

The preservation state of the flora and vegetation of the artillery range near the city of Toruń

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Abstract. The floral and phytosociological research conducted between 1998–2001 in the area of the artillery range shows that there are 460 different species, including 363 vascular plants and 96 algae, bryophytes and lichens. The aforementioned count includes 45 taxa that are fully or partially protected. In the investigated area there are 30 species of vascular plants and 13 lichen species endangered to a different extent, referring to the scale of the whole region, for example: *Aster amellus*, *Prunella grandiflora*, *Bryoria fuscescens*, *B. subcana*, *Peltigera praetextata* and *Ramalina fraxinea*.

Out of 335 species recorded in the same area by German researchers in the late 19th century and the early 20th century, the occurrence of 270 species was confirmed by our research, which constitutes 80.6%. The following species are considered as extinct, since they were not found again in the area: *Adenophora liliifolia*, *Cephalanthera damasonium*, *C. rubra*, *Dracocephalum ruyschiana* and *Gladiolus paluster*. During the one hundred years, which separate the two research projects, 95 new species appeared in the studied area, mostly archaeophytes and kenophytes.

According to the phytosociological research, there are 8 plant associations and one plant community in the unforested part of the range. Among the most rare associations, the following should be mentioned: *Caricetum arenariae*, *Caricetum ligericae* and *Festuco-Koelerietum glaucae*. *Calamagrostietum epigeji*, *Corniculario-Corynephorretum*, *Arctostaphylo-Callunetum* are typical associations of this area. The association *Scorzonero purpureae-Stipetum joannis* and the community of *Salix acutifolia-Epipactis atrorubens* are the most valuable ones. They will become the most endangered associations if the excessive pressure by the army or the highway construction should cease in the future.

To preserve the particularly valuable species and plant associations, new active preservation forms should be introduced in the whole area of the artillery range, especially after cessation of the excessive military exploitation. A part of the artillery range called “Piaski” should be protected as a sanctuary because of the association *Scorzonero purpureae-Stipetum joannis*, which occurs only here.

Key words: flora, heathlands, inland dunes, plant associations, the artillery range, Toruń and Bydgoszcz Valley.

1. Introduction

Among the numerous dune fields in Poland, the leading position is taken by areas of the Toruń Valley, also known as the Valley of Toruń and Bydgoszcz (Kondracki 2000; Andrzejewski 2001), which is a part of the Toruń-Eberswald ice-marginal valley. Within the area of the valley, dunes are one of the dominant morphological elements over the area of 1850 km².

The research deals with the vegetation of dune field IV, which has been exploited as the artillery range since the middle of the 17th century. The oldest, published floristic data related to the studied area come from the papers by Scholz (1896), Abromeit et al. (1898) and Preuss (1912). At a later date, the research on the vegetation of dune areas within the Toruń Valley was conducted on the Zadroże Dune, which is situated outside the artillery range (Anikiejówna & Gorska 1949; Symonides 1972). Floristic peculiarities of this area were also described by: Walas (1969),

Wilkoń-Michalska (1971), Ceynowa-Giełdon (1984), as well as Ceynowa-Giełdon and Nienartowicz (1994).

The main objectives of the present research was to make an inventory of the flora in the studied area, to describe plant communities, as well as to compare the present flora with its description from the turn of the 19th and 20th centuries. Moreover, an attempt was undertaken to evaluate how the land use method applied by the army, forestry and the local population affects the flora and the vegetation.

2. General description of the study area

The study area is located on dune field IV, defined also as the field of Toruń, Aleksandrów and Gniewkowo (Mrózek 1958). Parabolic dunes are the dominant forms there. They developed on broad sandy terraces. They also developed on the bottom of the ice-marginal valley – on alluvial fans, outwash plains and fields built of fluvioglacial sand. During the Holocene, sandy areas together with dunes were covered with coniferous, mainly pine forests. Only logging of forests led to the intensification of aeolian processes, particularly during the last millennium (Klimaszewski 1978).

Nowadays, dunes in the Toruń Valley are mostly inactive forms. They are usually covered with pine forest, less frequently with heaths and grassland communities. Parabolic dunes are the dominant morphological forms with arcs open towards the west. Apart from the arcuate forms, there are also linear dunes of latitudinal or almost longitudinal direction. The inclination of windward slopes, near the front of the dune, usually comes to 5–10°, and leeward slopes – to 12–20° (Dorożyński 2001).

The artillery range has been exploited since the middle of the 17th century until the present day, and it covers the area of 148.6 km², confined within the following coordinates: E 018°29'–018°44' and N 052°51'–052°59' (Dorożyński 2001; Wasilewski 2003). In the area of the artillery range, there is a network of hardened paved roads, asphalt and concrete roads, numerous unhardened roads and routes, firebreaks, as well as engineering and technical buildings in the form of trenches and concrete bunkers – fire command posts. On the dune ridges, points of the geodetic control network are located, usually in the form of triangulation towers or landmarks. In the northern part, there are anti-tank barriers and foundations of barracks – remains of the WWII POW camp; wells with horse water buckets are less frequent. Three tank traps run through the artillery range, with the original depth of ca. 4 m. Military activities intensified mainly during the 1980s, when annual trainings on the artillery range gathered ca. 35,000 persons.

With the Regulation of the Provincial Governor of Toruń, dated December 10th, 1992, the artillery range was

given the status of the protected landscape area – „Dune area to the south of Toruń” – and it was included within the protective forest zone around the city; the area of which comes to 15 657.2 ha (Burak 2001).

