

Relations between organic horizon properties and forest plant composition in Scots pine (*Pinus sylvestris*) stands in south west Poland



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Material and methods

Humic Substances in Ecosystems 8,
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Location of the investigated area

shown on the map of polish State Forests division for 17 Regional Directorates



Field works

- The researches were conducted on 100 study plots in timber Scots pine (*Pinus sylvestris*) stands. In each plot Scots pine was dominant tree species in overstory.

Soil Type /Subtype	Haplic Podzols	Gleyic Podzols	Cambic Arenosols	Cambisols	Luvisols	Gleysols
Number of study plots	18	14	46	8	7	7

- In each plot:
 - organic horizon sample (Of or Ofh subhorizon) was collected,
 - phytosociological relevé using Braun-Blanquet method was taken.

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Analytical methods

In each collected soil sample it was determined:

- reaction ($\text{pH}_{\text{H}_2\text{O}}$ and pH_{KCl}) by potentiometric method,
- total organic carbon (TOC) and total nitrogen (Nt) content by CNS analyser,
- hydrolytic acidity (Hh) by the Kappen method,
- content of exchange basic cation (Ca^{2+} , Mg^{2+} , K^+ , Na^+) following extraction of samples in $1\text{M CH}_3\text{COONH}_4$ at $\text{pH } 7.0$, and the ASA method.

Data analysis

- For each soil sample it was calculated:
 - total exchangeable base cations (S) as a sum of Ca^{2+} , Mg^{2+} , K^+ , Na^+ ,
 - capacity of the sorption complex (T) as $\text{Hh} + \text{S}$,
 - base saturation (BS) as: $(\text{S}/\text{T}) \times 100\%$.
- For each study plot **Broad-leaved Species Cover Indicator (BSCI)** was calculated as:

$$\text{BSCI} = a + 0,75b + 0,25c,$$

where: a – cover of broad-leaved species in an overstory,

b – cover of broad-leaved species in a second story,

c – cover of broad-leaved species in a shrub layer.

- Relations between vegetation and organic horizon properties were examined using: Spearman correlation in STATISTICA 4.0; DCA (Detrended Correspondence Analysis) and Canonical Correspondence Analysis (CCA) in CANOCO 4.5 package [ter Braak, Šmilauer 2002]

Results

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Chosen properties of phytocoenosis

Broad-leaved Species Cover Indicator (BSCI)	Cover of broad-leaved species [%]		Amount of plant species	Amount of vascular plant species	Cover [%]	
	second story	shrub layer			herb layer	moss layer
19 ±19 (0-75)	14 ±22 (0-85)	9 ±17 (0-80)	16 ±5 (7-31)	13 ±5 (4-29)	67 ±20 (5-95)	44 ±26 (0-90)



Properties of organic horizons

Reaction, TOC, Nt and TOC:Nt ratio

pH		TOC [%]	Nt [%]	TOC:Nt
H ₂ O	KCl			
3,8	3,0	38,6	1,462	27,0
±0,3 (3,2-4,9)	±0,3 (2,5-4,4)	±6,9 (19,4-64,4)	±0,344 (0,805-2,615)	±4,4 (12,9-41,0)

Sorption properties

Hh	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	S	T	BS [%]
[mmol ₍₊₎ /100g]							
145	8,68	1,49	0,28	0,85	11,3	156	7,62
±30 (56,7-223)	±5,73 (0,64-30,1)	±0,74 (0,26-3,78)	±0,11 (0,07-0,74)	±0,30 (0,22-1,74)	±6,6 (1,19-34,8)	±28 (57,9-231)	±5,44 (1,94-30,0)

