

GRINDELIA SQUARROSA (PURSH) DUNAL (ASTERACEAE) IN CHERNIVTSI REGION (UKRAINE)

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Results of research on chorological, ecological and coenotic characteristics of an alien species of North American origin – *Grindelia squarrosa* (Pursh) Dunal (*Asteraceae*) – in Chernivtsi region (Ukraine) are presented. The species was found in the region in three associations of synanthropic vegetation, such as the *Convolvulo-Agropyretum repentis* Felföldy 1943 and *Ambrosio artemisiifoliae-Grindelietum squarrosae* Smetana, Derpoluk, Krasova 1997 of the class *Artemisietea vulgaris* Lohmeyer et al. in Tx. ex von Rochow 1951, *Lolio-Plantaginetum majoris* (Linkola 1921) Beger of the class *Polygono-Poetea annuae* Rivas-Mart. 1975 and association of *Setario pumilae-Echinochloetum cruris-galli* Felföldy 1942 corr. Mucina in Mucina et al. 1993 of the class *Digitario sanguinalis-Eragrostietea minoris* Mucina, Lososová et Šilc in Mucina et al. 2016). The indices of main edaphic and climatic factors for the species were determined for the first time. According to the main climatic indices, such as thermo-, ombro-, and cryoregime, the species *G. squarrosa* is characterized by stenotopic amplitude and belongs to submezotherms, subaridophytes, and hemicyrphytes. The map of distribution of the species in the region is presented

Key words: *Grindelia squarrosa*, distribution, ecological and coenotic characteristics, Bukovinian Prut-Dniester area, Chernivtsi region, Ukraine.

Introduction. Biological invasion is considered one of the main threats to biodiversity, food security, human health, and global economics (Protopopova et al. 2002). Appearance of a new alien species beyond its natural range is always noteworthy because of its possible invasive behaviour in the new region.

The species *Grindelia squarrosa* (Pursh) Dunal (*Asteraceae*) is a common weed originated from the central prairies of North America (Britton, Brown, 1970). Currently it can be found in many European countries and in Australia.

In the steppe zone of Ukraine (Protopopova et al., 2002) and the Republic of Moldova (Myrza et al., 1987), the species is considered invasive, while for Spain it is noted as potentially invasive (Sanz-Elorza et al., 2001).

In Ukraine, *G. squarrosa* was cultivated in Kharkiv in the mid-20th century and in Kyiv (Kiev) in 1942. During World War II, it was brought with hay from the USA in the vicinity of settlements of Novobuhyskiy and Bashtanskiy districts (Mykolayiv region), the basin of the Berda river (Zaporizhzhia region), and the Slovyanoserbyskiy district (Luhansk region). The species was first recorded in the Ukrainian flora in 1949 (between Yavkino and Nova

Poltavka stations, Mykolayiv region, along the railway and on pastures). The species dispersed rapidly from the mentioned centres of Mykolayiv region into the steppe zone of Ukraine and later into northern and western regions as well, where new localities of occurrence are constantly reported.

The aim of the present article is to study of populations, ecological and coenotic characteristics of *G. squarrosa* in the Bukovinian Prut-Dniester area.

Material and methods. The research is based on original data obtained during fieldwork conducted between 2009–2016 and examination of herbarium collections deposited at Yuriy Fedkovych Chernivtsi National University (*CHER*), M. G. Kholodny Institute of Botany, NAS of Ukraine (*KW*), and Institute of Ecology of the Carpathians, NAS of Ukraine (*LWKS*).

The physical and geographical region of the Bukovinian Prut-Dniester area considered in this work follows A. Marynych et al. (1989).

The schematic distribution map of *G. squarrosa* in Chernivtsi region was prepared by the grid method of plant mapping using MapInfo Professional version 12.5 software packages, according to Atlas Florae European adapted for regional territories (Budzhak et al., 2009).

Phytosociological surveys were performed using ecological and floristic criteria of plant community relevés. The phytosociological relevés were carried out by the method of transformation of phytocoenotic tables using the FICEN 2 programme package (Syrenko, 1996). The calculation of score synphytoindication indices was performed by JUICE 6.5 (Tichy, 2002). The ecological analysis was conducted according to the phytoindication scales proposed by Ya. Didukh (1998) and P. G. Plyuta (1998). Syntaxonomic units were taken from L. Mucina et al. (2016). Earlier publications were used to determine syntaxa (Vegetace České republiky..., 2009; Solomakha, 2008).

