Natural Geoecosystems of the Upper Dnister Basin

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Abstract / Анотація

Природні геоекосистеми проаналізовані за допомогою середньомасштабного (1 : 250 000) цифрового геопросторового шару, створеного у середовищі географічної інформаційної системи на підставі топографічної та тематичних карт, літературних джерел та спеціальних польових обстежень. Геоекосистеми відображають взаємозв'язки між рельєфом, ґрунтоутворюючими відкладами, біокліматом, ґрунтом та потенційною природною рослинністю. Басейн Верхнього Дністра охоплює 42 типи геоекосистем, які формують п'ять макроекорегіонів. Західне Поділля (5 646 км²) є горбистою та хвилястою лесовою височиною з переважно сірими лісовими ґрунтами, в межах якої виділяємо два висотні біокліматичні пояси. Нижній пояс (~195–325 м н. р. м.) формують грабово-дубові, а верхній пояс (~325–471 м) – грабово-букові ліси. Розточчя (334 км²) – це горбиста лесова височина, розділена реліктовими піщанистими флювіогляціальними долинами. Інтервали висот (~275–397 м), а отже й біокліматичні характеристики, є близькими до попереднього регіону. Однак піщанисті ділянки зайняті сосново-дубовими та сосново-буковими лісами на дерново-слабопідзолистих ґрунтах. Сян-Дністерське Передкарпаття (1 261 км²) являє собою хвилясту лесову рівнину зі широкими реліктовими флювіогляціальними долинами. Абсолютні висот коливаються у межах 245–341 м. Серед природної рослинності домінують грабово-дубові ліси на сірих лісових ґрунтах та сосново-дубові ліси на дерново-слабопідзолистих піщанистих ґрунтах. Дністер-Прутське Передкарпаття (7 321 км²) є чергуванням хвилястих давньоалювіальних височин та широких сучасних річкових долин. Три висотні біокліматичні пояси представлені грабово-дубовими (~200–350 м), ялицево-дубовими (~350–500 м) та ялицево-буковими (~500–870 м) лісами на поверхневооглеєних дерново-підзолистих, буроземно-підзолистих та гірських лісових буроземних ґрунтах. Східні Зовнішні Карпати (6 933 км²) є низькими та середніми флішовими горами. П'ять біокліматичних поясів сформовані ялицево-буковими (~330–650 м), смереково-буковими (~650–950 м), буково-смерековими (~950–1 200 м) та кедро-вососново-смерековими (~1 200–1 500 m) лісами на гірських лісових буроземах, а також субальпійським чагарниками та луками (~1 500–1 818 м) на гірських кам'янистих лучних буроземах.

Introduction

Comprehensive and coherent information on land resources serves as a basis for sustainable physical planning (e.g. McHarg 1969; Steiner 1991). A significant part of this information can be efficiently represented as a single geo-dataset of natural landscape units (natural *geoecosystems* – I.K.) and be used for the design of landscape visions as an important step in physical planning processes (Bastian 2000).

Much has been published in Ukrainian and Russian about the nature of the Upper Dnister Basin – landforms, ***geology, climate, hydrology, soils,***

vegetation, fauna, and natural landscapes (e.g. Herenchuk 1968, 1972, 1973, 1979; Hofstein 1962, 1979, 1995; Holubets et al. 1988; Kravchuk 1999, 2000; Shabliy et al. 1989, 1990). However, the information is often not harmonised and presented in a not spatial or loosely-spatial (in a form of fine-scale schematic maps) manner, and, thus, is hardly suitable for practical use. There are also medium-scale (1 : 200,000) digital topographic maps (Anonymous 1997) as well as paper maps on the Quaternary deposits (Chalyi 1993) and the soils (Krupskyi 1967), which are not publicly available.

The description of the Upper Dnister Basin natural geoecosystems presented here is based on a respective medium-scale (1 : 250,000) digital geodataset produced in the ***geographical information system (GIS)*** environment using the above-mentioned material as well as field observation data.

Methods

Theoretical background

There are several apparently independent and, therefore, somewhat different definitions of a geoecosystem (Bachinskiy 1989; Huggett 1995; Leser 1991; Rowe & Barnes 1994). However, all definitions recognise geoecosystems as models of real landscapes, constructed using geospatial and ecological approaches in the broad sense – as a study of structure and functioning of nature (Odum 1959). Unlike (bio)ecosystems as objects of synecology which are essentially biocentric entities, geoecosystems are studied as complex geographical formations from a more holistic (Huggett 1995; Rowe & Barnes 1994), or even abiotic (Leser 1991) perspective. Socio-economic aspects may also be integrated into geoecosystem studies (Bachinskiy 1989). The science of geoecosystems is called geoecology (Bachinskiy 1989; Huggett 1995; Leser 1991).

Developing the current definitions, a geoecosystem is interpreted as a geospatial model of genetic and/or functional interrelations between selected properties of a real landscape (Kruhlov 2005a). The landscape properties are referred to as ***geocomponents.*** A natural geoecosystem represents geospatial relations only between the selected properties of the potential (primary) natural landscape – i.e. the landscape that could have evolved if no major disturbances, including ***human impact,*** had taken place. Hence, natural geoecosystems are ideal constructions representing spontaneous equilibrium between natural geocomponents, some of which (e.g. natural vegetation) do not exist in a real cultural landscape. This concept is close to the idea of a natural terrain complex (e.g. Isachenko 1965), or of a natural area ("Naturraum") (e.g. Haase et al. 1991), and, despite certain abstraction, is of high practical significance, because it offers a reference to environmental assessment, nature conservation, and sustainable planning of land resources.

This study focusses on genetic relationships between some principal natural geocomponents: landforms, surficial rocks, topobioclimate, soils, and ***potential natural vegetation (PNV)*** – the vegetation that possibly can develop under the given edaphic and climatic conditions without human impact (Tüxen 1956). The spatial structure of such natural geoecosystems is reduced to the geomorphic component and, thus, they can be more accurately named as natural morphogenic geoecosystems (Kruhlov 2005a). Solntsev's (1960) idea about the inequality of natural landscape factors is used to model interrelations between the geocomponents. It is assumed that lithogenic components (landforms and parent rock) determine hydroclimatic components (topoclimate) and, together with the latter, control both character and spatial pattern of the biotic components (soil cover and PNV) (Fig. 1).

The natural morphogenic geoecosystems of the Upper Dnister Basin are considered at two geospatial levels:

1. As relatively large and heterogeneous, in an ecological sense individual regions ***(ecoregions)*** formed mainly by neotectonics, which, nevertheless, reveal certain uniform spatial patterns of structure and processes;
2. As relatively small and homogeneous typological units, whose borders are predominantly shaped by exogenous geomorphic processes. In this study, the map of ecoregions provides a general frame for the description of the lower-rank typological units.