Correlation between properties of organic horizon and of phytocoenosis

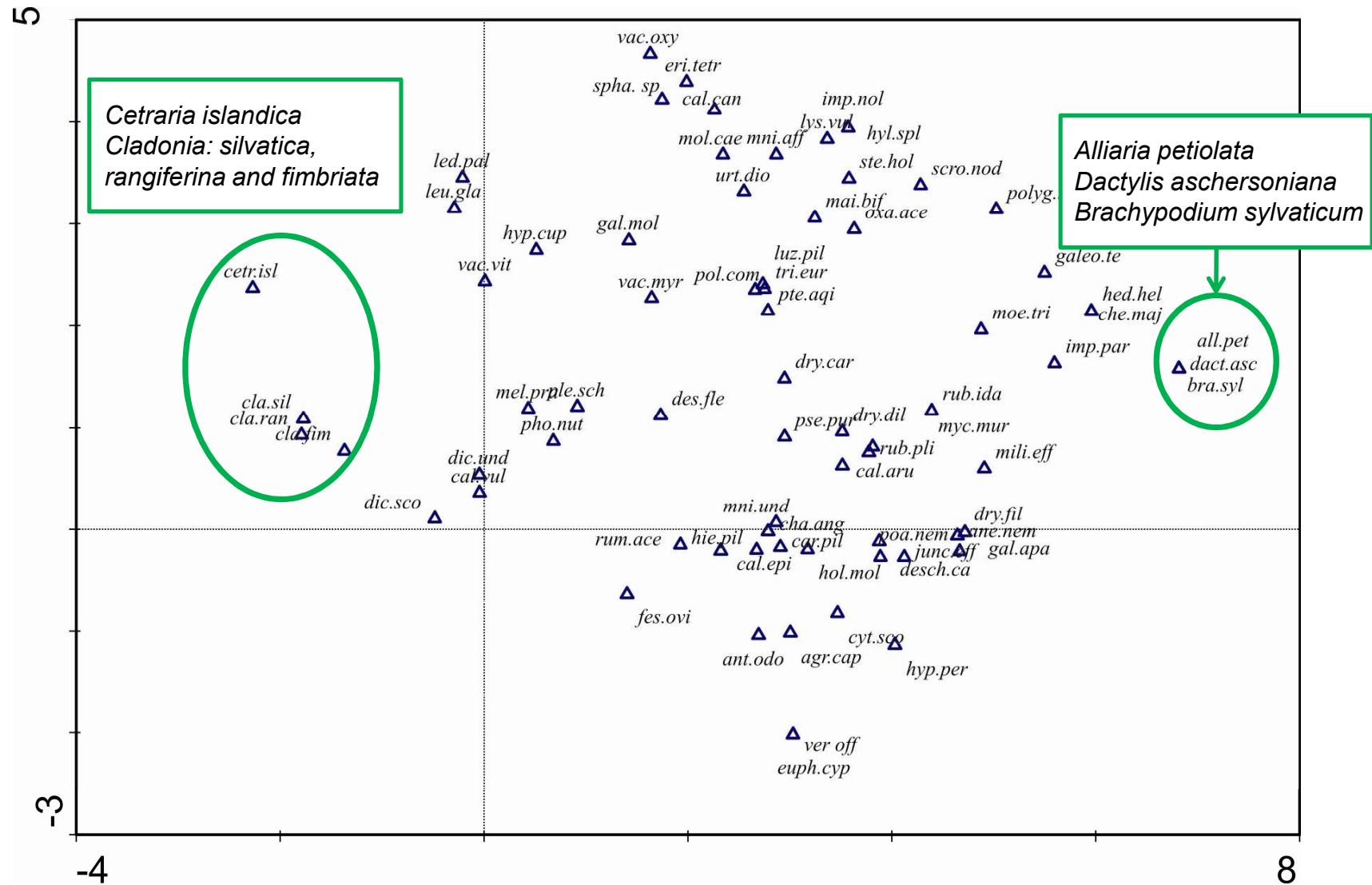
		Cation content [mmol ₍₊₎ /100g]					BS [%]	pH _{KCl}	Nt [%]	TOC:Nt
		Hh	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺				
Cover of broad-leaved species [%]	second story	-0,216*	0,337*	0,378*	0,083	0,290*	0,343*	0,324*	0,244*	-0,247*
	shrub layer	-0,296*	0,437*	0,424*	-0,002	0,139	0,456*	0,358*	0,186	-0,353*
	BSCI	-0,355*	0,367*	0,399*	-0,012	0,279*	0,431*	0,432*	0,208*	-0,381*
Amount of vascular plant species		-0,479*	0,538*	0,562*	-0,021	0,161	0,592	0,424*	0,251*	-0,449*
Cover [%]	herb layer (c)	0,124	0,006	0,081	0,055	0,029	0,001	-0,116	0,208*	-0,164
	moss layer (d)	0,249*	-0,509*	-0,560*	-0,016	-0,264*	-0,490*	-0,536*	-0,348*	0,379*