The nomenclature of taxa follows the publication of S. L. Mosyakin and N. M. Fedoronchuk (1999).

Results. In Ukraine, *G. squarrosa* is a biennial or rare annual plant with a flowering period lasting from July to October and a fruiting period starting in August, and xeromesophyte. The species shows a high reproductive capacity in Ukraine, producing up to 24,000 (Protopopova, 1973) or sometimes more than 261,000 (Makodzaba, Fisyunov, 1962) achenes per individual per year.

The main ways of dispersal are zoochory, hydrochory, and agestochgory. According to the degree of naturalization the species in Ukraine, it is considered an agrio-epoecophyte or agriophyte in the steppe zone, an epoecophyte or colonophyte in the forest-steppe zone, and an ephemerophyte in northern and western forest regions. In the studied region, the species is considered a colonophyte.

In Chernivtsi region, *G. squarrosa* was first recorded in 2009 in the territory of a former beetroot storehouse in the Nepolochkivtsi railway station (11.09. 2009, I. Chorney, A. Tokaryuk, V. Budzhak, *CHER*) near Nepolochkivtsi village, Kitsman district (Chorney et al., 2010). Later, the species was also noted in ruderalized plant communities a long road in the Stebnyk nature massive (19.08. 2014, Sychak, Kopyk, *LWKS*) of the territory of Vyzhnytsky National Nature Park (Sychak, 2015). Therefore, the species is known from two localities in Chernivtsi region: from the Bukovinian Carpathians and the Bukovinian Prut-Dniester area (Map 1).