3. Materials and methods

Floristic and phytosociological studies in the area of the artillery range were carried out in 1998–2001. Lichens were collected mainly from the soil and the bark of roadside trees. The following guidebooks were used for the identification of the collected material: Szafran (1957–1961), Rejment-Grochowska (1971), Nowak and Tobolewski (1975), Purvis et al. (1992), Hindák (1996) and Rutkowski (2004). Names of taxa of vascular plants were provided according to Mirek et al. (2002). Nomenclature of liverworts was accepted after Klama (1996) and Szweykowski (2006), mosses after Ochrya et al. (2003), and lichens mostly after Diederich et al. (2009) and Santesson et al. (2004).

Specimens of lichens from the genus *Cladonia*, the group of *chlorophaea*, which were not subject to thin-layer chromatography TLC (Orange et al. 2001) were defined as *Cladonia chlorophaea* s.l.

In the phytosociological studies, the classic method of the French-Swiss school was applied (Pawłowski 1977). The relevés were made according to the 6-degree scale of Braun-Blanquet. The phytosociological studies covered non-forest areas of the artillery range. Altogether 82 relevés were made. At the same time, during few growing seasons, floristic notes were drawn up from different objects and habitats, including the information on population resources of selected species. The affinity of species to particular phytosociological classes was based on papers by Matuszkiewicz (2002), as well as Brzeg and Wojterska (2001). The list of protected species was prepared in compliance with the Regulation of the Minister of Environment dated 09.07.2004, whereas species endangered in the Kujawy-Pomerania region and in Poland were determined based on the study of Cieśliński et al. (2006), Kaźmierczakowa and Zarzycki (2001), as well as Rutkowski (2005).

4. Flora

The number of species of native and domesticated vascular plants in the Kujawy-Pomerania region comes to ca. 1500 (Rutkowski 1997; Boinski et al. 2001). In the area of the artillery range, the presence of 460 species was confirmed, including 363 vascular plants, whereas the remaining 96 species are algae (1 species), bryophytes (25 species) and lichens (72 taxa). The following species are pioneers in the stabilization of dune sand: *Klebsormidium crenulatum*, *Cetraria aculeata*, *Diploschistes muscorum*, *Polytrichum*

piliferum, *Calamagrostis epigejos*, *Carex arenaria*, *Corynephorus canescens*, *Koeleria glauca* and *Leymus arenarius*. In more stabilized, insolated and treeless areas, the following species occur in large numbers: *Festuca trachyphylla*, *Hieracium pilosella*, *Spergula morisonii* and *Thymus serpyllum*. A characteristic feature of the range landscape are heaths on hillsides of the dunes dominated by *Arctostaphylos uva-ursi* and *Calluna vulgaris*, usually accompanied by many species of cup lichens, including such taxa as: *Cladonia cariosa*, *C. cenotea*, *C. crispata*, *C. gracilis* ssp. *elongata*, *C. gracilis* ssp. *turbinata*, *C. macilenta*, *C. rangiferina* and *C. squamosa*. Among lichens seldom recorded in these communities, there are: *Baeomyces rufus* and *Trapeliopsis granulosa*. Crests of dunes are covered with the willow *Salix acutifolia*, which occurs in large numbers and is accompanied by: *Hippophaë rhamnoides*, *Pinus sylvestris*, *Robinia pseudacacia* and *Salix repens*, and in the herbaceous layer – *Epipactis atrorubens* is a very frequent component. On the exposed terraces, there occur species that are very seldom in other habitats of the artillery range: *Alyssum montanum*, *Aster amellus*, *Avenula pratensis*, *Koeleria grandis*, *K. macrantha*, *Peucedanum cervaria*, *Prunella grandiflora*, *Pulsatilla patens*, *Scorzonera purpurea*, *Stipa joannis*, *Thesium ebracteatum*, *T. linophyllum*, *Trifolium lupinaster*, *Veronica austriaca*, *V. jacquinii* and others. Most of them were recognized as nearly extinct, vulnerable and rare species in the region of the Kujawy-Pomerania Province (Rutkowski 2005). *Cerasus fruticosa* is a peculiarity of the artillery range. The species is threatened with extinction; it is present at few sites, including „Góra Żymierskiego”, where it is subject to burning off, repeated several times every year (a field of fire). In the vicinity of „Góra Dziwak”, on the shores of a small water reservoir, overgrown with vegetation, the presence of a very rare liverwort was recorded – *Riccia huebeneriana*. Mosses occurred only on bunkers and others concrete constructions – *Grimmia apocarpa* and *G. pulvinata*. Constructions of any kind were accompanied by species of alien origin, including for instance: *Amaranthus retroflexus*, *Galinsoga parviflora*, *Lepidium densiflorum*, *Oenothera acutifolia*, *O. hoelscheri*, *O. pycnocarpa*, *O. royfraseri*, *O. depressa*, and at a transfer station in the village of Otłoczyn, *Sporobolus cryptandrus* was found.

At present, the flora of the artillery range comprises 47 protected species (Table 1), including 30 taxa strictly protected by law and 17 taxa partially protected. Only 17 species were recognized as endangered countrywide (Cieśliński et al. 2006; Kaźmierczakowa & Zarzycki 2001), including lichens: in the category of critically endangered species (CR) – *Bryoria subcana*, endangered species (EN) *Ramalina fraxinea*; *B. fuscescens* and *Peltigera praetextata*, as well as plants: *Prunus fruticosa* and *Pulsatilla patens* were recognized as vulnerable species. As many as 30 species, endangered on a regional scale, occur in the area of the

artillery range, including species threatened with extinction – *Aster amellus* and *Prunella grandiflora*.

