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Some aspects of site conditions of heathlands in the Toruń Basin

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Abstract. The aim of the paper is to characterize some aspects of site conditions in selected places with the occurrence of heather (*Calluna vulgaris*) within the certain area of the Toruń Basin affected by military activities. Relations of heathlands to the soil cover appear to focus on the position of heather in the ecological succession on presently developing, young sandy soils and regularities of the heather distribution in a mosaic with grasslands in isolated dune fields. Studies were performed at two sites: Stawki and Chorągiewka.

Heathlands of this area are connected with nutrient-poor and dry sandy habitats. In the ecological succession, which proceeds in places previously devoid of the vegetation cover and strongly deflated, they occur as a transitional type of vegetation, displacing plants of initial psammophilous community (*Spergulo-Corynephoretum*) and later giving place to pine forest. In the soil evolution, they are connected with the intermediate stage represented by arenosols (haplic arenosols) – weakly developed but sufficiently acid soils.

On deforested, parallel dunes of the Toruń Valley, there are specific regular mosaics of vegetation and soil. Heather occurs on podzolized soils (albic arenosols, haplic podzols) on north-western slopes. Dry grasslands (*Calamagrostis epigejos*) cover slopes with south-eastern exposition, with soils eroded down to bed-rock and now regenerating to the stage of arenosols (haplic arenosols). Podzolized soils seem not to be developed under heather but rather under the relics of former pine forests preserved from erosion and deflation on less steep and more moist slopes.

Key words: heathlands, soil development, podzols, arenosols, inland dunes.

1. Introduction

Heathlands of Europe are mostly thought to be the elements of artificial landscapes (Rose et al. 2000), covering acid soils of low fertility (Webb 1998; Hufkens et al. 2009). There are two main types of heather habitats described in the literature: 1 – dry sites developed mainly on mineral sandy soils, very poor in nutrients (Podzols, Arenosols; Stützer 1998; Mossin et al. 2001; Nørnberg et al. 1993) and 2 – wetlands connected with raised bogs (Histosols, Histic Podzols, e.g. Bardgett & Marsden 1995). Both types belong to habitats of high fragility and susceptibility to even small changes in environmental conditions and anthropogenic impact, and thus threatened with degradation.

Also in the Toruń Basin, the common occurrence of heather *Calluna vulgaris* (L.) Hull results from the human activity. The largest areas covered with dense heaths are found in formerly or still used military zones, where forest vegetation was removed some dozens years ago. Small patches of heather occur in many open places and on borderlines of woodlands (e.g. along forest roads). Actually, due to afforestation many heath habitats disappear, which can be exemplified by the Zadroże dune (Nienartowicz et. al. 2010).

Site conditions of heather occurrence in the Toruń Valley have not been studied until now. The purpose of this work is to characterize rules of spatial distribution of heathlands and their relations with the soil cover in that region, regarding two aspects: 1 – the position of heather in the ecological succession on presently developing young sandy soils and 2 – regularities in the occurrence of heathlands in isolated dune fields.

The research was carried out on the artillery range in Toruń, the main area of heath occurrence in the Toruń Valley.

2. Location of the study area

Two sites representing different aspects of heath occurrence were selected for the studies: Stawki and Chorągiewka (Fig. 1). Both sites represent landscapes typical of the whole Toruń Valley. They are located on glaciofluvial terraces of Late Vistulian age (Weckwerth 2004) built of sandy or sandy-gravelly deposits. The surface of terraces is more or less covered with aeolian mantles and dunes. Soils at both sites are built of loose sands, with the dominant fraction of fine and medium grained sand (0.1–0.25 and 0.25–0.5 mm) reaching 70–94%. Quartz predominates in the mineral composition (85–99%). The content of feldspar does not exceed 15% and heavy minerals constitute only 1% (Jankowski 2003). Thus, the mineral parent material of soils is excessively permeable and extremely poor in nutrients.

Continental forests of *Peucedano-Pinetum* and *Querco roboris-Pinetum* are thought to be potential, natural vegetation in the area (Matuszkiewicz 1995).