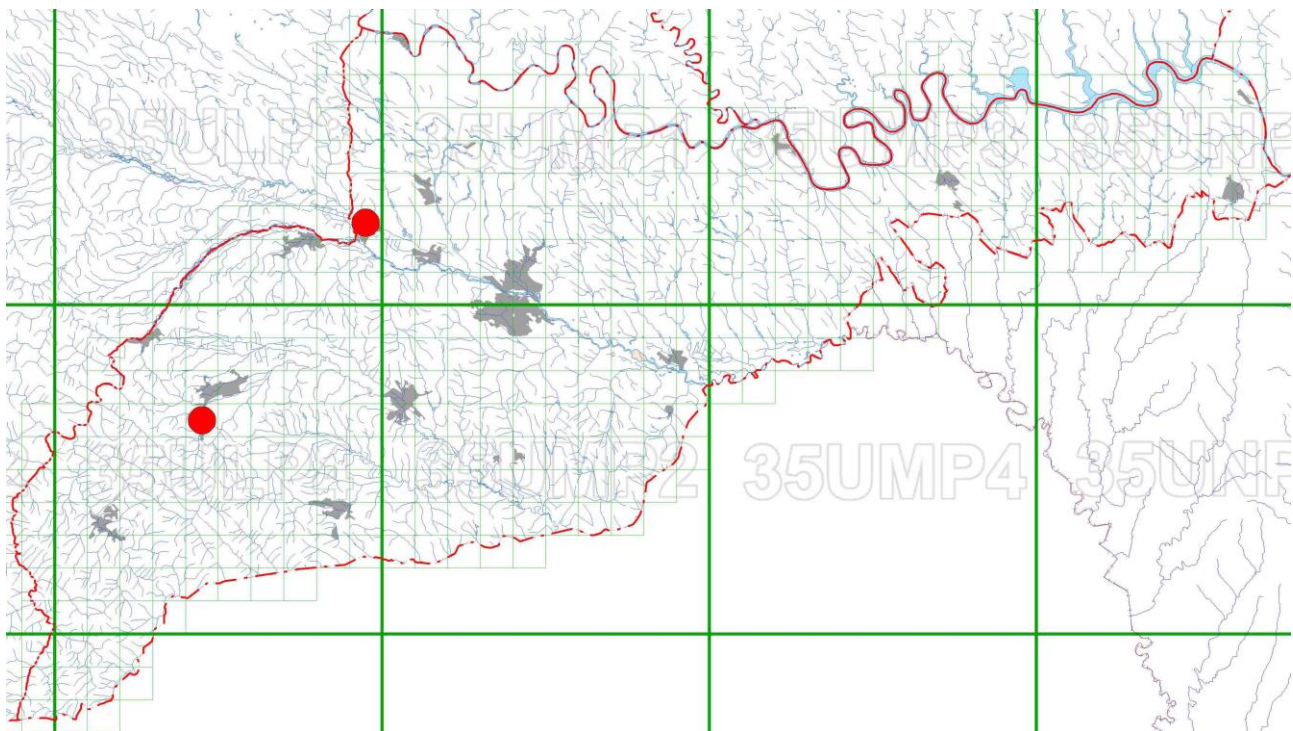


Fig. Location of *Grindelia squarrosa* (Pursh) Dunal in Chernivtsi region
Рис. Місцезнаходження *Grindelia squarrosa* (Pursh) Dunal у Чернівецькій області

The population near the Nepolokivtsi railway station was presented by two loci, the distance between which is 28 m.

The density of generative individuals in the first locus was 1–3 individuals/m², while in the second it was 1–2 individuals/m². The total number of generative individuals did not exceed 20. The total area of the loci is 70 m².

The first locus of *G. squarrosa* population is confined to a marginal community on disturbed gravel

and sand substrates along a dirt road. Its total projective cover is up to 80%. The floristic composition of the community includes 19 species, among which *Elytrigia repens* (L.) Nevski (60–70 %) and *Poa compressa* L. (10–15 %) predominate. Invasive species are represented in particular by *Ambrosia artemisiifolia* L., *Phalacrolooma annuum* (L.) Dumort. and *Setaria glauca* (L.) P. Beauv. According to the ecological-floristic classification, the plant community belongs to the *Convolvulo-Agropyretum re-*

pentis Felföldy 1943 association, *Convolvulo arvensis-Agropyrion repentis* Görs 1967 alliance, *Agropyretalia intermedio-repentis* T. Müller et Görs 1969 order, *Artemisietea vulgaris* Lohmeyer et al. in Tx. ex von Rochow 1951 class (see Table 1, relevé 1).

Table 1
Phytocoenotic characteristics of plant communities with *Grindelia squarrosa* in the Bukovinian Prut-Dniester area

Number of relevés	1	2	3	4	5	6
Total projective cover, %	100	80	95	85	100	95
Area, m ²	9	9	9	9	20	30
Number of species	19	19	22	17	22	15
Number of syntaxa	1	2	3	4		
<i>Grindelia squarrosa</i>	+	+	1	3	3	2
D. s. Ass. <i>Convolvulo-Agropyretum repentis</i>						
<i>Elytrigia repens</i>	5	.	.	1	1	1
<i>Convolvulus arvensis</i>	+	.	2	.	.	.
D. s. Ass. <i>Lolio-Plantaginetum majoris</i>						
<i>Polygonum aviculare</i>	.	4	.	+	.	.
<i>Lolium perenne</i>	.	2	.	.	.	.
<i>Plantago major</i>	.	1	1	.	.	.
<i>Poa annua</i>	.	1	1	.	.	.
D. s. Ass. <i>Setario pumilae-Echinochloetum cruris-galli</i>						
<i>Setaria glauca</i>	+	.	4	1	1	.
<i>Echinochloa crusgalli</i>	.	.	2	.	.	.
<i>Cirsium arvense</i>	.	.	2	.	.	.
<i>Galinsoga parviflora</i>	.	.	1	.	.	.
D. s. Ass. <i>Ambrosio artemisiifoliae-Grindelietum squarrosae</i>						
<i>Ambrosia artemisiifolia</i>	1	3	3	2	2	2
<i>Poa compressa</i>	2	.	.	3	2	1
D. s. Cl. <i>Artemisietea vulgaris</i>						
<i>Phalacrolooma annuum</i>	1	+	1	1	2	2
<i>Cichorium intybus</i>	+	+	.	.	1	.
<i>Conyza canadensis</i>	.	+	1	.	+	.
<i>Artemisia vulgaris</i>	+	.	.	.	.	+
<i>Tanacetum vulgare</i>	.	.	.	1	1	.
<i>Pastinaca sativa</i>	+	.	.	.	.	.
<i>Echium vulgare</i>	+	.	.	.	.	.
<i>Melilotus albus</i>	.	+	.	.	.	.
<i>Berteroa incana</i>	.	+	.	.	.	.
<i>Daucus carota</i>	.	+	.	.	.	.
<i>Lactuca serriola</i>	.	.	1	.	.	.
<i>Medicago lupulina</i>	.	.	.	+	.	.
D. s. Cl. <i>Molinio-Arrhenatheretea</i>						
<i>Lotus ucrainicus</i>	+	1	.	1	1	1
<i>Trifolium hybridum</i>	1	1	1	1	.	.
<i>Plantago lanceolata</i>	1	1	.	.	1	1
<i>Trifolium repens</i>	.	+	.	2	4	4
<i>Dactylis glomerata</i>	2	+	.	.	1	.
<i>Potentilla argentea</i>	+	.	.	.	.	+
<i>Trifolium pratense</i>	.	.	1	.	.	.
<i>Centaurea jacea</i>	.	.	.	.	1	.