Out of the 335 species of vascular plants listed from the artillery range by Scholz (1896), Abromeit et al. (1898) and Preuss (1912), the presence of 270 species was confirmed during the current research, which constitutes 80.6% of the original state. The group of 65 species (19.4%), not recorded for the second time, includes species recognized as extinct in the region: *Adenophora liliifolia*, *Cephalanthera damasonium*, *C. rubra*, *Dracocephalum ruyschiana* and *Gladiolus paluster*.

During the century separating the two research periods, the artillery range gained 95 new species, usually kenophytes: *Acer negundo*, *Amelanchier spicata*, *Armoracia rusticana*, *Cotinus coccygria*, *Echinocystis lobata*, *Padus serotina*, *P. virginiana*, *Pinus strobus*, *Robinia pseudoacacia*, *Sisymbrium loeselii*, *Solidago gigantea*, *S. canadensis*, the aforementioned species from the genus *Oenothera* and archaeophytes: *Descurainia sophia*, *Digitaria ischaemum*, *Lepidium ruderales*, *Papaver rhoeas* and others.

5. Plant communities

The phytosociological studies on the non-forest area of the artillery range proved the presence of 8 associations and one plant community (Table 2). They are classified within 5 classes:

- Cl. *Epilobietea angustifolii* R. Tx. et Prsg. 1950 in R. Tx. in R. Tx. 1950
- O. *Epilobietalia angustifolii* R. Tx. 1950
- All. *Epilobion angustifolii* R. Tx. 1950
 1. *Calamagrostietum epigeji* Juraszek 1928
- Cl. *Koelerio-Corynephoretea* Klika in Klika et Novak 1941
- O. *Corynephoretalia canescentis* Klika 1934
- All. *Corynephorion canescentis* Klika 1931
 2. *Corniculario-Corynephorum* (R. Tx. 1928) Steffen 1931
 3. *Caricetum arenariae* Steffen 1931
- O. *Festuco-Sedetalia* R. Tx. 1951 em. Krausch 1962
- All. *Koelerion glaucae* (Volk 1931) Klika 1934
 4. *Caricetum ligericae* Kępczyński et Rutkowski 1988
 5. *Festuco-Koelerietum glaucae* Klika 1931
 6. *Festuco psammophilae-Elymetum arenarii* (Kobendza 1930) Celiński et Balcerkiewicz 1973 ex Brzeg et M. Wojterska (1996) 2001
- Cl. *Festuco-Brometea* Br.-Bl. ex R. Tx. 1943
- O. *Festucetalia valesiacae* Br.-Bl. et R. Tx. 1943
 7. *Scorzonero purpureae-Stipetum joannis* (Ceynowa 1968) Brzeg in Brzeg et M. Wojterska 2001

- Cl. *Calluno-Ulicetea* Br.-Bl. ex R. Tx. 1943 em. Prsg 1949
 O. *Vaccinio-Genistetalia* Scgubert 1960
 All. *Calluno-Arctostaphylion* R. Tx. et Prsg 1949 ex Faliński 1965
 8. *Arctostaphylo-Callunetum* (Juraszek 1928) R. Tx. et Prsg. 1940 ex Faliński 1965
 Cl. *Erico-Pinetea* Horvat 1959 (?)
 O. *Erico-Pinetalia* Horvat 1959
 All. *Erico-Pinion* Br.-Bl. in Br.-Bl. et al. 1939
 9. The community *Salix acutifolia-Epipactis atrorubens*

The association *Calamagrostietum epigeji* is the most common one in the studied area. It occurs mainly in the central and southern part of the artillery range. Despite the field occurrence, the population of *Calamagrostis epigejos* does not reduce the development of other plants, therefore it consists of 65 species of vascular plants, 12 taxa of lichens and 10 mosses. Apart from the dominant species, also species from the classes *Nardo-Callunetea* and *Festuco-Brometea* occur in relatively large numbers. The association is composed of rare species, such as: *Oenothera pycnocarpa*, *O. royfraseri*, *Pulsatilla pratensis* and *Rosa sherardii*. The aforementioned association is extremely expansive. In the southern part of the artillery range, it became a dominant community and it continuously extends its range of occurrence.

Also *Corniculario-Corynephorum* is one of the most common associations within the artillery range. It is composed of 59 species, including 39 species of vascular plants, 4 species of mosses, 15 taxa of lichens and 1 alga. *Corynephorus canescens* and *Spergula morisonii* are the dominant species. In the initial phases of the association, the vegetation structure is very scattered, and at first the turfs of *Polytrichum piliferum* and thalli of *Klebsormidium crenulatum* appear on the sand. In the layer of lichens and mosses, *Cetraria aculeata*, *Cladonia macilenta* and *C. cervicornis* dominate. Among the accompanying plants, species from the class *Nardo-Callunetea* occur in large numbers, particularly *Carex ericetorum*.

Caricetum arenariae is yet another association described by Kępczyński and Rutkowski (1988) from the Toruń Valley. It is species rich and comprises 34 vascular species, 13 lichens and 6 bryophytes. It covers small areas (50–300 m²) in the northern and western part of the artillery range. Only occasionally it plays a role of an initial community, contributing to the stabilization of dunes. The remaining species from the class *Koelerio-Corynephoretea*, and particularly *Helichrysum arenarium* and *Polytrichum piliferum* play an important role in the association.