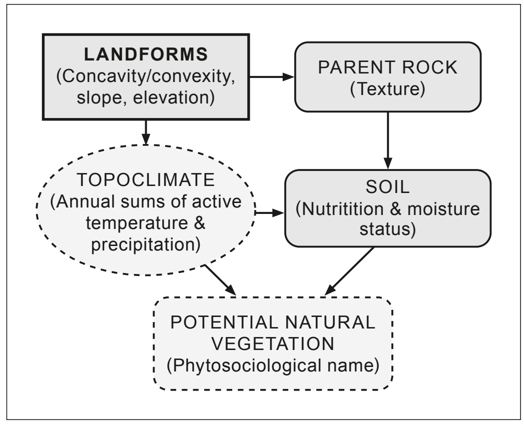


Fig. 1: Connections between components of a natural morphogenic geoecosystem

Materials and Techniques

To prepare a 1 : 250,000 map of the Upper Dnister Basin natural morphogenic geoecosystems, the following data sources were used:

1. 1 : 200,000 digital topographic map (Anonymous 1997);
2. 1 : 200,000 paper map of the Quaternary (Chalyi 1993);
3. 1 : 200,000 paper soil map (Krupskyi 1967);
4. Landsat ETM+ satellite scene of May 2000;
5. Numerous published texts and maps on geology, geomorphology, climate, hydrology, soils, vegetation, and natural landscapes of the Upper Dnister Basin (mentioned in the text);
6. Field observations on the dependencies between landforms, soils, vegetation, and cultural elements were made according to the modified methodology of Herenchuk et al. (1975); Miller (1974) on 204 sites in different parts of the Upper Dnister Basin during warm periods between spring and autumn in 2002 and 2003.

The map was compiled in a GIS via geoecological modelling. The essence of the geoecological modelling was to make a geospatial interpretation of the non-spatial, or loosely-spatial, knowledge on relationships between PNV, soil, and climate (published in the regional literature) using properly georeferenced data on topography and surficial rocks. ArcGIS and Erdas Imagine software was used for the digital processing, all geospatial data were referenced (WGS 84, UTM). The modelling consisted of the three main components (Kruhlov 2004, 2005b):

1. Delimitation of lithomorphic units based on topography (landforms) and surficial geological deposits (soil parent rock);
2. Bioclimatic characterisation of the landforms;
3. Determination of the biotic components (soil and PNV) for the landforms based on relationships between the parent rock and the bioclimate.

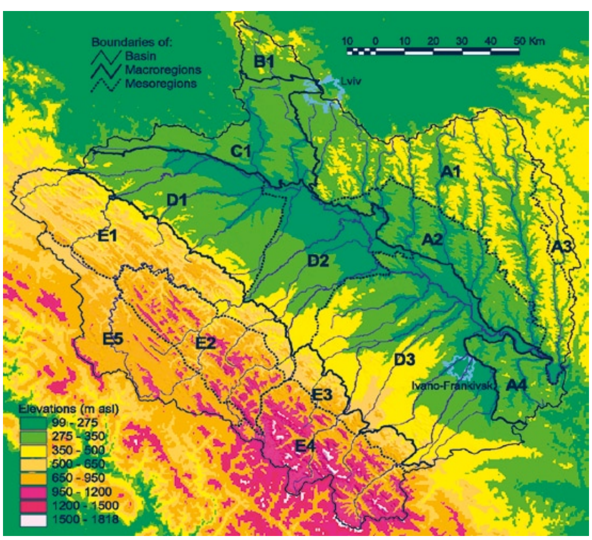
The borders of the macroecoregions and of the smaller regions with the uniform spatial distribution of landforms and surficial geological deposits were delineated and automated into the GIS. The borders of smaller landforms for relatively dissected ***interfluves*** were generated in the GIS environment via processing of the digital elevation model (DEM). This resulted in the geo-dataset of lithomorphic units which reveal information about landforms, geomorphic processes and the surficial deposits.

The topobioclimatic modelling included stratification of the DEM into altitudinal bioclimatic zones using data on average elevation spans of natural vegetation belts (Holubets & Milkina 1988; Kireev 1977; Sheliag-Sosonko 1985). Bioclimatic zones were characterised by annual precipitation (mm) and ***active air temperature*** (above 10 °C; Andrianov 1968, 1979). Then the average bioclimatic characteristics were calculated for each lithomorphic unit using a GIS zonal function. Narrow valleys and valley bottoms were excluded from the altitudinal topoclimatic characterisation owing to specific conditions caused by higher humidity and temperature inversions (🕮 *Topoclimate of the Upper Dnister Basin: Consequences for Crop Cultivation*).

The determination of the natural soils and PNV was based on the knowledge about their ecological relationships with the parent rock and topo-bioclimate, obtained from the literature, the soil map, and the field studies. The soils were given Ukrainian (Vernander & Tutunnyk 1986) and international (ISSS-ISRIC-FAO 1998) names. Information about soils afforded estimation of the nutrient and moisture status (edaphic conditions). The PNV was estimated at the level of the ***sub-formation*** (Holubets & Malinovskiy 1967). The non-spatial ecological models were coupled with the geo-dataset of the lithomorphic-bioclimatic units. Field observations from 97 sites carried out in 2002–2003 were used to verify the results of the geospatial modelling. The verification witnessed the maximum confidence of 83 % for the parent rock estimations and the minimum confidence of 79 % for the PNV estimations. Taking into consideration the map generalisation peculiarities, the overall confidence can be estimated even as somewhat higher.

Regional descriptions

Considering the existing geomorphological and landscape regionalisations (Herenchuk 1972, 1973, 1979; Kravchuk 2000; Mukha 2003; Shabliy et al. 1989, 1990), five natural ***macroecoregions*** (Tab. 1 and 2) – divided into smaller individual units (***mesoecoregions;*** Tab. 3) – can be delineated within the Upper Dnister Basin (Fig. 2 and 3; ✇ IV (2) Fig. 1).



A. *Western Podillia:* hilly and wavy loess upland with natural forests (beech, oak-hornbeam); **A1**. High Opillia; **A2**. Low Opillia; **A3**. Koropets-Seret ***Interfluve;*** **A4**. Pokuttia

B. *Roztochia:* hilly loess upland with sandy relict fluvioglacial valleys covered with forests (beech, pine-oak); **B1**. Southern Roztochia

C. *San-Dnister Precarpathians* (Peredkarpattia): wavy loess plains with vast flat relict fluvioglacial valleys once with oak forests; **C1**. Vyshnya-Dnister ***Interfluve***

D. *Dnister-Prut Precarpathians* (Peredkarpattia): sequence of wavy old-alluvium uplands separated by vast alluvial valleys once with oak and oak-fir forests; **D1**. Upper Dnister Precarpathians; **D2**. Stryi Precarpathians; **D3**. Bystrytsyia-Prut Precarpathians

E. *Eastern External Carpathians* (Karpaty): low and middle flysch mountains with beech, fir, and spruce forests; **E1**. Dnister Beskydy; **E2**. Skole Beskydy; **E3**. Marginal Gorgany; E4. Gorgany; **E5**. Verkhovyna.

