



**PARTNERSHIP
WITHOUT BORDERS**

ENVIRONMENTAL ISSUES OF ZAKARPATTIA

Manual



PARTNERSHIP WITHOUT BORDERS

ENVIRONMENTAL ISSUES OF ZAKARPATTIA

Manual

Project HUSKROUA/1901/6.1/0075
“Environment for the Future by Scientific Education”



Uzhhorod – 2023

UDC 502+504(477.87)
E45

Reviewers:

Dmytro Dubyna – Doctor of Biological Sciences, professor, chief researcher of the Department of Geobotany and Ecology, M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine

Svitlana Hapon – Doctor of Biological Sciences, Professor of the Department of Botany, Ecology and Teaching Methods of Biology, Poltava V.G. Korolenko National Pedagogical University

Yuriy Tyukh – Candidate of Biological Sciences, Deputy Director for Scientific Research, Synevyr National Nature Park

Mykhailo Haydur – Candidate of Pedagogical Sciences, Deputy Director of the Department of Ecology and Natural Resources, Transcarpathian Regional State Administration

Recommended for publishing by the Academic Council of STATE UNIVERSITY «Uzhhorod National University», protocol No. 11 of December 18, 2023

Environmental Issues of Zakarpattia. Manual / N. Kablak, Ya. Hasynets, L. Felbaba-Klushyna, V. Mirutenko and others ; Gen. Ed. prof. N. Kablak and prof. L. Felbaba-Klushyna. – Uzhhorod : RIK-U, 2023. – 324+356 p.

ISBN 978-617-8276-79-9

The manual contains scientific materials devoted to the coverage of contemporary environmental issues of Zakarpattia. Considerable attention is paid to the peculiarities of its natural conditions. Emphasis is placed on the preservation of biodiversity in the face of climate change. While devising this textbook, the authors resorted to the analysis of literary sources as well as the findings of their own research. It will benefit school teachers, students and postgraduates of higher educational institutions majoring in natural sciences, employees of the nature reserve fund, and representatives of the authorities.

This manual was produced with the financial support of the European Union within the project HUSKROUA/1901/6.1/0075 “Environment for the Future by Scientific Education” (EFFUSE) of ENI CBC Programme Hungary-Slovakia-Romania-Ukraine 2014-2020. Its contents are the sole responsibility of NGO “Institute of Development of Carpathian Region” and do not necessarily reflect the views of the European Union.

UDC 502+504(477.87)

More information on the project is available on the links below:

<https://idcr.info/current-project.php?id=11&lang=en>

<https://effuse.science.upjs.sk/index.php/en/>

© NGO “Institute of Development of Carpathian Region”, 2023

© State University “Uzhhorod National University”, 2023

ISBN 978-617-8276-79-9

CONTENTS

Introduction	5
Chapter 1. Geographical Location: Features and Natural Conditions of Zakarpattia	7
1.1. Orographic and Hydrographic Features (<i>V. Sabadosh</i>)	7
1.2. Natural Conditions and Anthropogenic Factors Affecting the Hydroecological State of the Upper Reaches of Tisza River Basin (<i>V. Leta, M. Karabiniuk</i>).....	14
1.3. Hydroecological State of the Upper Reaches of the Tisza River Basin (<i>V. Leta</i>).....	38
1.4. Characteristics of Current Climatic Conditions and Climate Change Manifestations (<i>R. Ozymko, M. Karabiniuk</i>)	47
1.5. Soils and Vegetation Cover (<i>V. Sabadosh</i>).....	65
1.6. Territorial Faunal Complexes (<i>V. Sabadosh</i>)	70
1.7. Landscape Tiering and Its Features (<i>M. Karabiniuk</i>)	75
1.8. Contemporary Landscape Structure (<i>M. Karabiniuk</i>).....	84
Chapter 2. General Characteristics of Environmental Disequilibrium Manifestations in Zakarpattia Oblast (<i>L. Felbaba-Klushyna, N. Kablak, Ya. Syvokhop</i>)	94
Chapter 3. Air Pollution Issues in Zakarpattia Oblast (<i>M. Vakerych</i>)....	99
3.1. Air Pollution Sources, National Issues of Their Conservation	99
3.2. State of the Air in Zakarpattia: Main Pollution Threats and Conservation Issues	116
Chapter 4. Pollution Issues of the Water Bodies of Zakarpattia (<i>M. Vakerych</i>).....	119
4.1. Sources of Polluting Water Bodies, National Issues of Their Preservation.....	119
4.2. Water Resources of Zakarpattia: Major Pollution Threats and Conservation Issues	123
Chapter 5. Issues of Soil Pollution in Zakarpattia (<i>Ya. Hasynets</i>)	132
5.1. Sources of Soil Pollution and Types of Soil Degradation. National Issues of Soil Conservation.	132
5.2. Soil Resources of Zakarpattia: Main Threats of Pollution and Degradation, Problems of Conservation.	145
Chapter 6. Environmental Threats to the Landscape Diversity of Highland Areas in Zakarpattia (<i>M. Karabiniuk</i>)	159