The association *Caricetum ligericae* also occurs on small areas in the northern part of the range, often in the vicinity of the association of the sand sedge. It prefers stabilized sand with a well developed soil (Kępczyński

& Rutkowski 1988). The composition of the association comprises 50 species, including as many as 47 vascular plants, and just 1 moss and 2 lichen species. *Carex ligerica* dominates in all the studied patches.

The association *Festuco-Koelerietum glaucae* is one of the rarest associations within the artillery range and some larger patches are present only at two sites in its central part. Floristically it is quite poor – 34 species, including 28 species of vascular plants, 3 lichens and 3 mosses. *Koeleria glauca* is the dominant species, whereas *Hieracium pilosella* and *Festuca duvalii* are codominants. Locally *Tragopogon floccosus* is a good differential species. The association is floristically poorer than the one described by Symonides (1972) from the Zdroże Dune, where the presence of 49 species of vascular plants was recorded, as well as 10 species of lichens and 1 moss species. In the Wielkopolska Region, Brzeg and Wojterska (2001) defined this community as rare, exposed to impoverishment and simplification of the structure.

The association *Elymetum arenarii* is a pioneer community growing on dunes. Its occurrence in the Vistula River valley is accounted for by migration from coastal areas and by human activity. Within the artillery range, it covers elevated roadsides, firebreaks strips and tank routes. Patches of the association are usually small and occur mainly in the northern part of the range. The association is characterized by a small contribution of characteristic species, mainly *Corynephorus canescens* and *Polytrichum piliferum*. This is the community where *Klebsormidium crenulatum* occurs again. 45 species were recorded in the association, including 32 vascular plants, 9 lichens and 4 mosses. Similarly like in the Wielkopolska Region, it is a rare xenospontaneous community under indeterminate threat (Brzeg & Wojterska 2001).

The class *Festuco-Brometea* is represented by the association *Scorzonero purpureae-Stipetum joannis*, and present mainly in the eastern part of the range („Piaski”). Within the remaining area, it occurs in the form of small patches on the slopes of dunes, in the depressions between elevations and along roadsides. The association is species rich. It comprises 90 species, including 68 species of vascular plants, 14 species of lichens and 8 species of bryophytes. Between tussocks of *Stipa joannis*, the following species grow: *Asperula tinctoria*, *Filipendula vulgaris*, *Helianthemum nummularium* ssp. *obscurum*, *Phleum phleoides*, *Pulsatilla pratensis*, *Scorzonera purpurea*, *Thesium linophyllum*, *Veronica jacquinii* and others. In the Wielkopolska Region, this association has the status of a very rare community, directly threatened with extinction (Brzeg & Wojterska 2001).

The class *Calluno-Ulicetea* is represented by the association *Arctostaphylo-Callunetum*, which occurs mainly in the central part of the range, mainly on the slopes of dunes, less frequently on flat areas. It is the richest association in

floristic respect. 94 species were recorded in its patches, including 57 species of vascular plants, 27 lichens and 10 mosses. The following species had the highest cover degrees in the association: *Calluna vulgaris*, *Arctostaphylos uva-ursi* and *Polytrichum piliferum*. In the layer of lichens and mosses, taxa from the genus *Cladonia* dominate, such as: *Cladonia arbuscula* ssp. *arbuscula*, *C. arbuscula* ssp. *mitis*, *C. cervicornis*, *C. floerkeana*, *C. pleurota*, *C. portentosa*, *C. rangiferina* and others. This association (under indeterminate threat) is widespread in the Toruń Valley.

Epipactis atrorubens, the population of which comes to ca. 2300 specimens within the artillery range, occurs as a component of thickets and xerothermic grasslands in central Europe, for instance from the class of *Erico-Pinetea*. The presence of this species on coastal dunes, stabilized also by planting of *Salix acutifolia*, was described by e.g. Wojterski (1957), Wojterski and Bednorz (1982) and Filinger (1992). It seems that this helleborine species prefers poorly stabilized dunes, bare or overgrown with thermophilous thickets of shrubs, including willows.

The presented community of *Salix acutifolia*-*Epipactis atrorubens* is rich in species. It is composed of 66 species of vascular plants, 11 species of bryophytes and 19 taxa of lichens. Only in this community *Botrychium lunaria* grows at one location. *Astragalus arenarius*, *Festuca psammophila* and *Helichrysum arenarium* occur in the largest numbers. The average cover of the shrub layer comes to 29%. Apart from *Salix acutifolia*, also the following species occur here: *Berberis vulgaris*, *Betula pendula*, *Crataegus monogyna*, *Frangula alnus*, *Pinus sylvestris*, *Populus x canescens*, *P. tremula*, *Padus serotina*, *P. virginiana*, *Pyrus pyraeaster*, *Quercus robur* and *Sorbus aucuparia*. The community can be threatened by ceasing the military penetration of dune crests, as well as by the increased density of the shrub layer or the domination of these habitats by *Calamagrostis epigejos*.

6. Summary and conclusions

The artillery range near Toruń, as a protected landscape area, is covered with multiage forests and heaths in 99.4%. Despite the fact that other communities and bare dunes cover only ca. 0.6% of the total area, it is very rich in species. The flora of this area consists of 25 species of bryophytes, 363 vascular species and 72 taxa of lichens. 47 protected species occur here and 28 species vulnerable to extinction to a different extent. Since the previous research, from the turn of the 19th and 20th centuries, 65 species were lost. Among them, there are species recognized as extinct in the region: *Adenophora liliifolia*, *Cephalanthera damasonium*, *C. rubra*, *Dracocephalum ruyschiana* and *Gladiolus paluster*. In the previous century, this area

was enriched with 99 new species, mostly kenophytes (189 species of synanthropic plants were recorded in the studied area).