Leucanthemum vulgare 1

Other species:

<i>Taraxacum officinale</i>	+	+	1	.	1	+
<i>Achillea submillefolium</i>	1	.	.	1	1	1
<i>Artemisia absinthium</i>	.	.	.	+	1	.
<i>Potentilla reptans</i>	.	.	.	.	1	1
<i>Juncus gerardii</i>	.	.	.	.	1	1
<i>Rumex confertus</i>	+	.	.	.	.	.
<i>Portulaca oleracea</i>	.	+	.	.	.	.
<i>Anagallis arvensis</i>	.	.	+	.	.	.
<i>Epilobium hirsutum</i>	.	.	.	+	.	.
<i>Geranium sibiricum</i>	.	.	.	+	.	.
<i>Atriplex patula</i>	.	.	.	+	.	.
<i>Polygonum hydropiper</i>	.	.	.	1	.	.
<i>Thlaspi arvense</i>	.	.	.	+	.	.
<i>Veronica arvensis</i>	.	.	.	2	.	.
<i>Eragrostis pilosa</i>	.	.	.	.	1	.
<i>Digitaria sanguinalis</i>	.	.	.	.	1	.
<i>Anisantha tectorum</i>	.	.	.	.	1	.
<i>Euphorbia cyparissias</i>	.	.	.	.	.	1
<i>Plantago media</i>	.	.	.	.	.	1
<i>Ranunculus repens</i>	.	.	.	.	.	+

Association localities of the relevés:

1, 2 – Chernivtsi region, Kitsman district, Nepolokivtsi village, Nepolokivtsi railway station, 11.09. 2009, A. Tokaryuk;

3, 4 – ibid, 29.09. 2010, V. Budzhak;

5, 6 – ibid, 29.09. 2010, A. Tokaryuk.

Number of syntaxa:

1 – *Convolvulo-Agropyretum repentis*; 2 – *Lolio-Plantaginetum majoris*; 3 – *Setario pumilae-Echinochloetum cruris-galli*; 4 – *Ambrosio artemisiifoliae-Grindelietum squarrosae*.

The second locus of *G. squarrosa* population is confined to the disturbed abandoned lawn located along the pavement near the station's office. In the plant community, which has a total projective cover of 80 %, the species *Polygonum aviculare* L. (30–40 %), *Lolium perenne* L. (10–15 %), *Plantago major* L. (3–5 %) and *Poa annua* L. (1–2 %) predominate. The coenosis consists of 19 species, including the invasive *Ambrosia artemisiifolia* (15–20 %), *Conyza canadensis* (L.) Cronq. and *Phalacrolooma annuum*. According to the classification, the plant community belongs to the *Lolio-Plantaginetum majoris* (Linkola 1921) Beger association, *Polygono-Coronopodium* Sissingh 1969 alliance, *Polygono-arenastri-Poetalia annuae* Tx. in Géhu et al. 1972 corr. Rivas-Mart. et al. 1991 order, *Polygono-Poetea annuae* Rivas-Mart. 1975 class (see Table 1, relevé 2).