Fig. 2: Ecoregions of the Upper Dnister Basin

Tab. 1: Some morphometric characteristics of the Upper Dnister Basin macroecoregions

region	area [km²]	elevation			mean slope
		mean	maximum	minimum	
Western Podillia	5,646	325 m	Kamula – 471 m	195 m	3.3°
Roztochia	334	326 m	Bulava – 397 m	275 m	2.0°
San-Dnister Precarpathians	1,261	283 m	341 m	245 m	0.8°
Dnister-Prut Precarpathians	7,321	319 m	Kleva – 870 m	200 m	1.3°
Eastern External Carpathians	6,933	761 m	Syvulya – 1,818 m	330 m	10.4°
Whole Upper Dnister Basin	**21,493**	**461 m**	**1,818 m**	**195 m**	**4.7°**

Tab. 2: Bioclimatic altitudinal belts of the Upper Dnister Basin macroecoregions

short designations of bioclimatic belts	elevation [m a.s.l.]	annual sum of		dominating potential natural vegetation
		active T [°C]	precipitation [mm]	
Western Podillia, Roztochia and San-Dnister Precarpathians				
Warm I	195–325	2,400–2,600	600–700	*Carpineto-Querceta*
Warm II	325–471	2,300–2,500	650–800	*Carpineto-Fageta*
Dnister-Prut Precarpathians				
Warm III	200–350	2,300–2,600	600–800	*Carpineto-Querceta*
Moderately Warm	350–500	2,100–2,400	700–900	*Abieto-Querceta*
Moderately Cool	500–870	1,700–2,200	800–1,000	*Abieto-Fageta*
Eastern External Carpathians				
Moderately Cool	330–650	1,700–2,200	800–1,000	*Abieto-Fageta*
Cool	650–950	1,400–1,900	900–1,100	*Piceeto-Fageta*
Very Cool	950–1,200	1,000–1,500	1,000–1,200	*Fageto-Piceeta*
Moderately Cold	1,200–1,500	600–1,100	1,100–1,300	*Pineto cembrae-Piceeta*
Cold	1,500–1,818	<700	1,200–1,400	*Piceeto-Pineta mugo*

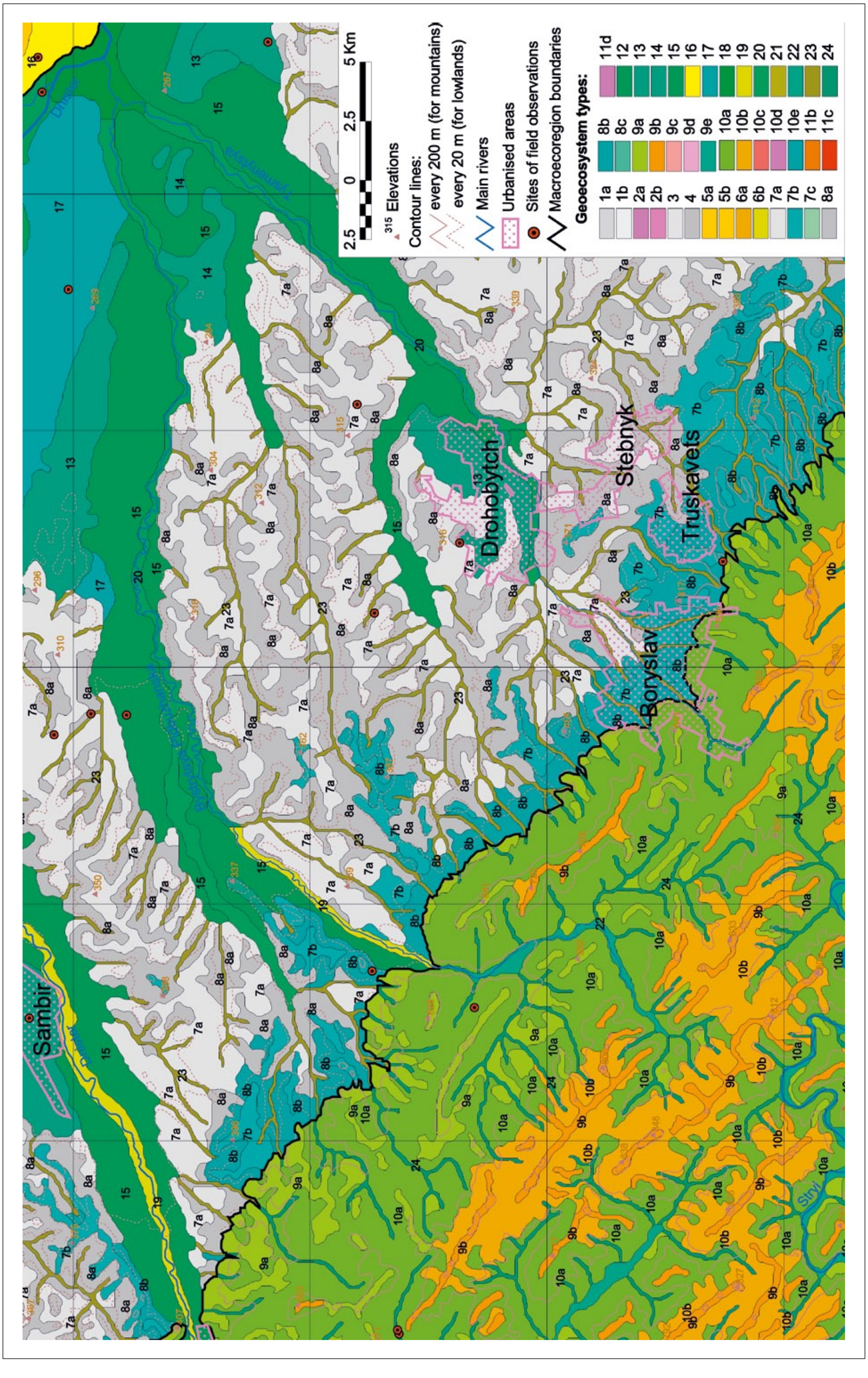


Fig. 3: Section of the 1:250,000 map of geoecosystems (explanations to geoecosystem type in Tab. 3)

Tab. 3: Geoecosystems types of the Upper Dnister Basin (legend of the map)

Type	Area [ha]	Landforms	Surface (parent) rock	Bioclimate	Soils	Nutrition status	Moisture status	Potential natural vegetation
Ecoregions Western Podillia, Roztochia and San-Dnister Precarpathians								
6a	205,994	Moderate & steep slopes (6–30°) – deluvial & defluctional	Eluvial-deluvial loam & loess-like loam	Warm I	Umbric Albeluvisol & Albic Phaeozem	Oligo-mesotrophic & mesotrophic	Mesic	*Carpineto-Querceta*
6b	161,304			Warm II	Umbric Albeluvisol & Rendzic Leptosol	Mesotrophic		*Carpineto-Fageta*
5a	96,773	Watershed surfaces & gentle slopes (0–6°) – deluvial	Eluvial (eolian)-deluvial loess-like loam	Warm I	Albic Phaeozem	Eutrophic	Mesic & hydric	*Carpineto-Querceta*
5b	98,300			Warm II	Umbric Albeluvisol & Albic Phaeozem	Mesotrophic & eutrophic		*Carpineto-Fageta & Carpineto-Querceta*
3	20,252		Eluvial-deluvial loess-like sandy loam	Warm I	Haplic & Umbric Albeluvisol	Oligo-mesotrophic & mesotrophic		*Carpineto-Querceta*
4	4,813	Moderate slopes (6–20°) – deluvial					Mesic	
1a	10,984	Watershed surfaces & gentle slopes (0–6°) – deluvial	Eluvial-deluvial sand		Haplic Albeluvisol	Oligo-mesotrophic	Mesic & hydric	*Pineto sylvestrae-Querceta*
1b	3,271			Warm II			Mesic	*Pineto sylvestrae-Fageta*
2a	5,850	Moderate slopes (6–20°) – deluvial		Warm I			Xeromesic & mesic	*Pineto sylvestrae-Querceta*
2b	1,782			Warm II				*Pineto sylvestrae-Fageta*
12	12,616	Alluvial low terraces, gently sloping (0–3°)	Eluvial-deluvial loess-like loam	Warm I	Umbric Albeluvisol & Albic Phaeozem	Mesotrophic & eutrophic	Mesic & hydric	*Fraxineto-Querceta*
21	55,579	Alluvial valley bottoms	Alluvial loam & peat	Topocli-mate of valleys	Haplic & Histic Fluvi-sol & Sapric Histosol	Eutrophic	Hydric & ultra-hydric	*Alneto glutinosae-Querceta*
23	65,627	Alluvial valleys with deluvial & delapsial slopes	Deluvial & alluvial loam		Albeluvisol, Phaeozem & Fluvisol	Mesotrophic & eutrophic		*Fraxineto-Querceta & Alneta glutinosae*
Ecoregion Dnister-Prut Precarpathians								
7a	92,128	Watershed surfaces & gentle slopes (0–6°) (alluvial high terraces) – deluvial	Eluvial-deluvial silt loam	Warm III	Albeluvisol stagnic	Mesotrophic	Mesic & hydric	*Carpineto-Querceta*
7b	52,746			Moderately Warm				*Abieto-Querceta*