Different activities of the armed forces, including cutting of trees and shrubs, different types of training and frequent fires, brought about also by the local civilian population, contribute to the preservation of habitats covered with non-forest communities, including the association *Scorzonero purpureae*-*Stipetum joannis* – very rare and threatened with extinction.

In order to preserve the particularly valuable species and plant communities, it is necessary to introduce some forms of active protection for the whole artillery range, especially after ceasing the exploitation of this area by the army. Part of the artillery range, where the large population of *Stipa joannis* occurs („Piaski”), should be designated as a nature reserve, where it would be necessary to remove young specimens of Scots pine. *Cerasus fruticosa* is yet another species, the population size of which should be monitored regularly. It is a species threatened with extinction, at least within a certain part of the artillery range.

Further research, together with searching for locations of species recognized as currently extinct, as well as the documentation of all nature and aesthetic values of the artillery range is worthwhile of a separate research programme. It is also indispensable to introduce the natural values to residents of Toruń and the nearby towns and villages, for whom the artillery range is a valued area for walks and mushroom picking.

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Table 1. The preserved plants in the area of the artillery range near Toruń

Takson	Full protection		Part protection	
	XIX/XX w.	XX/XXI w.	XIX/XX w.	XX/XXI w.
Lichenes:				
<i>Bryoria fuscescens</i> (Gyeln.) Brodo & D. Hawksw.	-	++	.	.
<i>Bryoria subcana</i> (Stizenb.) Brodo & D. Hawksw.	-	+	.	.
<i>Cetraria aculeata</i> (Schreb.) Fr.	.	.	.	+++
<i>Cetraria islandica</i> (L.) Ach. ssp. <i>islandica</i>	.	.	.	++
<i>Cladonia arbuscula</i> (Wallr.) Flot. subsp. <i>arbuscula</i>	-	.	.	++
<i>Cladonia arbuscula</i> (Wallr.) Flot. subsp. <i>mitis</i> (Sandst.) Ruoss	.	.	.	+++
<i>Cladonia ciliata</i> Stirt.	-	.	.	+
<i>Cladonia portentosa</i> (Dufour) Coem.	.	.	.	++
<i>C. rangiferina</i> (L.) F. H. Wigg.	.	.	.	+
<i>Evernia prunastri</i> (L.) Ach.	-	.	.	++
<i>Hypogymnia tubulosa</i> (Schaer.) Hav.	-	+	.	.
<i>Peltigera canina</i> (L.) Willd.	.	++	.	.
<i>Peltigera didactyla</i> (With.) J. R. Laundon	-	++	.	.
<i>Peltigera polydactylon</i> (Neck.) Hoffm.	-	+	.	.
<i>Peltigera praetextata</i> (Sommerf.) Zopf	-	+	.	.
<i>Peltigera rufescens</i> (Weiss) Humb.	.	+++	.	.
<i>Platismatia glauca</i> (L.) W.L. Culb & C.F. Culb.	-	+++	.	.
<i>Pseudevernia furfuracea</i> (L.) Zopf	-	++	.	.
<i>Ramalina fraxinea</i> (L.) Ach.	-	+	.	.
<i>Usnea hirta</i> (L.) F. H. Wigg.	.	+	.	.
<i>Tuckermannopsis sepicola</i> (Ehrh.) Hale	-	+	.	.
Marchantiophyta:				
<i>Ptilidium ciliare</i> (L.) Hampe	-	.	.	+
<i>Riccia huebeneriana</i> Lindenb.	-	+	.	.
Bryophyta:				
<i>Dicranum scoparium</i> Hedw.	.	.	.	++
<i>Pleurozium schreberi</i> Mitt.	.	.	.	++
<i>Polytrichum commune</i> L.	.	.	.	+
Pteridophyta:				
<i>Botrychium lunaria</i> (L.) Sw.	+	+	.	.
<i>Botrychium multifidum</i> (S. C. Gmel.) Rupr.	+
<i>Diphasiastrum tristachyum</i> (Pursh) Holub	+	.	.	.
<i>Diphasiastrum complanatum</i> (L.) Holub	+	.	.	.

<i>Polypodium vulgare</i> L.	+	+	.	.
Spermatophyta:				
<i>Adenophora liliifolia</i> (L.) Besser	+	.	.	.
<i>Arctostaphylos uva-ursi</i> (L.) Spreng.	+++	+++	.	.
<i>Aster amellus</i> L.	+	+	.	.
<i>Carex arenaria</i> L.	.	.	.	++
<i>Carlina acaulis</i> L.	+	.	.	.
<i>Centaurium erythraea</i> Rafn	.	+	.	.
<i>Cephalanthera damasonium</i> (Miller) Druce	+	.	.	.
<i>Cephalanthera rubra</i> (L.) L. Rich.	+	.	.	.
<i>Cerasus fruticosa</i> Pall.	+++	+	.	.
<i>Cimicifuga europaea</i> Schipcz.	+	.	.	.
<i>Convallaria majalis</i> L.	-	.	++	+++
<i>Dianthus arenarius</i> L.	+	++	.	.
<i>Dianthus superbus</i> L.	+	.	.	.
<i>Dracocephalum ruyshiana</i> L.	+	.	.	.
<i>Epipactis atrorubens</i> (Hoffm.) Besser	++	+++	.	.
<i>Epipactis helleborine</i> (L.) Crantz	+	.	.	.
<i>Frangula alnus</i> Mill.	-	.	++	++
<i>Gladiolus paluster</i> Gaudin	+	.	.	.
<i>Gymnadenia conopsea</i> (L.) R. Br.	+	.	.	.
<i>Helichrysum arenarium</i> (L.) Moench	.	.	++	+++
<i>Hierochloë australis</i> (Schrad.) Roem. & Schult.	.	.	+	.
<i>Hippophaë rhamnoides</i> L.	.	+	.	.
<i>Lilium martagon</i> L.	+	.	.	.
<i>Oxytropis pilosa</i> (L.) DC.	++	+	.	.
<i>Primula veris</i> L.	.	.	+	.
<i>Pulsatilla patens</i> (L.) Mill. ssp. patens	++	+	.	.
<i>Pulsatilla pratensis</i> (L.) Mill.	+++	++	.	.
<i>Ribes nigrum</i> L.	-	.	+	+
<i>Scorzonera purpurea</i> L.	++	+	.	.
<i>Sorbus intermedia</i> (Ehrh.) Pers.	.	+	.	.
<i>Stipa joannis</i> Čelak	+	++	.	.
<i>Thesium ebracteatum</i> Hayne	++	+	.	.
<i>Vinca minor</i> L.	-	.	+	-