3. The position of heather in the ecological succession on presently developing young sandy soils

Site 1 – Stawki represents the remains of an anthropogenic „desert". As a consequence of the former military activity lasting over 100 years, the place was totally devoid of vegetation. Thus, aeolian processes, which are present here, bring about the development of a deflational landscape with typical, active micro- and mezo- forms of both, erosive origin (stony aeolian pavements, bowl-like depressions, deflational remnants) and accumulative origin (ripple marks, hillocks or even small dunes). Former, well developed rusty soils (according to IUSS 2007: brunic arenosols) and podzolized soils (IUSS 2007: Haplic Podzols and Albic Arenosols) were eroded or covered with fresh wind-blown sand. Deflation exposed deeper soil horizons or even parent material to the surface. In some places older, buried soils were also exposed (Jankowski 2003). Nowadays, pioneer psammophilous plants are overgrowing the area along borderlines (Photo 1), forming following stages of ecological succession (Fig. 1). The process is very slow, due to low fertility and low water retention

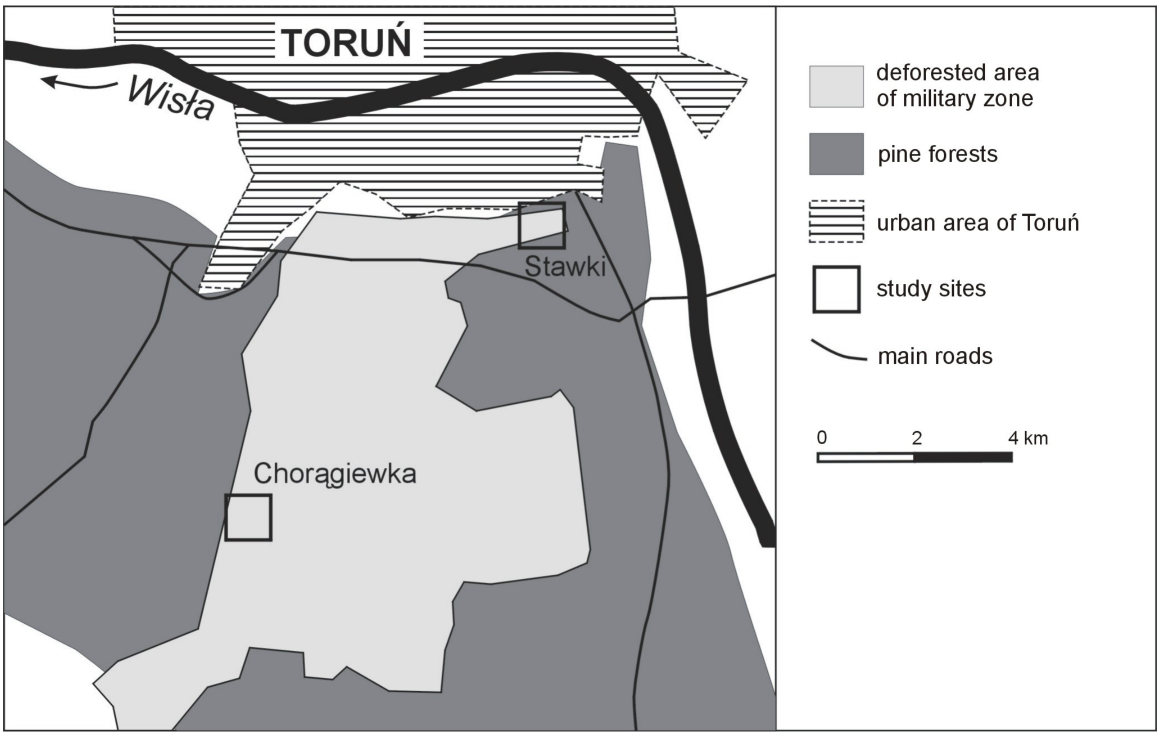


Figure 1. Location of the study sites

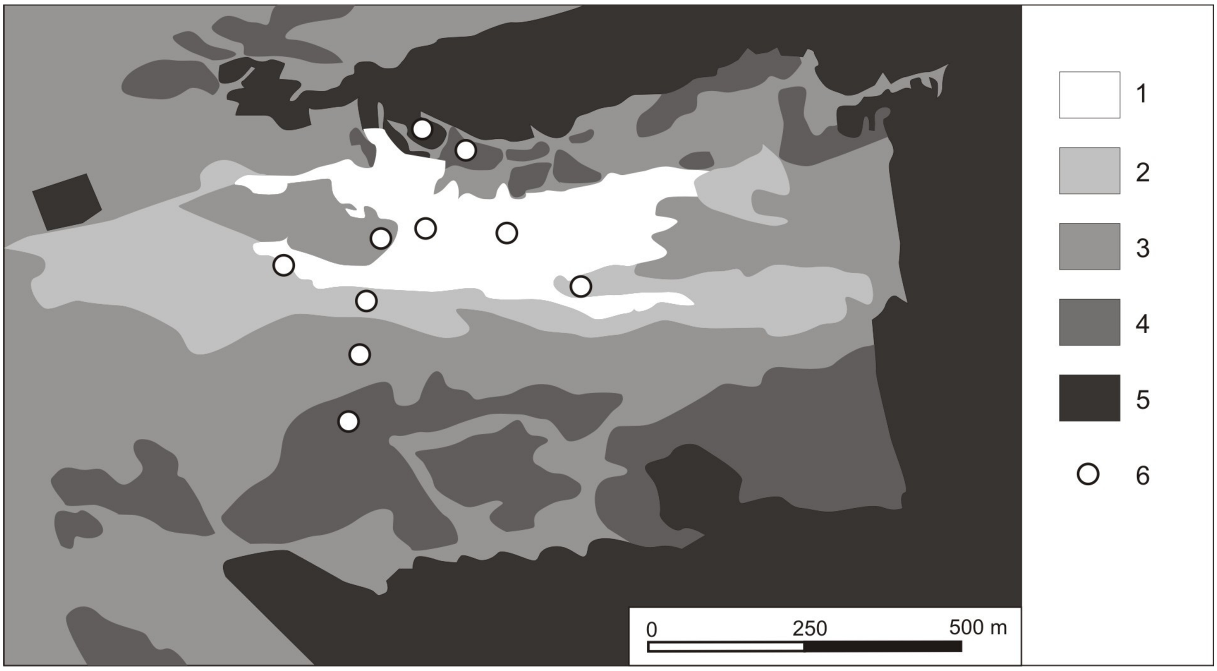


Figure 2. Soils and vegetation at the site Stawki. 1 – bare sands/no vegetation, 2 – Protic Arenosols/single *Corynephorus canescens*, 3 – Haplic Arenosols/dense *Spergulo-corynephoretum*, 4 – Haplic Arenosols/*Calluna vulgaris,* single *Pinus sylvestris*, 5 – Podzolic soils (Albic Arenosols) /pine forest, 6 – soil pits

of sands covering the area. In places already stabilized by plants, the soil development proceeds parallel to vegetation succession, leading to slow regeneration of the eroded or buried soil cover and the whole ecosystem (Photo 2).

Mechanisms of vegetation succession and its relations with soil forming processes in loose sands constituted a subject of many researches (e.g. Kobendzina 1969; Chabarov 1977; Stützer1998; Rahmonov 1999, 2007). In the study area, they were described by Jankowski and Bednarek (2000, 2002). Three developmental stages were distinguished in the soil evolution, correlated with changes in the vegetation (Fig. 3):

– In the initial stage, initial soils, classified as protic arenosols according to the IUSS Working Group WRB (2007) or aeolian regosols according to the Systematics of Polish Soils (PTG 1989), begin to develop under single plants of *Corynephorus canescens*, which with time forms more and more dense plant cover stabilizing the bare sand. As it was demonstrated by Rahmonov (2007), also *Algae* play a significant role at this stage. Protic arenosols are built only of an initial, often discontinuous humic horizon (A) with a depth of 1–3 cm, appearing on the top of the stratified parent material C (Photo 3).