Type	Area [ha]	Landforms	Surface (parent) rock	Bioclimate	Soils	Nutrition status	Moisture status	Potential natural vegetation
Ecoregion Dnister-Prut Precarpathians								
7c	6,932	Watershed surfaces & gentle slopes (0–6°) (alluvial high terraces) – deluvial	Eluvial-deluvial silt loam	Moderately Cool	Stagnic Cambisols	Mesotrophic	Mesic & hydric	*Fageto-Abieta*
8a	109,215	Moderate & steep slopes (6–30°) – deluvial, defluctional & delapsial		Warm III	Stagnic & Umbric Albeluvisol		Mesic	*Carpineto-Querceta*
8b	67,501			Moderately Warm			Mesic & hydric	*Abieto-Querceta & Abieto-Fageta*
8c	15,152			Moderately Cool	Dystric Cambisol		Mesic	*Abieto-Fageta*
13	81,093	Alluvial low terraces, gently sloping (0–3°)	Alluvial-deluvial silt loam	Warm III	Stagnic Albeluvisol		Mesic & hydric	*Carpineto-Querceta & Fraxineto-Querceta*
14	54,586	Alluvial low terraces, flat & slightly wavy		Warm III			Hydric	*Fraxineto-Querceta & Alneto glutinosae-Querceta*
15	108,772		Alluvial silt loam		Haplic Luvisol			
16	36,584		Alluvial loamy sand		Arenic Luvisol	Oligo-mesotrophic	Mesic & hydric	*Carpineto-Querceta & Pineto sylvestrae-Querceta*
17	9,791	Peat-bogs	Peat	Topocli-mate of valleys	Histosol	Eutrophic	Ultrahydric	*Alneta glutinosae & Prata turfosa*
18	27,126	Alluvial floodplains with oxbows	Alluvial loam		Haplic Fluvisol	Mesotrophic & eutrophic		*Fraxineto-Querceta & Alneta glutinosae*
19	24,905	Alluvial floodplains	Alluvial sand & gravel		Leptic & Arenic Fluvisol	Oligo-mesotrophic & mesotrophic		*Saliceta*
20	26,411		Alluvial loam		Haplic Fluvisol	Mesotrophic & eutrophic		*Fraxineto-Querceta & Alneta glutinosae*
Ecoregion Eastern External Carpathians								
9a	45,063	Watershed surfaces & moderate slopes (0–20°) – deluvial, defluc-tional & delapsial	Eluvial-deluvial rocky silt loam (flysch)	Moderately Cool	Dystric & Stagnic Cambisol	Mesotrophic & eutrophic	Mesic & hydric	*Fageto-Abieta*
9b	39,943			Cool		Mesotrophic	Mesic	*Piceeto-Fageta*

Type	Area [ha]	Landforms	Surface (parent) rock	Bioclimate	Soils	Nutrition status	Moisture status	Potential natural vegetation
Ecoregion Eastern External Carpathians								
9c	16,070	Watershed surfaces & moderate slopes (0–20°) – deluvial, defluc-tional & delapsial	Eluvial-deluvial rocky silt loam (flysch)	Very Cool	Dystric & Stagnic Cambisol	Mesotrophic	Mesic	*Fageto-(Abieto)-Piceeta*
9d	3,975			Moderately Cold		Oligo-mesotrophic & mesotrophic	Mesic & hydric	*Pineto cembrae-Piceeta*
9e	2,311	Watershed surfaces & moderate slopes (0–20°) (nival) – defluc-tional	Eluvial-deluvial rocky silt loam & dispersial debris (flysch)	Cold	Umbric & Hyperskel-etic Leptosol	Oligotrophic	Mesic & hydric	*Pineta mugo & Junipereta commune* ssp. *nanae*
10a	162,309	Steep & very steep slopes (>20°) – deflubtional & delapsial	Eluvial-deluvial rocky silt loam (flysch)	Moderately Cool	Dystric Cambisol	Mesotrophic	Mesic	*Abieto-Fageta*
10b	209,186	Steep slopes (20–30°) – defluctional & delapsial		Cool		Mesotrophic		*Piceeto-Fageta*
10c	54,171			Very Cool				*Fageto-(Abieto)-Piceeta*
10d	7,144			Moderately Cold		Oligo-mesotrophic & mesotrophic		*Pineto cembrae-Piceeta*
10e	2,982	Steep & very steep slopes (>20°) (nival) – defluctional & dispersial	Eluvial-deluvial rocky silt loam & dispersial debris (flysch)	Cold	Umbric & Hyperskel-etic Leptosol	Oligotrophic		*Pineta mugo & Junipereta commune* ssp. *nanae*
11b	33,432	Very steep slopes (>30°) – defluctional & dispersial		Cool	Dystric & Skeletic Cambisol	Oligo-mesotrophic & mesotrophic		*Piceeto-Fageta & Fageto-Piceeta*
11c	29,512			Very Cool				*Fageto-(Abieto)-Piceeta*
11d	20,454			Moderately Cold				*Pineto cembrae-Piceeta*
22	25,548	Alluvial valley bottoms	Alluvial loam, sand & gravel	Topocli-mate of valleys	Umbric Fluvisol & Umbric Leptosol		Hydric & ultra-hydric	*Piceeta, Saliceta & Alneta incanae*
24	41,195	Alluvial valleys with deluvial & delapsial slopes	Eluvial-deluvial rocky silt loam (flysch) & alluvial gravel		Dystric Cambisol & Umbric Leptosol			*Fageta, Piceeta, Saliceta & Alneta incanae*

continuation of Tab. 3

Ecoregions Western Podillia, Roztochia and San-Dnister Precarpathians

Although Western Podillia, Roztochia, and San-Dnister Precarpathians are different macroecoregions, they share common types of geoecosystems of ***interfluve*** surfaces and slopes covered with ***loess***-like ***loam*** (Types 3–6). The climate becomes somewhat drier from the north-west to the south-east of the region. Two altitudinal bioclimatic zones (warm I and warm II) are delineated for the uplands of the Western Podillia and Roztochia.