Explanations:

XIX/XX century – data by Scholz (1896), Abromeit et al. (1898) and Preuss (1912), XX/XXI century – own collected data 1998–2002; the frequency of occurring: +++ – often, ++ – quite often, + – rarely, -- no data, . – species not occurring during the research period

Table 2. Selected communities on the artillery range near Toruń: 1 – *Calamagrostietum epigeji*, 2 – *Corniculario-Corynephorum*, 3 – *Caricetum arenariae*, 4 – *Caricetum ligericae*, 5 – *Festuco-Koelerietum glaucae*, 6 – *Elymetum arenarii*, 7 – *Scorzonero purpureae-Stipetum joannis*, 8 – *Arctostaphylo-Callunetum*, 9 – community *Salix acutifolia-Epipactis atrorubens*

Community Species	1	2	3	4	5	6	7	8	9
Number of records	9	10	5	4	3	10	10	20	8
Mean number of species in the record	18	15	19	22	22	11	26	25	33
Number of species in community	87	59	53	50	34	45	90	94	96
Mean of plant cover (%)									
a	-	-	-	-	-	-	-	-	33
b	1	0,5	-	-	-	-	4	2	3
c	82	54	92	85	57	84	80	83	66
d	12	51	32	24	47	7	31	42	47
<i>Epilobietea angustifolii:</i>									
<i>Calamagrostis epigejos</i>	V 6528	IV 104	II 4		1 3	II 51	IV 377	III 30	II 471
<i>Koelerio-Corynephoretea:</i>									
<i>Corynephorus canescens</i>	III 113	V 4550	IV 104	2 250	1 3	V 206	III 477	V 34	II 65
<i>Hieracium pilosella</i>	II 3	IV 5	III 6	3 8	3 173	III 4	III 54	IV 11	V 9
<i>Helichrysum arenarium</i>	I 1	I 1	II 102	4 133	3 10	II 3	IV 6	I 1	V 9
<i>Polytrichum piliferum</i>	III 306	V 233	V 190		1 3	IV 429	IV 1001	V 1783	II 221
<i>Ceratodon purpureus</i>	IV 170	I 2	II 4		2 7	II 3	II 600	I 1	I 1
<i>Brachythecium albicans</i>	I 1	I 2	I 2		2 7	I 1	III 5	I 1	II 1
<i>Potentilla argentea</i>	I 1	I 1	I 100	3 8	1 3		IV 7	I 1	
<i>Jasione montana</i>	II 2	I 2	III 6	1 3		II 3	II 3	II 3	
<i>Koeleria glauca</i>			II 4	1 3	3 3917	II 51	II 52	III 78	IV 470
<i>Carex arenaria</i>	I 1	I 1	V 3625	1 3		I 1		I 1	
<i>Festuca trachyphylla</i>	II 2	III 178	II 102	3 8			III 752	IV 153	III 2096
<i>Cetraria aculeata</i>		III 177	II 102		1 3	III 14	III 4	IV 31	III 128
<i>Tragopogon floccosus</i>	I 1	I 2		2 5	2 7	III 14		I 2	II 4
<i>Spergula morisonii</i>		IV 55	I 2	1 3		III 4	I 1	II 3	
<i>Hypericum perforatum</i>	III 58		II 4	2 128			III 5	II 2	
<i>Cladonia foliacea</i>	I 1	I 2	II 102				IV 104	I 1	II 126
<i>Rumex acetosella</i>	II 2	I 2				II 2	III 4	III 30	II 1
<i>Thymus serpyllum</i>	III 59	II 51		1 3			II 2	II 28	II 1
<i>Galium verum</i>	III 198			2 5			IV 203	II 2	II 1
<i>Agrostis vinealis</i>	I 1	I 2				II 2	II 2	II 53	
<i>Scleranthus perennis</i>		II 3			1 3	I 1	I 1	I 1	
<i>Festuca ovina</i>	I 1	I 2						I 51	II 500
<i>Trifolium arvense</i>				2 128	2 7		II 2		I 1
<i>Silene otites</i>	I 1		I 2		1 3				II 4
<i>Festuca psammophila</i>		I 1				II 2			IV 877
<i>Astragalus arenarius</i>		I 1						I 2	III 128
<i>Knautia arvensis</i>	I 1			2 5			I 1		
<i>Leymus arenarius</i>				1 3		V 7000			
<i>Carex ligerica</i>				4 5625		I 1			