One year later, the area of population increased to 1900 m². Generative individuals of *G. squarrosa* with a density of 1–2 individuals/m² were noted in plant communities of *Setario pumilae-Echinochloetum cruris-galli* Felföldy 1942 corr. Mucina in Mucina et al. 1993 association. The total

projective cover was 80–85 %, while the projective cover of *G. squarrosa* was only 1–2 %. The species *Echinochloa crusgalli* (L.) P. Beauv. and *Setaria glauca* predominate with the participation of *Cirsium arvense* (L.) Scop., *Convolvulus arvensis* L., *Galinsoga parviflora* Cav., etc. The coenosis consisted of 22 species, including such invasive as *Ambrosia artemisiifolia*, *Conyza canadensis*, *Geranium sibiricum* L., *Phalacrolooma annuum*, *Echinochloa crusgalli*, *Galinsoga parviflora* and *Setaria glauca* (see Table 1, relevé 3). According to the classification, the plant community belongs to the *Setario pumilae-Echinochloetum cruris-galli* Felföldy 1942 corr. Mucina in Mucina et al. 1993 association, *Spergulo arvensis-Erodion cicutariae* J. Tx. in Passarge 1964 alliance, *Eragrostietalia* J. Tx. ex Poli 1966 ordo, *Digitario sanguinalis-Eragrostietea minoris* Mucina, Lososová et Šilc in Mucina et al. 2016 class .

A high-density and abundant population of *G. squarrosa* (the density of generative individuals varied from 1–2 to 6–14 individuals/m²) was noted in the community of *Ambrosio artemisiifoliae-Grindelietum squarrosae* Smetana, Derpoluk, Krasova 1997 association. The number of species in the coenosis varied from 15 to 22. In the coenosis having a total projective cover of 85–100 %, such invasive species predominated as *Ambrosia artemisiifolia* (10–15 %), *Grindelia squarrosa* (10–25 %) and *Phalacrolooma annuum* (1–15 %) with participation of *Poa compressa*, *Trifolium repens* L. and other species. The species *Anisantha tectorum* (L.) Nevski, *Conyza canadensis* and *Setaria glauca* occurred rarely. According to the classification, the plant community belongs to the *Onopordion acanthii* Br.-Bl. et al. 1936 alliance, *Onopordetalia acanthii* Br.-Bl. et Tx. ex Klika et Hadač 1944 ordo, *Artemisietea vulgaris* class (see Table 1, relevés 4–6).

It was established that the studied area of population during 2009–2016 increased to 18,500 m² (Map 2).



Fig. 2. The dynamics of *Grindelia squarrosa* (Pursh) Dunal population in Chernivtsi region during 2009–2016
Рис. 2. Динаміка популяції *Grindelia squarrosa* (Pursh) Dunal у Чернівецькій області (2009–2016)

Based on the phytosociological relevés, it was established that *G. squarrosa* in the Bukovinian Prut-Dniester area is component of plant communities four associations, four alliances, four orders, and three classes of synanthropic vegetation.

The syntaxonomic scheme of plant communities with the species in Chernivtsi region is given below.

Syntaxonomic scheme of plant community with participation of *Grindelia squarrosa* (Pursh) Dunal in the Bukovinian Prut-Dniester area

Cl. *Artemisietea vulgaris* Lohmeyer et al. in Tx. ex von Rochow 1951

Ord. *Agropyretalia intermedio-repentis* T. Müller et Görs 1969

All. *Convolvulo arvensis-Agropyron repentis* Görs 1967

Ass. *Convolvulo-Agropyretum repentis* Felföldy 1943

Ord. *Onopordetalia acanthii* Br.-Bl. et Tx. ex Klika et Hadač 1944

All. *Onopordion acanthii* Br.-Bl. et al. 1936

Ass. *Ambrosio artemisiifoliae-Grindelietum squarrosae* Smetana, Derpoluk, Krasova 1997

Cl. *Polygono-Poetea annuae* Rivas-Mart. 1975

Ord. *Polygono arenastri-Poetalia annuae* Tx. in Géhu et al. 1972 corr. Rivas-Mart. et al. 1991

All. *Polygono-Coronopodium* Sissingh 1969

Ass. *Lolio-Plantaginetum majoris* (Linkola 1921) Beger

Cl. *Digitario sanguinalis-Eragrostietea minoris* Mucina, Lososová et Šilc in Mucina et al. 2016

Ord. *Eragrostietalia* J. Tx. ex Poli 1966

All. *Spergulo arvensis-Erodion cicutariae* J. Tx. in Passarge 1964

Ass. *Setario pumilae-Echinochloetum cruris-galli* Felföldy 1942 corr. Mucina in Mucina et al. 1993

It was established that, according to the main climatic indices such as thermo-, ombro- and cryoregime, *G. squarrosa* in the Bukovinian Prut-Dniester area is characterized by stenotopic amplitude and belongs to the submezotherm, subaridophyte and hemicryophyte ecological groups, respectively (Table 2).