Type 6a geoecosystems occupy the largest area within the elevation span of 195–330 m a.s.l., which corresponds to the warm I bioclimatic altitudinal zone of the Upper Dnister Basin. Loess-like deluvial loam of several metres thickness covers lower-grade areas, while steeper sections are characterised by relatively thin layers of eluvial-deluvial debris loam. Surficial deposits overlay clay, sand, ***sandstone, limestone,*** or ***marlstone*** strata. Under recent humid climate, the slopes experience deluvial wasting and gully ***erosion***. The steeper sections may also be influenced by soil creep and occasional ***landsliding.*** Covered karst may develop in the areas of gypsum and anhydrite occurrence on the Podillia and Pokuttia. Somewhat exceeding, in comparison with evaporation, the amount of precipitation (Andrianov 1979) and good heat provisions caused the development of well-drained, slightly acidic podzolised grey and almost neutral dark-grey ***forest soils*** (➁ IV (2) Tab. 1). The tree layer is formed mainly by ***Quercus robur*** and ***Carpinus betulus*** but also contain ***Fagus sylvatica, Acer pseudoplatanus, A. platanoides, Tilia cordata, T. grandifolia, Betula verrucosa.*** The shrub layer is formed by ***Corylus avellana*** and ***Lonicera xylosteum,*** while ***Galeobdolon luteum, Asarum europeum, Carex pilosa, Aegopodium podagraria*** and ***Athyrium filix-femina*** (Berezhnyi 1979; Sheliag-Sosonko 1977a) are prevailing amongst the herbs.

Type 6b is widely spread at the Western Podillia and Roztochia. It corresponds basically with Type 6a, except the less developed loess cover. The higher elevation causes a somewhat higher amount of precipitation and lower heat supply which influence the biotic components. The soil is slightly more acidic and podzolised, in comparison with Type 6a. The rather humid topoclimate, in combination with a good drainage, increases competitiveness of *F. sylvatica,* which replaces *Q. robur* and becomes the main forest tree species, often as ***Carpineto-Fageta*** stands. Pure *F. sylvatica* stands also occur quite frequently, as well as *Fagus-Carpinus-Quercus* forests. *A. pseudoplatanus, A. platanoides, Tilia* sp., ***Sorbus aucuparia,*** *B. verrucosa,* ***Fraxinus excelsior*** can be found in the *Fageta* forests, too. ***Abies alba*** and *P. abies* may accompany *F. sylvatica* in Roztochia, where precipitation is somewhat higher than on the Western Podillia. The herb layer, which may be rather sparse because of a dense shady canopy, is represented by ***Asperula odorata, Carex pilosa*** and ***Aegopodium podagraria.*** A shrub layer of e.g. ***Corylus avellana, Swida sanguinea, Euonymus verrucosa, Daphne mezereum*** may be formed under less dense tree canopy (Berezhnyi 1979; Berezhnyi & Shyshova 1972; Sheliag-Sosonko 1977a).

Steep slopes of Types 6a and 6b geoecosystems often have shallow calcareous soddy soil developed on the eluvium of limestone and marlstone. These habitats of southern aspect may be occupied by patches of relict steppe vegetation with predominance of ***Festuca sulcata*** and ***Carex humilis.*** In addition, there may be stands of ***Quercus petraea*** on steep slopes with a shallow stony soil (Berezhnyi 1979; Sheliag-Sosonko 1977a).

Type 5a is associated respectively with flat and slightly convex (0–3°) watershed surfaces and gentle (3–6°) slopes. The thickness of the loess-like eolian-deluvial loam varies from 2 to 6 m and more (Bohutskyi 1979; Bohutskyi & Demeduk 1972). Geomorphic processes at the watershed surfaces are not explicit, except for occasional surface subsidence in a form of wet micro-depressions caused by loess suffusion and covered gypsum karst. The gentle slopes are characterised by deluvial wasting and gully erosion. The drainage of the soil is bad, owing to the insignificant surface gradient. A fragmentary ground water table may be within several meters from the surface in the places, where surficial loam is bedded on clay. Therefore, the soil may be gleyic in the lower part of the profile. The soil has a well-developed silt-loam humus horizon, slightly acidic reaction, and slightly pronounced podzolic differentiation of the profile. It is the most productive soil in the Upper Dnister Basin region. The natural vegetation is the *Q. robur* forest with a significant participation of *C. betulus* at drier locations (Berezhnyi & Shyshova 1972; Sheliag-Sosonko 1977a).

Type 5b has similar geomorphic conditions as Type 5a, but differs in its cooler and moister topoclimate owing to higher altitudinal location (330–471 m a.s.l.). Therefore, the soil is somewhat more acidic and podzolised. Dark-grey forest soil, sometimes together with podzolised ***chernozem,*** dominates in the eastern part of the Upper Dnister Basin (Ternopil Plateau), where precipitation is lower. Here, hydric habitat conditions prevent extensive expansion of *F. sylvatica* and the dominant natural vegetation is ***Carpineto-Querceta*** (Sheliag-Sosonko 1985). In the northern part of the Upper Dnister Basin (in Roztochia and Upper Opillia) with the higher amount of precipitation and better drainage, owing to erosional dissection, natural geoecosystems of this type are characterised by *Carpineto-Fageta* forests.

Type 3 occurs on the Vereshchytsia-Stavchanka ***interfluve*** within the San-Dnister Precarpathians. The geoecosystems have similar geomorphic and topoclimatic characteristics as of Type 5a. However, the soil parent material has a coarser texture. This is loess-like sandy loam bedded on fluvioglacial clay and sand. The coarser texture caused more acidic soils with pronounced podzolic differentiation of the solum and respectively less humus accumulation. The insignificant surface gradient and availability of clayey underlying deposits do not provide enough drainage. Thus, the soil is gley, slightly podzolic soddy loamy sand as well as light-grey and grey forest loam. The local habitats support ***Querceta*** and ***Carpineto-Querceta*** natural forests with predominance of ***Aegopodium podagraria,*** *Asperula odorata,* ***Carex brizoides,*** *C. pilosa,* and ***Oxalis acetosella*** in the herb layer (Berezhnyi & Shyshova 1972; Sheliag-Sosonko 1977a).

Type 4 is also located within the Vereshchytsia-Stavchanka ***interfluve,*** it has the same surficial deposits as Type 3, but refers to moderate slopes, sometimes dissected by shallow gullies. The slightly podzolic soddy and grey forest soils are better drained, owing to a greater surface gradient and thus form habitats which are suitable for *Carpineto-Querceta* forests with predominance of *Aegopodium podagraria* and *Carex pilosa* in the herb layer (Berezhnyi & Shyshova 1972; Sheliag-Sosonko 1977a).

Type 1a is associated with slopes of Pleistocene fluvioglacial valleys and plains of the Roztochia and the San-Dnister Precarpathians located below 330 m a.s.l. – in the warmest bioclimatic altitudinal zone. The soil parent material is fluvioglacial sand re-deposited by deluvial and, sometimes, eolian processes. The sand overlays clay strata as well as bedrock sand and sandstone. The soil is gleyic, slightly podzolic soddy sandy loam. The natural vegetation is represented by ***Pineto-Querceta*** forests with *Oxalis acetosella* and ***Pteridium aquilinum*** (Berezhnyi & Shyshova 1972; Sheliag-Sosonko 1977a).

Type 2a is characterised by the same occurrence, geological and topoclimatic properties as Type 1a, but refers to moderate slopes with more pronounced deluvial processes and gully erosion. Greater surface gradients cause better drainage and respectively somewhat drier slightly podzolic soddy soil favoured by *Pineto-Querceta* forest. *Q. petraea* may substitute *Q. robur* at drier places (Sheliag-Sosonko 1977a).