Festuco-Brometea:									
<i>Euphorbia cyparissias</i>	II 2		I 2	1 3	2 7	II 52	IV 55	II 2	III 5
<i>Artemisia campestris</i>	I 1	I 1	I 2	4 10	3 10		I 1		I 1
<i>Asparagus officinalis</i>	I 1	I 1		1 3					II 65
<i>Dianthus carthusianorum</i>	II 3			II 5			V 57	II 3	I 1
<i>Centaurea stoebe</i>		I 1		2 5	2 7		II 52		
<i>Potentilla arenaria</i>	II 13			2 5			III 5	I 1	II 1
<i>Veronica spicata</i>	II 2			2 5			III 4	I 1	I 1
<i>Centaurea scabiosa</i>	I 1						I 1		III 5
<i>Stipa joannis</i>							V 3375		
Trifolio-Geranietea:									
<i>Agrostis capillaris</i>	II 13	II 52	II 4	2 128		III 180	II 377	II 29	
<i>Poa angustifolia</i>	I 1			1 3		II 2	II 3		II 1
Calluno-Ulicetea:									
<i>Peucedanum oreoselinum</i>	II 5	IV 6	II 102			I 1	V 8	IV 32	I 1
<i>Calluna vulgaris</i>	III 59	III 4	II 102			I 1	II 3	V 6776	
<i>Carex ericetorum</i>	III 59	IV 153				I 1	IV 6	IV 31	I 1
<i>Hieracium umbellatum</i>			II 4	1 3		I 1		III 78	III 128
<i>Viola canina</i>	II 3				1 3			I 26	I 1
<i>Arctostaphylos uva-ursi</i>		I 1						IV 3112	
Remaining:									
<i>Cladonia arbuscula</i>	II 2	I 1	III 104	4 255		I 1	II 3	III 362	II 470
<i>Cladonia macilenta</i>	II 2	I 52	III 4	2 128		I 1	III 4	V 204	I 1
<i>Cladonia pyxidata</i>	I 1	I 2	II 102	1 3		I 1	II 52	II 28	I 1
<i>Pinus sylvestris</i> a, b, c		I 2	I 2	1 3	1 3		I 1	II 28	V 690
<i>Chondrilla juncea</i>	I 1		I 2	1 3	2 7	III 4	I 1	I 1	
<i>Conyza canadensis</i>	I 1	III 4		1 3	2 7	I 1	I 1		
<i>Cladonia phyllophora</i>	I 1	I 2	I 2			I 2	II 3	III 4	I 1
<i>Cladonia cornuta</i>	II 3	IV 55	III 6			III 4	III 54	II 27	I 1
<i>Solidago virgaurea</i>	I 1	III 102	I 2			I 1	II 2		IV 6
<i>Cladonia fimbriata</i>	I 1	I 1				I 1	II 2	I 1	I 1
<i>Cladonia uncialis</i>			I 2			I 1	III 401	II 4	I 1
<i>Carex hirta</i>	I 1		I 2	3 8		II 52		I 1	
<i>Achillea millefolium</i>				2 5	3 10	II 1	III 4	I 1	
<i>Cladonia chlorophaea</i> s.l.	I 1	I 1	I 2				III 54		I 1
<i>Linaria vulgaris</i>	II 2		I 2	2 128			II 2		II 1
<i>Cladonia rangiformis</i>	I 1					I 1	II 3	II 27	I 1
<i>Populus tremula</i> b, c	III 3	I 1					II 2	I 1	I 1
<i>Pleurozium schreberi</i>	I 1			3 375			IV 652	I 1	
<i>Cladonia cervicornis</i>		II 3	II 4		1 3			III 78	
<i>Hypnum cupressiforme</i>	II 2						I 1	I 1	II 65
<i>Cladonia subulata</i>	II 2		I 2	2 5				I 2	

<i>Convolvulus arvensis</i>				1 3	1 3	I 1	I 1		
<i>Cephalozia starkei</i>		I 1				II 3	I 1	II 2	
<i>Betula pendula</i>	II 2	I 1					I 1	II 2	
<i>Deschampsia flexuosa</i>	I 1	I 1	I 2					II 52	
<i>Anthericum ramosum</i>	II 2		I 2					III 55	II 1
<i>Convallaria majalis</i>	II 2	I 2						II 27	II 4
<i>Padus serotina</i> b, c		I 2	I 2					I 1	III 5
<i>Dicranum scoparium</i>	II 2						I 1	I 1	I 1
<i>Cladonia portentosa</i>		I 1					I 1	I 1	II 1
<i>Vincetoxicum hirundinaria</i>	II 3	I 1				I 1	I 1		II 1
<i>Lotus corniculatus</i>	I 1	I 1						I 1	I 1
<i>Festuca duvalii</i>					3 173	II 51	I 1		
<i>Vicia tetrasperma</i>				1 3			II 52		IV 68
<i>Polygonatum odoratum</i>	III 4	I 1						III 5	IV 68
<i>Cetraria islandica</i>		I 2						II 4	IV 68
<i>Sedum acre</i>					3 10		I 1		II 65
<i>Oenothera rubricaulis</i>	II 2					II 51	I 1		
<i>Cladonia furcata</i>	I 1							I 26	III 5
<i>Oenothera biennis</i>			II 4		2 7				II 1
<i>Trifolium alpestre</i>				1 3			II 2		I 1
<i>Trifolium campestre</i>				1 3				I 1	I 1
<i>Pulsatilla pratensis</i>	I 1			1 3			I 1		
<i>Cladonia coniocraea</i>		I 1	I 2					I 1	
<i>Sorbus aucuparia</i> b	I 1							I 1	I 1