0,437* p < 0,01

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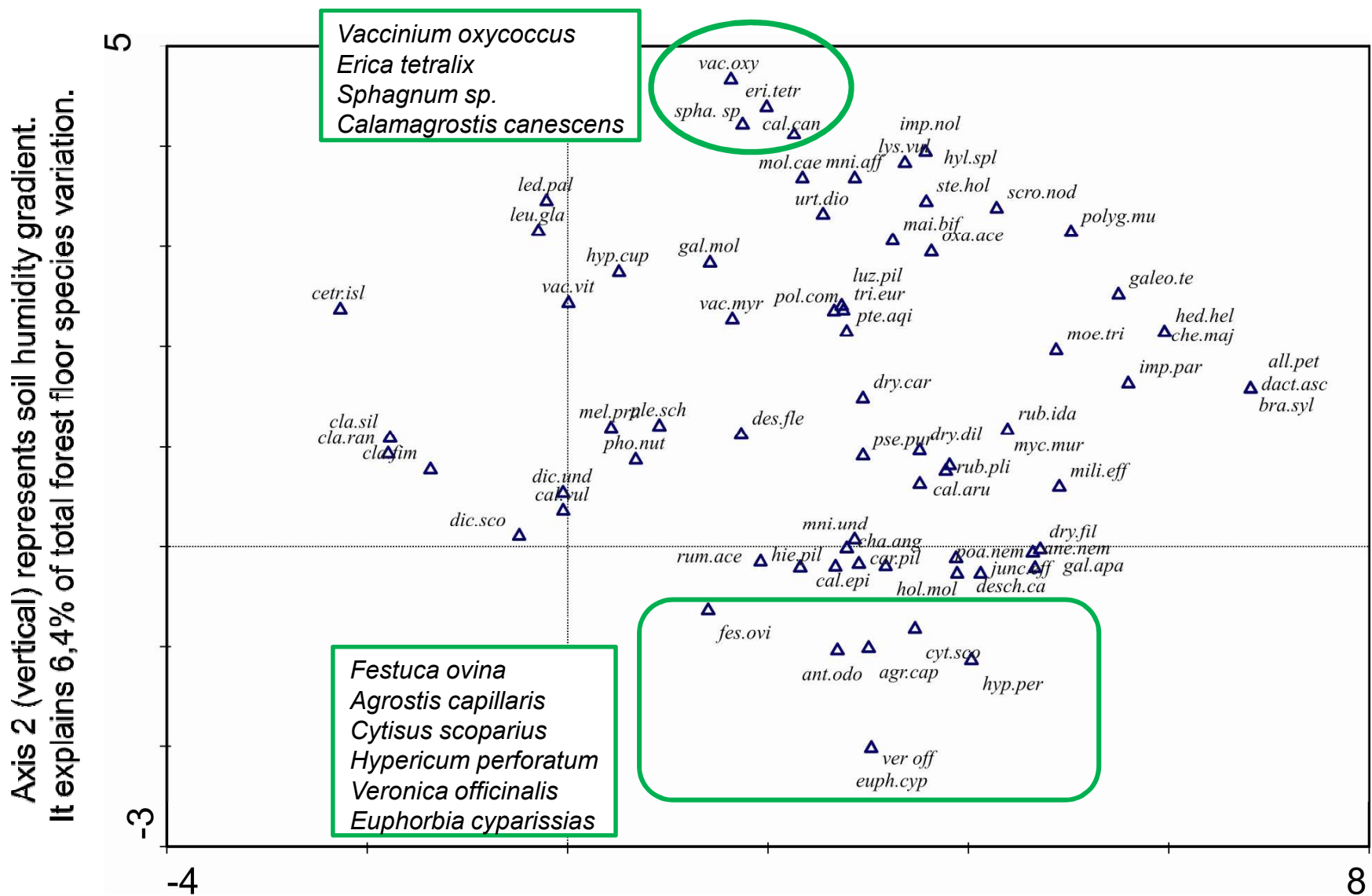
0,208* 0,01 < p < 0,05