Type 1b, which occurs only in Roztochia, is a geomorphological analogy of Type 1a, but has a higher altitudinal location (above 330 m) and thus belongs to a moister and cooler bioclimatic zone. The parent material of some watershed surfaces consists of sandy eluvium of bedrock sandstone and limestone that lacks loess cover. The soil is slightly podzolic soddy sandy loam. The combination of the moist topoclimate and the coarse-textured soil caused development of rather rare natural vegetation – a ***Pineto-Fageta*** forest. The tree stand may contain also *A. alba* and *P. abies.* The herb layer is dominated by *Oxalis acetosella* and ***Vaccinium myrtillus.*** In the forests with less dense canopy, the understorey may include *Corylus avellana,* ***Frangula alnus, Sambucus racemosa,*** etc. (Berezhnyi & Shyshova 1972; Sheliag-Sosonko 1977a).

Type 2b refers to moderate and, sometimes, steep slopes in Roztochia formed by sandy bedrock eluvium and by re-deposited Pleistocene fluvioglacial sand. The geoecosystems have basically the same topoclimate and biotic properties as Type 1b, but are characterised by more intensive deluvial wasting and gully erosion as well as somewhat drier xero-mesic habitats.

Type 12 is associated with flat and wavy surfaces of Neopleistocene alluvial terraces, which are located along the river Vereshchytsia on the San-Dnister Precarpathians. A fragment of a gently sloping terrace in the Dnister Canyon on the Western Podillia can be also considered to be this type of geoecosystems. The ground water table is rather shallow in the depressions, so the soil is often gleyic. Most likely, the natural vegetation for this area is the *Querceta* forest with significant participation of ***Fraxineto-Querceta*** and ***Alneto glutinosae-Querceta.***

Type 21 represents geoecosystems of river valley bottoms which are similar for the three macroecoregions. The flat surfaces are formed by a Holocene mineral fine-texture alluvium and peat, which frequently overlays Pleistocene fluvioglacial sand on the San-Dnister Precarpathians and Roztochia. The topoclimate is somewhat cooler than in the surroundings, owing to higher soil humidity. Temperature inversions (cold air lake effects 🕮 *Topoclimate of the Upper Dnister Basin: Consequences for Crop Cultivation*) are possible. The high ground water table determined the development of ***hydromorphic soils.*** The over-moistened and nutrition-rich substrate is suitable for *Alneto glutinosae-Querceta* forests with participation of *F. excelsior* (Povarnitsyn 1971; Stoyko 1988). Depressions may be occupied by boggy and peat meadows (Berezhnyi & Shyshova 1972).

Type 23 designates relatively narrow (up to 100–200 m wide) alluvial valleys spread on the Podillia, Roztochia, and the whole Precarpathians. The steeper sections of the slopes may experience landslides. The valleys have a specific topoclimate as of Type 21, and the soils of the slopes are usually the same as of the surrounding ***interfluves,*** but with higher content of organic matter and moisture owing to deluvial accumulation. Under natural conditions, hydric habitats are occupied by *Fraxineto-Querceta* forests, sometimes with *C. betulus* and *F. sylvatica.* The valley bottoms feature hydromorphic alluvial soils covered with ***Alneta glutinosae*** communities.

Ecoregion Dnister-Prut Precarpathians

The macroecoregion features uplands with flat and wavy upper surfaces composed of ancient (Pliocene-Mesopleistocene) alluvium (geoecosystems of Types 7 and 8) and vast terraced river valleys filled with more recent deposits (Types 13–20). The macroclimate becomes cooler and moister towards the mountains. Three altitudinal bioclimatic zones (warm III, moderately warm, and moderately cool) are distinguished in the region.

Type 7a belongs to flat and slightly convex watershed surfaces and gentle slopes of eroded high alluvial terraces located within the warmest bioclimatic zone, the upper limit of which reaches approximately 350 m a.s.l. The fine-texture parent material, in combination with an exceeding precipitation, caused the development of an acidic brownish podzolic pseudogleyic soil. This substrate is more suitable for *Querceta* forest, because *F. sylvatica* does not tolerate gleyic substrate. In drier (mesic) habitats, *Q. robur* is accompanied by *C. betulus,* while in moister (hydric) locations, which are less typical of these geoecosystems, it can form monodominant stands, or together with *F. excelsior* (Sheliag-Sosonko 1977a; Stoyko &

Odynak 1988a). The ***Carpino-Querceta*** forests of the Dnister-Prut Precarpathians are similar to those of the Western Podillia and the San-Dnister Precarpathians (Type 6a).

Type 8a is in the same topoclimatic altitudinal zone as Type 7a, but refers to moderate and steep slopes (over 6°) dissected by gullies. Deluvial wasting, soil creep, and landslides are the major geomorphic processes here. The soil and the natural vegetation are similar to the geoecosystems of Type 7a, but there are less hydric habitats owing to a better surface drainage.

Type 7b is a geomorphic analogy of Type 7a, which belongs to a cooler and moister bioclimatic zone located within the elevation span of approximately 350–500 m a.s.l. The podzolised soil has a more distinct brownish colour and contains more traces of ***pseudogley*** process owing to a higher amount of precipitation in comparison with Type 7a. The natural vegetation is represented by ***Abieto-Querceta*** forest. The first tree layer is usually formed by *Q. robur* and *A. alba,* sometimes together with *F. sylvatica.* The second and the third layers contain *C. betulus, A. alba, F. sylvatica,* and sometimes *Tilia* sp. The hydric habitats are characterised by vast occurence of *Vaccinium myrtillus, Carex brizoides* in the herb/dwarf shrub layer and of ***Polytrichum*** among mosses. The mesic habitats are more likely to feature *Oxalis acetosella, Carex pilosa,* and *Galeobdolon luteum* (Sheliag-Sosonko 1977a; Stoyko & Odynak 1988a).

Type 8b is associated with moderate and steep slopes of the moderately warm bioclimatic zone. The slope processes such as gully erosion, ***soil creep,*** and landslides are spread here. The soil and natural vegetation are basically the same as of Type 7b, however, better drained substrate also provides habitats for ***Abieto-Fageta*** stands (Sheliag-Sosonko 1977a).

Type 7c represents slightly convex upper surfaces and gentle deluvial slopes. Sometimes the loam is rocky – when it is a regolith of flysch that composes the most elevated south-eastern part of the Bystrytsia-Prut Precarpathians. The geoecosystems occupy the highest areas of the region, which are within 500–870 m elevation span and thus belong to the moderately cool bioclimatic zone. The high amounts of precipitation and a relatively cool vegetation period cause the development of a typical low-mountain biotic complex. The soil is acidic brown podzolic and brown mountain forest pseudogley. The climate is too moist and too cool for *Q. robur* stands and, therefore, *A. alba* becomes the main tree species here. In mesic and hydric habitats, it forms together with *F. sylvatica* ***Fageto-Abieta*** forests, which are widely spread in the low mountains of the Upper Dnister Basin Carpathian section (Type 9a).

Type 8c designates moderate and steep slopes of the same moderately cool bioclimatic zone as of Type 7c. Slope processes such as gully erosion, soil creep and landslides take place here. Better drainage provides somewhat drier habitats that are suitable for *Abieto-Fageta* stands.