– The intermediate stage is represented by weakly developed soils, haplic arenosols (IUSS 2007; or proper arenosols in the Systematics of Polish Soils PTG 1989), occurring under the dense vegetation cover of *Spergulo-Corynephoretum* with *Corynephorus canescens*, *Polytrichum piliferum* and *Cladonia* spp. as the main components. At the end of that stage, single bushy pines (*Pinus sylvestris*) and birch (*Betula pendula*) appear and during 20–30 years, they form single biogroups (Rahmonov 1999) in a mosaic with psammophilous plants. Haplic arenosols have only 5 cm deep, continuous humic horizon A over the parent material C (Photo 4). In some examined profiles, the aeolian stratification of sediments disappeared down to 30 cm, but mostly it can be observed directly underneath the A horizon.

– The semi-mature stage was distinguished for coniferous forest, when pines form close canopy and lose their bush-like shapes. Psammophilous turf plants disappear due to the increase of shadow and accumulation of litter produced from coniferous forest plants (Photo 5). In *mor* soil types of the humus formation, podzolization proceeds. At this stage, weakly developed E and Bs horizons are evidently morphological effects of this process, however diagnostic criteria of the well developed podzols (IUSS 2007) are not yet met.

In such a scheme of ecological and soil-forming succession, the existence of heather suits to the later part of the intermediate stage. Single clusters of *Calluna vulgaris* appear when the mineral soil surface is already densely covered with lichens and mosses, and *Corynephorus canescens* is declining. At that moment, haplic arenosols are