Gatunki sporadyczne – occasional species:

Epilobietea angustifolii: *Centaurium erythraea* (9/II 1), *Chamaenerion angustifolium* (1/I 1)

Koelerio-Corynephoretea: *Arenaria serpyllifolia* (7/II 2; 9/II 1), *Armeria maritima* (7/I 1), *Dianthus arenarius* (2/I 1; 8/I 1), *Plantago arenaria* (2/I 1), *Rhacomitrium canescens* (3/I 2; 7/I 1), *Silene chlorantha* (5/1 3), *Teesdalea nudicaulis* (3/II 102)

Festuco-Brometea: *Asperula tinctoria* (7/I 1), *Carex praecox* (7/I 1), *Filipendula vulgaris* (7/I 1), *Helianthemum nummularium* ssp. *obscurum* (7/II 3), *Koeleria pyramidata* (7/I 1), *Phleum phleoides* (7/II 51), *Poa compressa* (1/I 1), *Salvia pratensis* (7/II 3), *S. verticillata* (1/I 1), *Scabiosa canescens* (7/II 2), *S. ochroleuca* (8/I 1), *Scorzonera purpurea* (7/I 1), *Thesium linophyllum* (7/I 1), *Veronica austriaca* (7/I 1)

Remaining: *Anchusa officinalis* (1/I 1), *Anthoxanthum odoratum* (3/I 2), *Arabidopsis thaliana* (4/1 3), *Berberis vulgaris* b (1/I 1; 9/IV 8), *Berteroa incana* (5/2 7; 7/I 1), *Botrychium lunaria* (9/I 1), *Brachythecium salebrosum* (9/I 1), *B. velutinum* (9/I 1), *Bryum inclinatum* (1/I 1), *Campanula rotundifolia* (1/I 1; 8/V 1), *Cardaminopsis arenosa* (9/I 1), *Carex pilulifera* (8/I 1), *Carlina vulgaris* (9/I 1), *Cerastium holosteoides* (7/I 1), *Chiloscyphus polyanthos* (9/II 1), *Cladonia cenotea* (8/I 1), *C. ciliata* (9/II 471), *C. coccifera* (3/I 2; 8/II 90), *C. crispata* (2/I 1; 8/I 1), *C. deformis* (8/II 3), *C. glauca* (9/I 1), *C. gracilis* (8/II 51), *C. pleurota* (7/I 1; 8/III 4), *C. rangiferina* (1/I 1; 8/I 1), *C. squamosa* (9/I 1), *C. symphyocarpa* (9/I 1), *Coronilla varia* (7/II 2), *Crataegus monogyna* (9/I 1), *Sarothamnus scoparius* (8/I 1), *Diploschistes muscorum* (5/2 333), *Echium vulgare* (5/1 3), *Epipactis atrorubens* 9/V 629), *Equisetum arvense* (1/I 1; 2/I 1), *E. hyemale* (5/1 3), *Euphrasia stricta* (4/1 3; 7/I 1), *Fallopia convolvulus* (1/I 1; 3/I 2), *F. polesica* (9/I 1), *F. tenuifolia* (9/II 64), *Frangula alnus* (9/I 1), *Galium boreale* (7/I 1), *G. mollugo* (9/II 4), *Geranium sanguineum* (1/I 1; 8/I 1), *Gypsophila fastigiata* (9/II 1), *Hieracium echinoides* (9/I 1), *H. laevigatum* (8/I 1), *Hypochoeris radicata* (8/I 1), *Hypogymnia physodes* (8/I 2; 9/I 1), *Juniperis communis* b (8/I 1), *Klebsormidium crenulatum* (2/I 2; 6/I 1), *Koeleria macrantha* (7/I 1; 9/III 5), *Lecanora conizaeoides* (8/II 4), *Medicago lupulina* (5/1 3), *Melampyrum pratense* (8/I 138), *Mnium rugicum* (8/I 1), *Trapeliopsis flexuosa* (2/I 1), *Oenothera acutifolia* (4/1 3), *O. pycnocarpa* (1/I 1; 1/I 2; 4/1 3), *O. royleana* (1/I 1), *Padus virginiana* (9/I 1), *Peltigera canina* (7/I 1), *Pimpinella saxifraga* (7/I 1), *Poa trivialis* (4/1 3), *Pohlia nutans* (1/I 1; 8/II 2), *Polytrichum commune* (1/I 1), *P. juniperinum* (3/I 2; 8/I 113), *Populus x canescens* (9/I 1), *Prunus spinosa* b/c (1/I 1; 7/I 1), *Pyrus pyraeaster* (9/I 1), *Quercus robur* b/c (8/I 1; 9/II 1), *Rosa canina* (4/1 3), *R. sherardii* (1/I 1), *Rubus saxatilis* (1/I 1), *Rumex acetosa* (1/I 1), *Salix acutifolia* (9/V 3190), *Senecio jacobaea* (9/I 1), *S. viscosus* (3/I 2), *Silene latifolia* (1/I 1; 7/I 1), *S. vulgaris* (5/1 3), *Solidago gigantea* (1/I 1; 8/V 34), *Taraxacum officinale* (9/II 65), *Tortula ruralis* (3/I 2; 9/II 1), *Trapeliopsis granulosa* (8/I 1), *Trifolium repens* (9/I 1), *Vaccinium vitis-idaea* (8/I 1), *Verbascum phlomoides* (4/II 3), *Vicia hirsuta* (4/II 3), *Viola arvensis* (3/I 1)

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