Type 13 describes geoecosystems on mostly gently sloping surfaces dissected by small stream valleys. Deluvial movement of slope material is the main geomorphic process here. The area is located in the warmest altitudinal bioclimatic zone, but the heat supply significantly decreases and the precipitation increases towards the mountains in the same way as for Type 7a. The soil and the PNV are also similar to Type 7a – respectively brownish podzolic pseudogleyic silt and *Carpineto-Querceta.* However, owing to somewhat moister substrate (because of a lower surface gradient), *Q. robur* can form monodominant stands here, or together with hydrophilic species such as *F. excelsior* or *A. glutinosa* (Hryn 1971; Sheliag-Sosonko 1977a; Stoyko & Odynak 1988a).

Type 14 is similar to Type 13, except that the surface is almost flat. Predominance of poorly drained hydric habitats implies *Fraxineto-Querceta* forests, with *Alneto glutinosae-Querceta,* and with extensive participation of *Carex brizoides* in the herb layer as natural vegetation (Stoyko & Odynak 1988a).

Type 15 refers to flat and slightly wavy surfaces of a 5–10 m Neopleistocene river terrace with loamy and silt-loamy alluvial podzolised (meadow) soil. A flat surface, a fine soil texture and a relatively shallow ground water table produce hydric habitats favoured by *Fraxineto-Querceta* and *Alneto glutinosae-Querceta* forests.

Type 16 also describes the same 5–10 m Neopleistocene river terrace, but with sandy and sand-loamy alluvial sod podzolised soil. These better drained but less productive habitats support oak forests with a mixture of ***Pineto sylvestrae-Querceta*** and ***Carpineto-Querceta.***

Type 17 characterises ***peat bogs*** located on the low ***alluvial terrace.*** Peat is at the surface, or is buried under up to one-metre-thick layer of a mineral soil. The ground water is right near the surface, which is suitable for *Alneta glutinosae* stands as well as for ***peat*** meadows ***(Prata turfosa).*** The ***Alneta*** forest is mostly associated with ***Filipendula ulmaria,*** or with ***Phragmites communis,*** while the meadows are: ***Cariceto (appropinquatae, inflatae, lasiocarpae)-Hypneta, Phragmiteto-Hypneta,*** and ***Cariceto (lasiocarpae)-Sphagneta*** (Sheliag-Sosonko 1977a).

Type 18 represents the Dnister floodplain, composed of loam overlaying gravel, and with several Holocene "row terraces" (🕮 *Late Pleistocene and Holocene Landscape Evolution of the Upper Dnister Valley*) and oxbows produced by the meandering river (Huhmann et al. 2004). The soil is alluvial soddy loam, which, in combination with a shallow groundwater and floods, provides habitats for *Fraxineto-Querceta* and *Alneta glutinosae* forests.

Type 20 geoecosystems are similar to Type 18, but refer to floodplains of smaller lowland rivers with less intensive flood regime.

Type 19 describes floodplains of rivers with fast flow rate and braided channels. Therefore, the soil has a coarser texture (with sand and gravel as a parent material) and contains less organic matter. The habitats are more suitable for ***Salicetea*** which include ***Salix alba, S. fragilis, S. pentadra*** as well as *Populus nigra* (Stoyko 1988).

Ecoregion Eastern External Carpathians

A series of low (up to ~1,000 m a.s.l.) and middle (up to 1,818 m a.s.l.) mountain ridges stretching in north-west to south-east direction is composed of flysch. The ridges are separated by small parallel river valleys; they are also dissected by larger river valleys sub-perpendicular to the direction of their stretch. Five altitudinal bioclimatic zones are delineated here – from moderately cool to cold. The climate also becomes cooler and moister towards south-west (mountain interior) owing to orography and air macro-circulation.

Type 9a is associated with flat surfaces of mountain ridges and moderate slopes (up to 20°) that have elevations of up to approximately 650 m a.s.l., which indicate the moderately cool altitudinal bioclimatic zone. Surface gradients are relatively small, as for the region, and allow the development of a rather thick ***regolith,*** which, in humid climate conditions, experiences gully erosion, deluvial wasting, soil creep, and landslides. The soil is a relatively deep loam with a moderate and small content of small rocks in the profile – brown podzolic and brown mountain forest, sometimes pseudogleyic. The natural vegetation is ***Abieto-Fageta*** forests with a change in dominance to ***Fageto-Abieta.*** The altitude of 650 m fixes the upper margin of *F. sylvatica* and *A. alba* forests without natural admixture of *P. abies* (Holubets & Milkina 1988). Although *F. sylvatica* and *A. alba* have close ecological requirements, *A. alba* is likely to dominate in the areas of a deep soil on non-calcareous flysch with good moisture supply, but not boggy. Eutrophic mesic *A. alba* forests usually include up to 30 % of *F. sylvatica* that creates the second tree layer. The stands may also contain *A. pseudoplatanus, A. platanoides, Ulmus* sp. and *F. excelsior.* The shrub layer of *Corylus avellana, Sambucus nigra,* and *S. racemosa* is poorly developed. The herb layer is usually dominated by ***Asperula odorata*** and ***Dentaria glandulosa*** (Holubets 1971, 1988; Holubets & Milkina 1988).

Type 10a is located in the same altitudinal bioclimatic zone as Type 9a, but refers to steep (20–30°) and, sometimes, very steep (over 30°) slopes that are characterised by gully erosion, soil creep, and landslides. The brown mountain forest soil is moderately deep or shallow and contains rocks in the profile. The habitats are suitable for *Abieto-Fageta* forest. Monodominant *F. sylvatica* stands have one or two tree layers with a very dense canopy and undeveloped understorey. A dispersed herb layer may be represented by *Asperula odorata, Dentaria bulbifera, D. glandulosa, Asarum europeum,* ***Symphytum cordatum.*** *Abieto-Fageta* forests are stable communities, which are most likely accompanied by *Vaccinium myrtillus* in mesotrophic habitats and by *Dentaria* sp. in eutrophic habitats (Stoyko & Odynak 1988a).

Type 9b has the same geomorphic properties as Type 9a, but is located, on the average, within the elevation span of 650–950 m a.s.l., which is associated with the cool altitudinal bioclimatic zone. The whole period of vegetation here is 135 days, and the active vegetation period is limited to 85 days (Andrianov 1968). The soil is brown mountain forest, usually rocky and moderately deep. The cool topoclimate determines the participation of *P. abies* in the *Abieto-Fageta* forest stands. Usually the first and rather sparse tree layer in ***Piceeto-Abieto-Fageta*** forests is formed by *A. alba* and *P. abies,* while the second and dense layer is represented by *F. sylvatica. Vaccinium myrtillus* and *Oxalis acetosella* dominate among herbs in mesotrophic mesic habitats (Stoyko & Odynak 1988a).

Type 10b refers to steep (20–30°) slopes dissected by gullies. The area is also located in the cool bioclimatic zone. The brown mountain forest soil is moderately deep or shallow, owing to rather intensive slope wasting, and contains a significant amount of rocks. According to Stoyko & Odynak (1988a), *P. abies* is more competitive on the rocky substrate and thus may be better represented here than in Type 9b forming *Abieto-Piceeto-Fageta* forests.

Type 11b characterises very steep (over 30°) slopes of the cool zone. High surface gradients determine the predominance of gravitational processes – soil creep and debris flow. The brown mountain forest soil is shallow and rocky. The natural vegetation is the same as for Type 10b, but there may be so-called lithogenic *P. abies* and *Fageto-Piceeta* forests in oligotrophic habitats with a very rocky soil (Holubets & Milkina 1988).