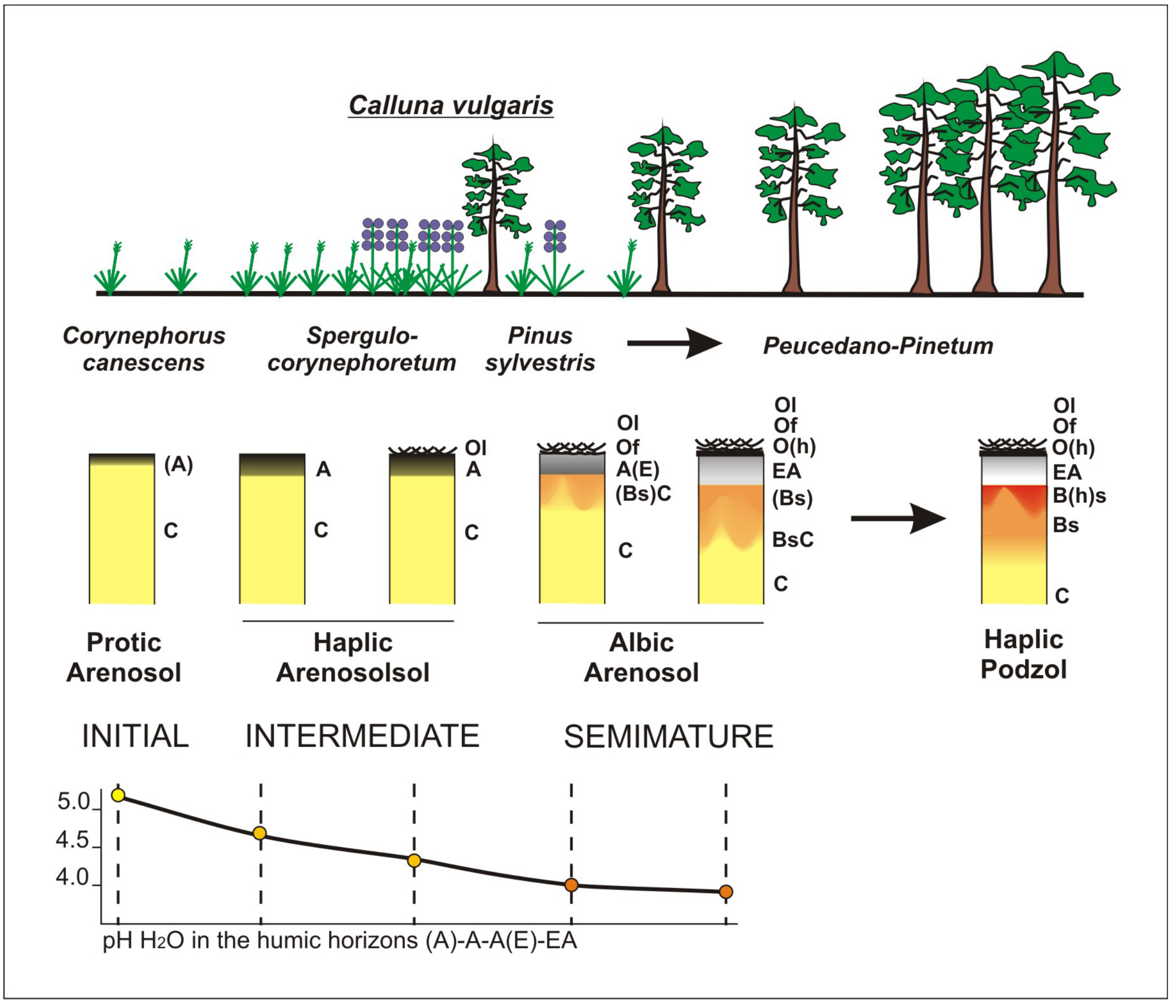


Figure 3. Scheme of soil developmental stages in relation to plant succession (Jankowski & Bednarek 2000; Jankowski 2003)

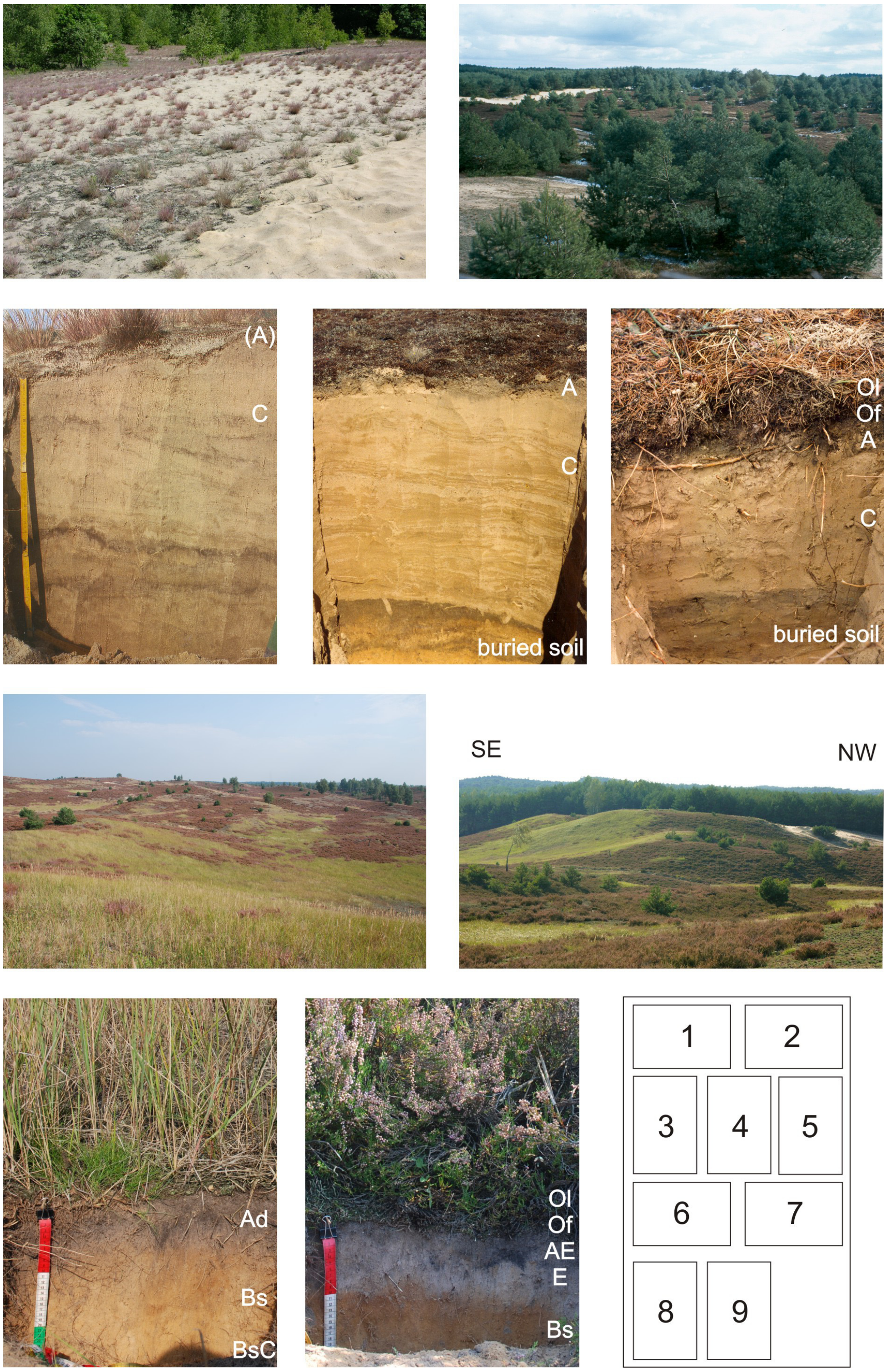
ca. 0.5 pH more acid than protic arenosols at the initial stage and 0.5 pH less acid than podzolized soils at the semi-mature stage. The water pH value of 4.4 approaches the range of Al buffer, which is considered to be one of the driving forces of podzolization (Stützer 1998). Also the light conditions are still suitable for heather. The occurrence of trees and further increase of their density worsens the light conditions and intensifies the podzolization process.