DCA ordination diagram of forest floor vegetation species



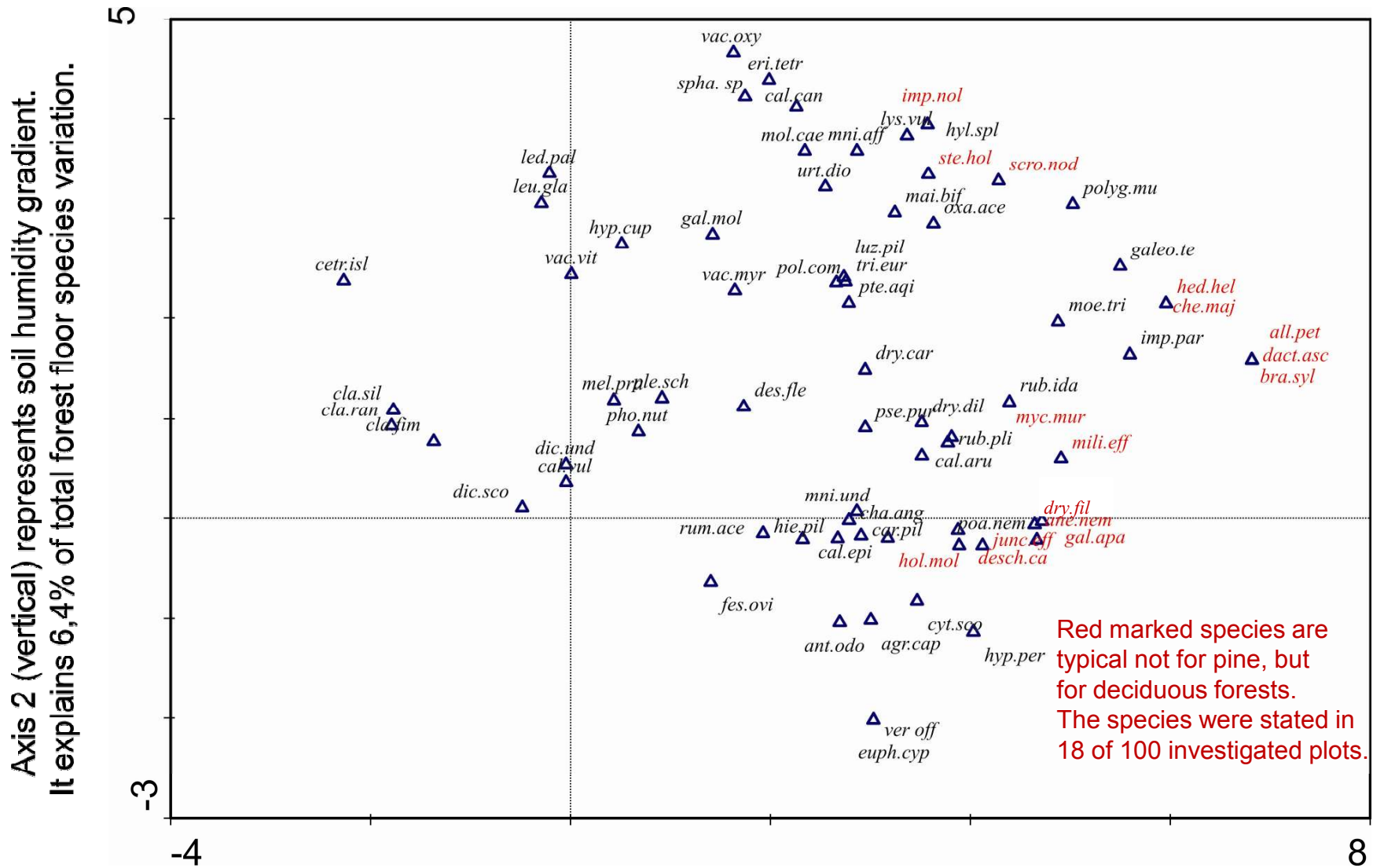
Axis 1 (horizontal) represents soil fertility gradient. It explains 11,6% of total forest floor species variation.