In Chernivtsi region, in relation to soil water regime and moisture variability, *G. squarrosa* is a mezophyte, hemihydrocontrastophyllous, subacardophyllous, semieutrophyllous, acarbonatophyllous, heminitrophyllous, and subaerophyllous species (Table 3).

It was established that the limits of tolerance of *G. squarrosa* to the leading environmental factors in the Bukovinian Prut-Dniester area are within the limits established for Ukraine (Didukh, 2011).

Data on the population dynamics of *G. squarrosa* indicate that the species is a viable component of

anthropogenic habitats. In our opinion, the area of the population of the species will increase in future accordingly to the increase of ruderal areas with disturbed soil and vegetation cover.

Table 2
Ecological characteristics (climatope) of Grindelia squarrosa (Pursh) Dunal in the Bukovinian Prut-Dniester area and in Ukraine

Index of climatic factors (pontes), ecological groups, width of ecological amplitude			
Tm*	Om	Kn	Cr
8.71–9.57 9.22	10.71–11.95 11.37	8.65–8.93 8.82	8.62–9.09 8.82
Stenotopic submezo-term	Stenotopic subaridophyte	Stenotopic hemicontinental	Stenotopic hemicyrphyte
8.00–12.00 10.00	–	–	–
Stenotopic submezo-term	–	–	–

* Explanations: Tm – termoregime, Om – ombroregime, Kn – continentality of climate Cr – cryoregime; here and in the Table 3: the numerator indicates the value of tolerance amplitude, while the denominator is the mean value of tolerance amplitude for the ecological factor;

In bold are given the values of indicators of the species in the Bukovinian Prut-Dniester area, while in usual font are given the corresponding indicators, which are based on literature data (Didukh, 2011)

Conclusion

In the Bukovinian Prut-Dniester area, *G. squarrosa* is a submezo-therm, subaridophyte, hemicontinental, hemicyrphyte, mezophyte, hemihydrocontrastophyllous, subacydophyllous, semi-euthrophyllous, acarbonatophyllous, hemitrophyllo, and subaerophyllous species having a viable population in community of four associations of three classes of synanthropic vegetation (associations *Convolvulo-Agroproyretum repentis* and *Ambrosio artemisiifoliae-Grindelietum squarrosae* of the class *Artemisietea vulgaris*, association *Lolio-Plantaginetum majoris* of the class *Polygono-Poetea annuae* and association of *Setario pumilae-Echinochloetum cruris-galli* of the class *Digitario sanguinalis-Eragrostietea minoris*).

Since the species in Ukraine tends to spread actively, it requires constant monitoring, including the studied region.

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Table 3
Ecological characteristic (edatope) of Grindelia squarrosa (Pursh) Dunal in the Bukovinian Prut-Dniester area and in Ukraine

Index of edaphic factors (pontes), ecological groups, width of ecological amplitude						
Hd*	fH	Rc	Tr (Sl)	Ca	Nt	Ae
10.47–11.32 10.93	7.08–8.03 7.45	7.95–8.60 8.32	7.87–8.77 8.38	6.41–7.38 6.95	5.62–6.68 5.98	5.94–6.81 6.49
Stenotopic mesophyte	Stenotopic hemihydrocontrastophyllous	Stenotopic subacidophyllous	Stenotopic semieutrophe	Stenotopic acarbonato-phyllous	Stenotopic heminitro-phyllous	Stenotopic subaerophyllous
5.00–12.00 8.50	5.00–9.00 7.0	8.00–11.00 9.50	5.00–13.00 9.00	6.00–11.00 8.50	4.00–8.00 6.00	4.00–7.00 5.50
Stenotopic mezo-phyte	Stenotopic hemihydrocontrastophyllous	Stenotopic subacydophyllous	Stenotopic semieutrophe	Stenotopic acarbonato-phyllous	Stenotopic heminitro-phyllous	Stenotopic subaerophyllous

**Explanations: Hd – soil humidity, fH – moisture change, Rc – soil acidity, Sl – soil salinity, Ca – content of carbonates in the soil, Nt – content of nitrogen in the soil, Ae – soil aeration.

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