4. Regularities in the occurrence of heathlands in dune fields

Site 2 – Chorągiewka is situated in the central part of a big dune filed (according to Mrózek 1958: the dune field of Toruń-Aleksandrów-Gniewkowo), in the western part of the area deforested for military purposes (Fig. 4). The site represents features typical of the largest area with heathlands in the Toruń Valley.

Bow-shaped dunes, high up to 30 m, form a regular pattern of parallel ridges stretching from the North-East to the South-West (Photo 6). Also the vegetation shows a clear regularity of occurrence according to exposition (Fig. 4). Slopes of dunes faced to the South-East (distal) are covered with grasslands of *Calamagrostis epigejos* and north-western slopes (proximal) are overgrown with dense heathlands (Photos 6, 7). Patches of both types of vegetation form mosaics also at bottoms of intra-dune depressions.

A regular pattern in the distribution of vegetation reflects the site conditions (Fig. 5). Although topoclimate and light relationships are rather obvious, the soil conditions seem to be more complex. The variability in the occurrence of soil types due to exposition can be observed. Arenosols are typical of grasslands on south-eastern slopes and podzolized soils (haplic podzols, albic arenosols) for



Photos of the Stawki site: 1. *Corynephorus canescens* fixing windblown sands at the initial stage, 2. *Pinus sylvestris* overgrowing heathland at the end of the intermediate stage, 3. Protic Arenosol under single *Corynephorus canescens*, 4. Haplic Arenosol under dense *Spergulo-Corynephoretum*, 5. Haplic Arenosol with organic O horizon under young *Pinus sylvestris*. **Photos of the Chorągiewka site:** 6. General view of the dunes, 7. Vegetation pattern: *Calamagrostis epigejos* on SE and *Calluna vulgaris* on NW dune slopes, 8. Haplic Arenosol developed in remnants of former Podzolic soil under *Calamagrostis epigejos*, 9. Podzolic soil (Albic Arenosol) under *Calluna vulgaris*