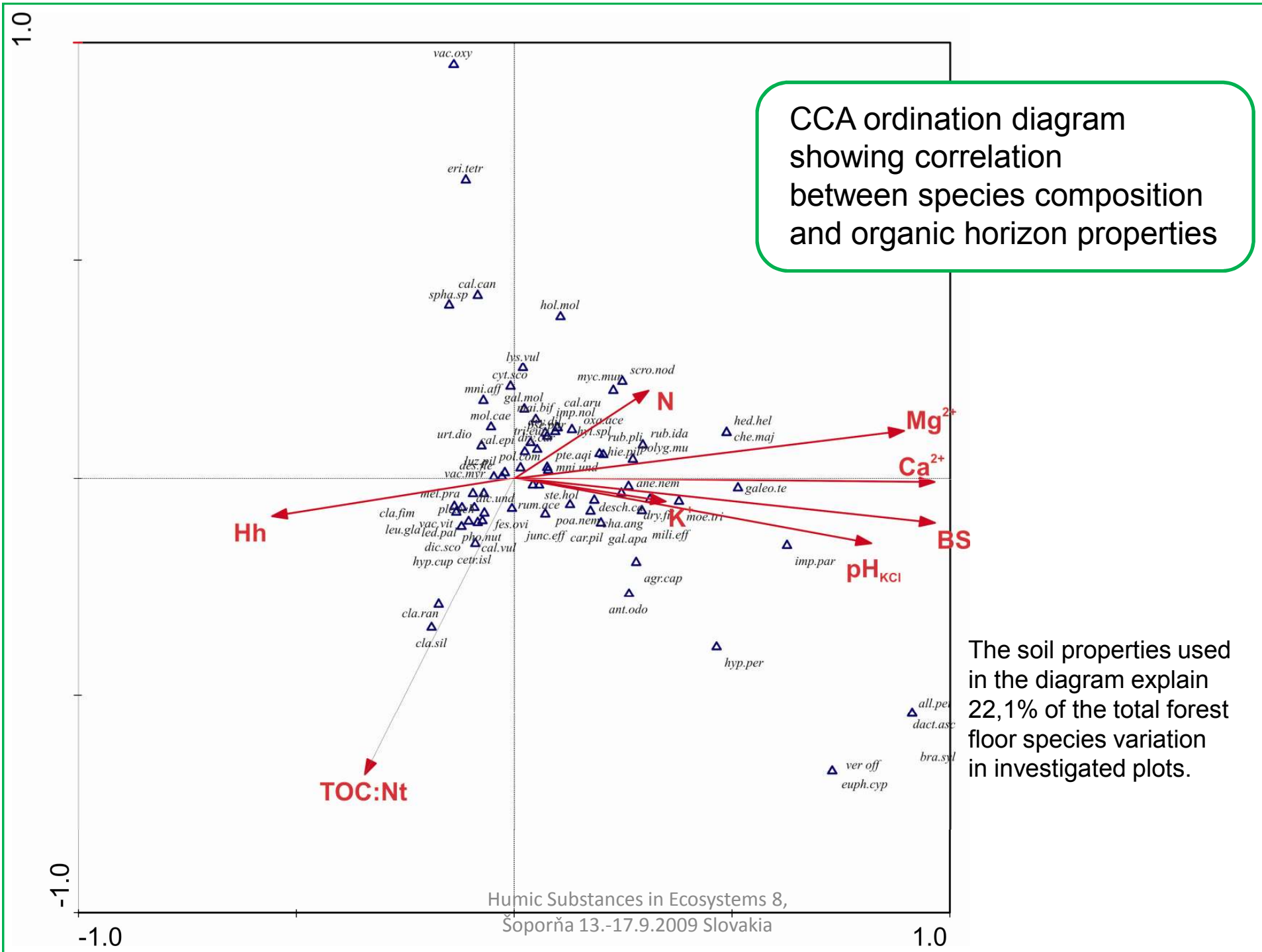
DCA ordination diagram of forest floor vegetation species



Axis 1 (horizontal) represents soil fertility gradient. It explains 11,6% of total forest floor species variation.

