiatowe, pp. 220-222. Instytut Botaniki im. W. Szafera, Instytut Ochrony Przyrody, Polska Akademia Nauk, Kraków.

Sutkowska A. & Pasierbiński A. 2009. Pochodzenie spontanicznie rozprzestrzeniającego się gatunku *Bromus carinatus* (Poaceae) na siedliskach ruderalnych i segetalnych w Polsce. Fragm. Flor. Geobot. Polonica 16(2): 281-295.

Szafer W. 1919. Rodzina Gramineae. Trawy. In: M. Raciborski & W. Szafer (eds.). Flora polska. Rośliny naczyniowe Polski i ziem ościennych. 1. Paprotniki, iglaste i jednoliścienne, pp. 230-365. Akademia Umiejętności, Kraków.

Szafer W., Kulczyński S. & Pawłowski B. 1986. Rośliny polskie. xxxi+1020 pp. PWN Warszawa.

Tokarska-Guzik B. 2005. The Establishment and Spread of Alien Plant Species (Kenophytes) in the Flora of Poland. Prace naukowe Uniw. Śląskiego w Katowicach 2372: 1-192.

Tokarska-Guzik B. 2007. Trawy inwazyjne. In: L. Frey (ed.). Księga polskich traw, pp. 361-387. Instytut Botaniki im. W. Szafera, Polska Akademia Nauk, Kraków.

Tokarska-Guzik B., Wężrzynek B., Urbisz A., Bzdęga K, & Pasierbiński A. 2006. Spektrum siedliskowe wybranych gatunków traw w Polsce. In: L. Frey (ed.). Zeszyt streszczeń. VII Ogólnopolskie Spotkanie Naukowe "Biologia traw" 16-17 listopada 2006, p. 57. Instytut Botaniki im. W. Szafera PAN, Kraków.

Urbisz A. 2007. Dynamics of appearance of transiently introduced grasses (ephemerophytes) in Poland. In: L. Frey (ed.). Biological issues in grasses, pp. 81-90. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Urbisz A. & Urbisz A. 2003. *Eleusine indica* - an interesting ephemerophyte in the flora of Poland. In: L. Frey (ed.). Problems of grass biology, pp. 369-373. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Urbisz A. & Węgrzynek B. 2007. *Tragus racemosus* (Poaceae) – nowy efemerofit dla flory Polski. Fragm. Flor. Geobot. Polonica Suppl. 9: 19-22.

Waga J. 1847. Flora polska. 1. 766 pp. W drukarni Stanisława Strąbskiego, Warszawa.

Warcholińska A. U. & Siciński J. 1976. Z badań nad występowaniem i rozprzestrzenianiem się *Anthoxanthum aristatum* Boiss. w środkowej Polsce. Fragm. Flor. Geobot. 22(4): 409-413.

Warcholińska A. U. & Siciński J. 1996. Ekspansja *Anthoxanthum aristatum* Boiss. w środkowej Polsce. Zesz. Nauk. Akad. Techn.-Roln. Bydgoszcz, Ser. Rolnictwo 196(38): 183-191.

Weiner J. 1999. Życie i ewolucja biosfery. Podręcznik ekologii. PWN, Warszawa.

Wilson E. O. 2003. The future of life. Wydawnictwo Zysk i S-ka, Poznań.

Zając A. & Zając M. (eds.). 2001. Distribution Atlas of Vascular Plants in Poland. xii+714 pp. Edited by Laboratory of Computer Chorology, Institute of Botany, Jagiellonian University, Cracow.

Zając A., Zając M. & Tokarska-Guzik B. 1998. Kenophytes in the flora of Poland: list, status and origin. In: J. B. Faliński, W. Adamowski & B. Jackowiak (eds.). Synantropization of plant cover in new Polish research. Phytocoenosis 10 (N.S.) Suppl. Cartogr. Geobot. 9: 107-116.

Załuski T. 2007. Zagrożenie i ochrona zespołów trawiastych. In: L. Frey (ed.). Księga polskich traw, pp. 283-316. Instytut Botaniki im. W. Szafera, Polska Akademia Nauk, Kraków.

Zarzycki K. 1986. Lista wymierających i zagrożonych roślin naczyniowych Polski. In: K. Zarzycki & W. Wojewoda (eds.). Lista roślin wymierających i zagrożonych w Polsce, pp. 11-28. PWN, Warszawa.

Zarzycki K. & Kaźmierczakowa R. 1993. Polska czerwona księga roślin . Paprotniki i rośliny kwiatowe. 310 pp. Instytut Botaniki im. W. Szafera, Instytut Ochrony Przyrody, Polska Akademia Nauk, Kraków.

Zarzycki K. & Szeląg Z. 1992. Czerwona lista roślin naczyniowych zagrożonych w Polsce. In: K. Zarzycki, W. Wojewoda & Z. Heinrich (eds.). Lista roślin zagrożonych w Polsce, wyd. 2, pp. 87-98. PAN Instytut Botaniki im. W. Szafera, Kraków.

Zarzycki K. & Szeląg Z. 2006. Red list of the vascular plants in Poland. In: Z. Mirek, K. Zarzycki, W. Wojewoda & Z. Szeląg (eds.). Red list of plants and fungi in Poland, pp. 9-20. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Żukowski W. & Jackowiak B. 1995. List of endangered and threatened vascular plants in Western Pomerania and Wielkopolska (Great Poland). In: W. Żukowski & B. Jackowiak (eds.). Endangered and threatened vascular plants of Western Pomerania and Wielkopolska. Publications of the Department of Plant Taxonomy of the Adam Mickiewicz University in Poznań 3: 9-93. Bogucki Wyd. Nauk., Poznań.