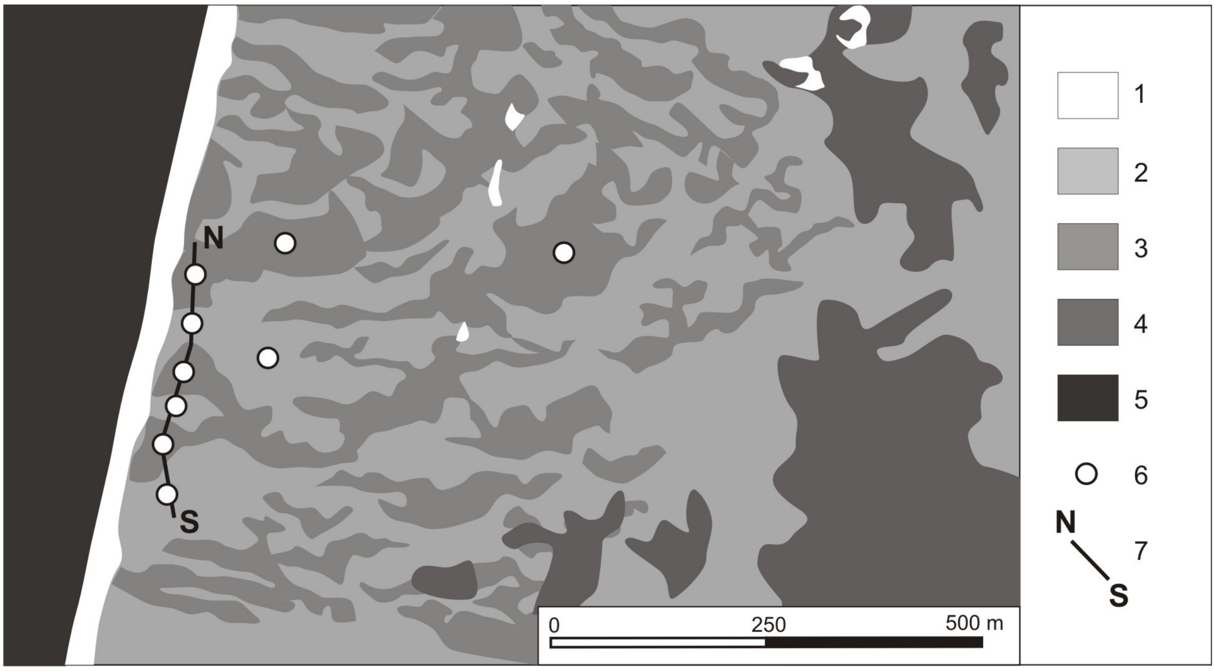


Figure 4. Soils and vegetation at the site Chorągiewka. 1 – bare sands/no vegetation, 2 – Haplic Arenosols and Rusty soils (Brunic Arenosols) /*Calamagrostis epigejos*, *Spergulo-corynephoretum*, 3 – Podzolic soils (Albic Arenosols) and Haplic Arenosols/ dense *Calluna vulgaris*, 4 – Rusty soils (Brunic Arenosols), Arenosols/single *Pinus sylvestris*, *Betula pendula* 5 – Podzolic soils (Albic Arenosols, Haplic Podzols)/Pine forest, 6 – soil pits, 7 – transect shown in the Figure 5

north-western slopes covered with heather. Flat bottoms of intra-dune depressions are built of slightly more rich glaciofluvial sediments and are covered by generally well preserved rusty soils (IUSS 2007: brunic arenosols).

Arenosols under the dense cover of *Calagrostis epigejos* differ from these found at the Stawki site, under *Spergulo-Corynephoretum*, in the presence of better developed humic Ad horizon of sod-like character formed on the top of remnants of eroded former soil (Bs, BC or C; Photo 8). Podzolized soils under the heather at the Chorągiewka site represent the early stage of podzolization. Their structure is: AE-E-Bs-C (Photo 9), however the Bs horizon mostly does not meet the criteria of the spodic horizon according to the WRB classification (IUSS 2007).