DCA ordination diagram of forest floor vegetation species





CCA ordination diagram showing correlation between species composition and organic horizon properties

The soil properties used in the diagram explain 22,1% of the total forest floor species variation in investigated plots.

Forest humus type: moder-mor



OI 4-2cm
Ofh 2-0cm
ABw

Bw

Quercus robur in the second story (cover: 70%)

BwC

IIC



Forest floor plants:

Herbs:

<i>Vaccinium myrtillus</i>	3
<i>Deschampsia flexuosa</i>	2
<i>Calamagrostis arundinacea</i>	2
<i>Pteridium aquilinum</i>	2
<i>Rubus plicatus</i>	2
<i>Dryopteris carthusiana</i>	1
<i>Calamagrostis epigejos</i>	1
<i>Rubus idaeus</i>	1
<i>Maianthemum bifolium</i>	1
<i>Epilobium angustifolium</i>	+
<i>Calluna vulgaris</i>	+
<i>Carex pilulifera</i>	+

Mosses:

<i>Pseudoscleropodium purum</i>	2
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Cambisol

Parent material:

loess silt on fluvioglacial sand

Main conclusions

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1. Organic horizon properties are strongly related to broad-leaved species portion in pine stands. The portion is positively correlated to soil properties that are connected with high soil fertility (base saturation, base cation content, pH). The correlation is significant negatively for biological activity soil indicator (TOC:Nt).
2. The analysis of forest floor species compositions suggests that many of pine stands in south west Poland are planted on soils that are originally connected with deciduous forests.
3. Organic horizon properties are more related to vegetation species composition than to potential soil fertility. Even on eutrophic soils, when forming under pine stands, organic horizon morphology is more similar to Mor than to Mull forest humus type.

The researches were
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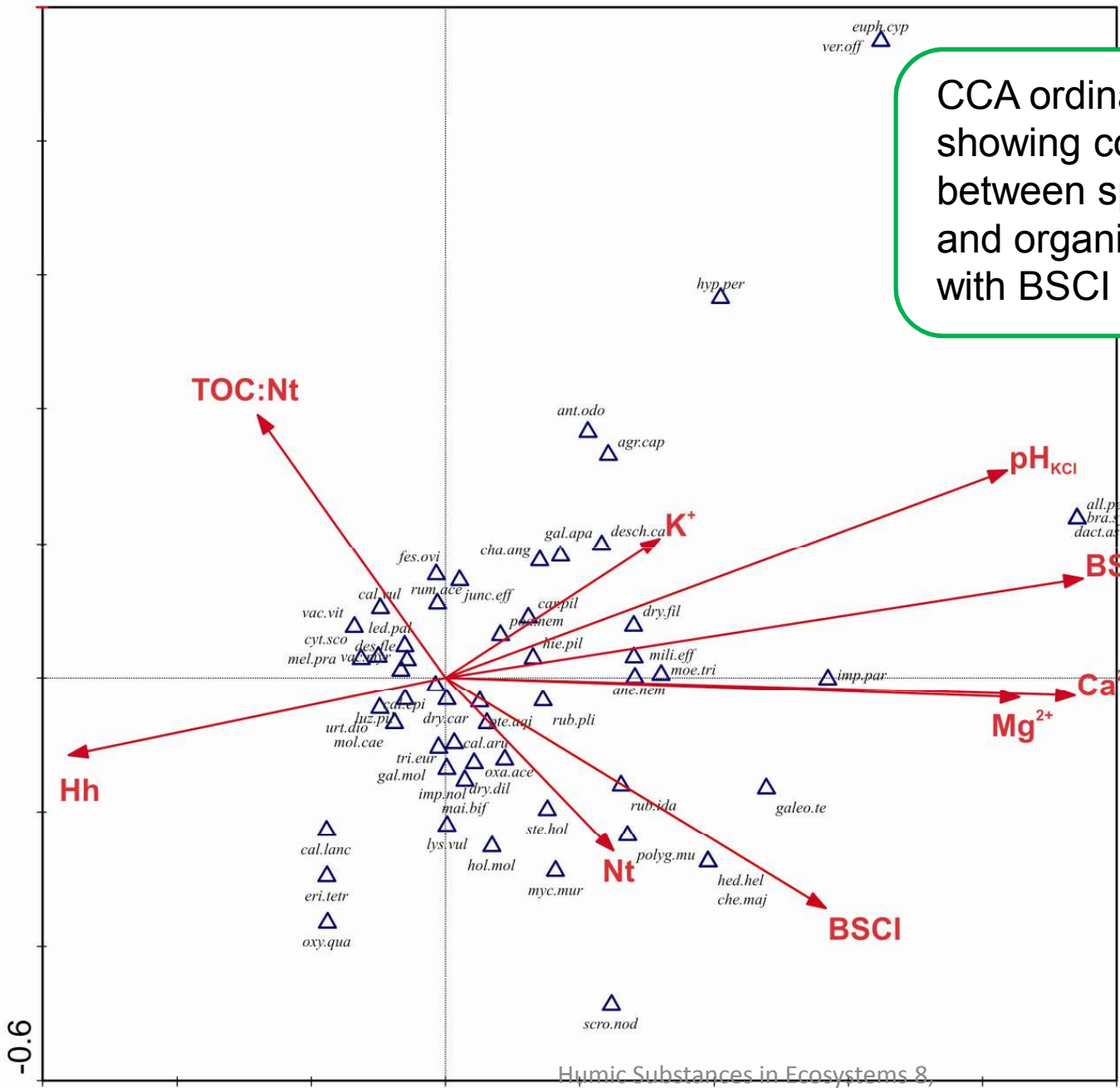