Type 9c describes geoecosystems of convex surfaces on ridges and moderate slopes of the very cool altitudinal bioclimatic zone, which occupies elevations between approximately 950 and 1,200 m a.s.l. The geomorphic properties are basically the same as of Type 9a. The topoclimate is characterised by further decrease of heat supply and increase of precipitation – the whole vegetation period is about 120–130 days, while the active vegetation period (average daily temperature >10 °C) is about 50–60 days (Andrianov 1968). The soil is deep and moderately deep brown mountain forest rocky silt loam. The natural vegetation is ***Fageto-Piceeta*** and ***Fageto-Abieto-Piceeta*** forest. The stands may also contain *A. pseudoplatanus* and *B. verrucosa.* The herb layer is formed by nemorose and boreal species such as *Asperula odorata, Dentaria glandulosa,* ***Mercurialis perennis,*** *Galeobdolon luteum, Oxalis acetosella,* ***Dryopteris austriaca,*** *Vaccinium myrtillus,* ***Luzula sylvatica, Homogyne alpina, Soldanella hungarica, Lycopodium annotinum.*** The moss cover is quite well-developed in more humid habitats. ***Spiraea ulmifolia,*** *Sambucus racemosa* and ***Lonicera nigra*** can be found among the shrubs (Holubets 1988).

Type 10c geoecosystems are in the same bioclimatic zone, but refer to steep slopes with rather intensive deluvial wasting and soil creep as well as gully erosion and occasional landslides. The biotic components are similar to Type 9c, but the soil may have a somewhat shorter profile and contain more rocks.

Type 11c is also located in the very cool zone, but on very steep gravitational slopes. The brown mountain forest soil is shallow and rocky. The participation of *A. alba* and *F. sylvatica* is likely to decrease on the oligotrophic rocky substrate.

Type 9d belongs to convex surfaces on ridges and moderate slopes of the moderately cold bioclimatic belt that has an elevation span of approximately 1,200–1,500 m a.s.l. and is almost exclusively located in the Gorgany mesoecoregion of the Upper Dnister Basin. The brown mountain forest soil is characterised by a significant content of rocks in the profile and may have a peat horizon under the forest litter – the limited warm period does not allow complete decomposition of organic matter. The climatic conditions prevent the occurrence of *F. sylvatica* and *A. alba,* and thus monodominant *P. abies* stands as well as ***Pineto cembrae-Piceeta*** are the natural vegetation here. The tree layer is formed by *P. abies,* sometimes with a significant admixture (10–40 %) of *P. cembra* and solitary *B. verrucosa* trees. The understorey is usually rather sparse in the middle-aged forests. The shrub layer may contain *Lonicera nigra, Sambucus racemosa, Sorbus aucuparia,* ***Daphne mezereum, Spiraea ulmifolia*** as well as ***Pinus mugo, Alnus viridis, Juniperus communis*** ssp. *nana* – closer to the timber line. The boreal dwarf-shrub species such as *Vaccinium myrtillus* and *V. vitisidaea* are well represented here. The herb layer includes *Luzula sylvatica, Oxalis acetosella,* ***Calamagrostis villosa, Athyrium alpestre, Dryopteris austriaca, Homogyne alpina, Soldanella hungarica*** and other boreal species. The moss cover is well-developed and formed by ***Sphagnum*** sp., ***Hyloconium splendens, Pleurozium schreberi,*** *Polytrichum juniperinum, P. commune,* ***Dicranum scoparium*** (Holubets 1971, 1988).

Type 10d also belongs to the moderately cold belt, but describes steep (20–30°) slopes with rocky and sometimes peaty brown mountain forest soils. The natural vegetation component is the same as for Type 9d.

Type 11d is in the same way as Types 9d and 10d located in the moderately cold belt. However, it refers to very steep slopes with explicitly developed gravitational processes such as soil creep and debris flow. The surface may be covered with platy sandstone debris, which causes fragmentation of the vegetation cover. The participation of *P. cembra* increases in the natural *P. abies* stands on rocky and shallow brown mountain forest soils (Holubets 1988).

Type 9e describes watershed surfaces and moderate slopes of the Gorgany ecoregion, which are elevated to 1,500–1,818 m a.s.l. and belong to the cold altitudinal bioclimatic zone. The whole vegetation period is limited to 90–120 days here (Andrianov 1968). Frost gradation is the main geomorphic process, which has formed vast debris fields composed of platy sandstone fragments. The soil cover is fragmentary and represented by rocky brown mountain meadow soils that often have a peat horizon under the sod layer (Gogolev 1986; Gogolev & Proskura 1968; Milkina 1988). The habitats support communities of *P. mugo* and sometimes *Juniperus communis* ssp. *nana.* The latter more likely occupies warmer southern slopes. *P. abies* may form a low light forest in the lower part of the zone. The shrub layer may also include *Alnus viridis.* Dwarf shrubs are represented by *Vaccinium myrtillus, V. vitisidaea, V. uliginosum,* while *Calamagrostis villosa* is most frequent among herbs. Lichen and moss cover is well-developed here (Malynovskyi 1980, 1988).

Type 10e refers to steep and very steep slopes of the cold belt, where frost gradation is supplemented by gravitational processes – regolith creep and rock sliding. The biotic components are basically the same as for Type 9e.

Type 24 stands for the geoecosystems of relatively wide mountain valley bottoms with alluvial terraces formed by gravel and sandy alluvium. The floodplains consist of gravel, while on the terraces gravel is covered by loam sometimes transported from the slopes (Gogolev 1986). The local climatic conditions are defined by the position of the valley bottoms within the moderately cool-very cool altitudinal zones (330–1,000 m a.s.l.), relatively high humidity, and by the possibility of temperature inversions during calm weather (🕮 *Topoclimate of the Upper Dnister Basin: Consequences for Crop Cultivation*). The alluvial brown soil usually features a shallow ground water table and creates habitats, which are suitable for spruce stands and formations of ***Alnus incana.*** *Saliceta* communities are frequently observed in the floodplains. Hydrophilic species such as P*etasites albus, Carex brizoides* and *Athyrium* sp. dominate among the herbs.

Type 22 describes narrow alluvial mountain valleys with V-shaped profiles. The narrow bottoms are filled with gravel alluvium. The steep slopes are with deluvial fans and experience landslides provoked by the side erosion of the streams. The same type of valley geoecosystems is delimited for all altitudinal bioclimatic zones (from moderately cool to cold), so the characteristics of the biotic components vary and are similar to those of the steep slopes of the respective zone.

Conclusions

The analysis shows that the Upper Dnister Basin embraces a high diversity of geoecosystems ranging from warm lowland oak forests to subalpine rocky ***shrublands.*** This diversity is predominantly caused by contrasting geomorphic conditions and various parent rock material, which differently modify macroclimate and lead to the formation of manifold soil and vegetation cover. The absolute majority of the natural geoecosystems is of the forest type, thus indicating that the Upper Dnister Basin, in its natural state, should be almost completely covered by ***broad-leaved*** and ***coniferous forests.*** The high diversity of the Upper Dnister Basin natural geoecosystems offers many possibilities and challenges to the sustainable planning of the region, some issues are considered in 🕮 *The Sustainability of Agricultural Land Use,* 🕮 *From Sector Evaluation to Integrated Land Use Planning.*