The apparent variability of the soil mantle due to the exposition of dune slopes is interpreted as a result of various susceptibility to deflation and erosion in case of vegetation destruction. The south-eastern slopes (distal) are more steep and more dry. They are eroded very easily, what results in the initiation of the development of the next generation of young soils (arenosols). The north-western slopes are less sunny and more moist, so more resistant to geomorphological processes. Thus, older podzolized soils could be much more preserved, as relics of the former forest landscape. In the surrounding area, on dunes overgrown with pine forests, podzolization is the dominant soil-forming process, regardless of the exposition (Jankowski 2003). In the literature, heather is considered as a plant causing the podzolization process in the soil, however within the moderate range, much less than coniferous trees (Nørnberg et al. 1993; Mossin et al. 2001).

On the other hand, arenosols under grasslands show higher accumulation of nitrogen together with organic matter in the sod humic Ad horizon, which stimulates the expansion of grasslands and limits the heathlands (Heil & Diemont 1983). It is noteworthy that due to the development of the sod-like humic horizon, arenosols under *Calamagrostis epigejos* on south-eastern slopes can be periodically even more moist than podzolized soils under the heather covering the north-western slopes (Fig. 5).

5. Conclusions

Heathlands are an important element of pedo-ecological processes proceeding in a dynamic landscape of sandy terraces and dunes of the Toruń Valley, susceptible to degradation. The heather colonizes mainly the surface of wind-

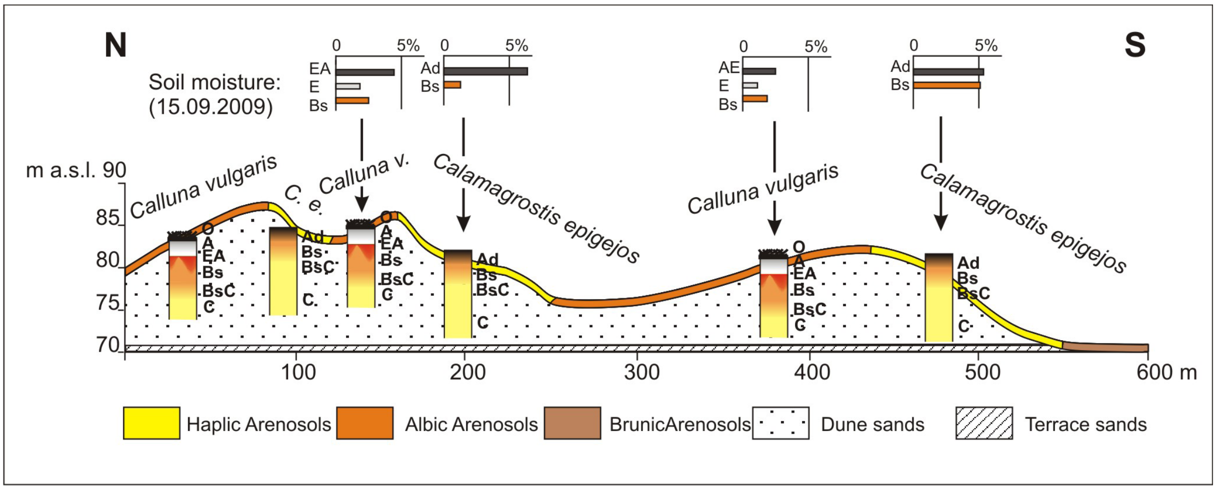


Figure 5. Soil conditions in mosaics of *Calluna vulgaris* and *Calamagrostis epigejos* at the site Chorągiewka

blown sands, which are already stabilized by plants of the initial psammophilous *Spergulo-Corynephoretum* community, when acidification increases the initiation of the podzolization process in the soil. However, heathlands in the Toruń Valley are a non-climax type of vegetation and they have transitional character. In natural conditions, if the human activity ceased, they would constantly shrink and give place to pine forest vegetation enhancing the podzolization process in soils.

The most common heathlands occur on deforested but not completely eroded podzolized soils, formerly developed under the forest vegetation. Probably, factors like the adequate level of acidification and the limited content of nitrogen in these soils prove their existence.

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