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CCA ordination diagram showing correlation between species composition and organic horizon properties with BSCI



The soil properties used in the diagram explain 24,3% of the total forest floor species variation in investigated plots.

Correlation between properties of organic horizon and phytocoenosis

		Cation content [mmol ₍₊₎ /100g]					BS [%]	pH _{KCl}	Nt [%]	C:N	Thick-ness of O hor. [cm]
		Hh	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺					
Cover of broad-leaved species [%]	lower story	-0,216*	0,337*	0,378*	0,083	0,290*	0,343*	0,324*	0,244*	-0,247*	-0,161
	shrub layer	-0,296*	0,437*	0,424*	-0,002	0,139	0,456*	0,358*	0,186	-0,353*	-0,088
BSCI		-0,355*	0,367*	0,399*	-0,012	0,279*	0,431*	0,432*	0,208*	-0,381*	-0,125
Amount of vascular plant species		-0,479*	0,538*	0,562*	-0,021	0,161	0,592	0,424*	0,251*	-0,449*	-0,184
Cover [%]	herb layer (c)	0,124	0,006	0,081	0,055	0,029	0,001	-0,116	0,208*	-0,164	0,274*
	moss layer (d)	0,249*	-0,509*	-0,560*	-0,016	-0,264*	-0,490*	-0,536*	-0,348*	0,379*	0,196

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0,208* 0,01 < p < 0,05

Korelacje między właściwościami poziomu organicznego a cechami fitocenozy

H ⁺ + Al ³⁺	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	S	T	BS [%]		pHKC I	Nt [%]	C:N	Miąższość poz. O [cm]
[mmol ₍₊₎ /100g]								H ₂ O	KCl			
145	8,68	1,49	0,28	0,85			7,62		3,0	1,462	27,0	6,5
±30 (56,7 -223)	±5,73 (0,64 -30,1)	±0,74 (0,26 -3,78)	±0,11 (0,07 -0,74)	±0,30 (0,22 -1,74)			±5,44 (1,94 -30,0)		±0,3 (2,5 -4,4)	±0,344 (0,805 -2,615)	±4,4 (12,9 -41,0)	±1,7 (3-12)

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Properties of investigated organic horizons

Thickness of O horizon, pH, TOC, Nt and TOC:Nt ratio

Thickness of O horizon [cm]	pH		TOC [%]	Nt [%]	TOC:N
	H2O	KCl			
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