6.1. Genesis and Evolution of Highland Landscape Complexes	159
6.2. The Impact of Climate Change on Development and Modern Landscape Diversity	166
6.3. Ecological Threats and Anthropogenisation of Highland Landscape Complexes	177
Chapter 7. Modern Changes in the Structure of the Forest Cover of Zakarpattia (L. Felbaba-Klushyna, V. Klushyn, L. Miklovsh).....	192
7.1. Forest Structure and Trends in Their Change.....	192
7.2. Functional Importance of Forest Cover (Hydrological and Soil Protection Role)	196
Chapter 8. Changes in the Biodiversity of Zakarpattia in the Context of Anthropogenic Pressure.....	205
8.1. Impact of Anthropogenic Factors on the Microbiota of Natural Ecosystems (M. Kryvtsova, M. Savenko)	205
8.2. Problems of Floral Diversity Preservation (R. Kish).....	211
8.3. Protection of Phytocoenotic Diversity of Zakarpattia (L. Felbaba-Klushyna, V. Klushyn, L. Miklovsh)	233
8.4. Influence of Anthropogenic Factors on the Fauna (F. Kurtiak, O. Mateleshko)	247
8.5. Threats and Decline of Amphibians (F. Kurtiak).....	249
8.6. Changes in the Composition of the Ichthyofauna (F. Kurtiak).....	256
8.7. The Influence of Anthropogenic Factors on the Entomofauna of Main Biotopes (O. Mateleshko).....	259
8.8. Threats of Spread and Impact of Invasive Species (R. Kish, Yu. Shpontak, D. Tomenchuk, V. Mirutenko, I. Besehanych)	267
Chapter 9. The Impact of Climate Change on the Ecosystems of Zakarpattia and Adaptation Measures (O. Stankiewicz-Volosianchuk) ..	276
Chapter 10. Development of Natural and Technogenic Processes in Zakarpattia Oblast	292
10.1. Geological and Geomorphological Exogenous and Technogenic Processes (N. Kablak, M. Nychvyd, I. Kalynych)	292
10.2. Dangerous and Spontaneous Meteorological Phenomena (R. Ozymko, M. Karabiniuk).....	308
Chapter 11. Environmental Education	315
11.1. Features and Place of Environmental Education in Our Life (M. Vakerych, Ya. Hasynets, V. Mirutenko, M. Balazh, H. Popovych, A. Hiutler)	315
11.2. Scientific Education of Environmental Issues (Ivana Slepakova).....	318

13. Chyselnist naselennia ta serednia chyselnist za periody roku [The Population and the Average Population for the Periods of the Year]. [Elektronnyi resurs] / Derzhavna sluzhba statystyky Ukrainy: ofitsiyni veb-sait. Data ostannoï modyfikatsii: 13.05.2022. – Rezhym dostupu: <https://ukrstat.gov.ua/>. [in Ukrainian]
14. Carpathians relief location map [Internet]. From Wikipedia, the free encyclopedia. Available from: https://en.wikipedia.org/wiki/File:Carpathians_relief_location_map.svg#file

1.7. LANDSCAPE TIERING AND ITS FEATURES (*M. Karabiniuk*)

The interaction and relationship among natural components (rocks, air masses, water, vegetation cover, etc.) lead to the formation of integral natural units on the earth surface, which in geographical science are called natural territorial complexes (landscape complexes, geocomplexes) (Herenchuk, 1968; Melnyk, 1999; Hrodzynskyi, 2005; Karabiniuk, 2020). Their functioning and development mainly depends on internal and external factors, among which an important role is played by climatic conditions. Sharp climatic changes at various stages of the development of Zakarpattia's landscapes impacted the specifics of the formation of landscape complexes and determined their main features, which were changing in the process of evolution. Therefore, the recent trends of climate change in Zakarpattia Region and the Carpathian region in general affect the current state and development of landscapes, whose functioning and geocological state strongly depends on the interaction and influence of climatic factors and progressive anthropogenic loading.

The landscapes of the mountainous part of Zakarpattia Region were formed mainly in the conditions of dominance, in the geological substratum, of sandstone-argillite flysch, highly fragmented mountain relief and vertical differentiation of hydro-climatic conditions, which together determined the principal morphological features of landscape complexes of various ranks. The landscapes of the plain part of the oblast are characterized by accumulative and erosional origin, whose development is closely related to the evolution of the Carpathian mountain system. As a result, over 85 % of the territory of the oblast is characterized by a mountainous relief with a system of mountain massifs (Chornohora, Svydovets, Borzhava, etc.), steep ridges and their spurs, which are dissected and separated by deeply incised river valleys of the Tysa's tributaries (Fig. 1.7.1.).

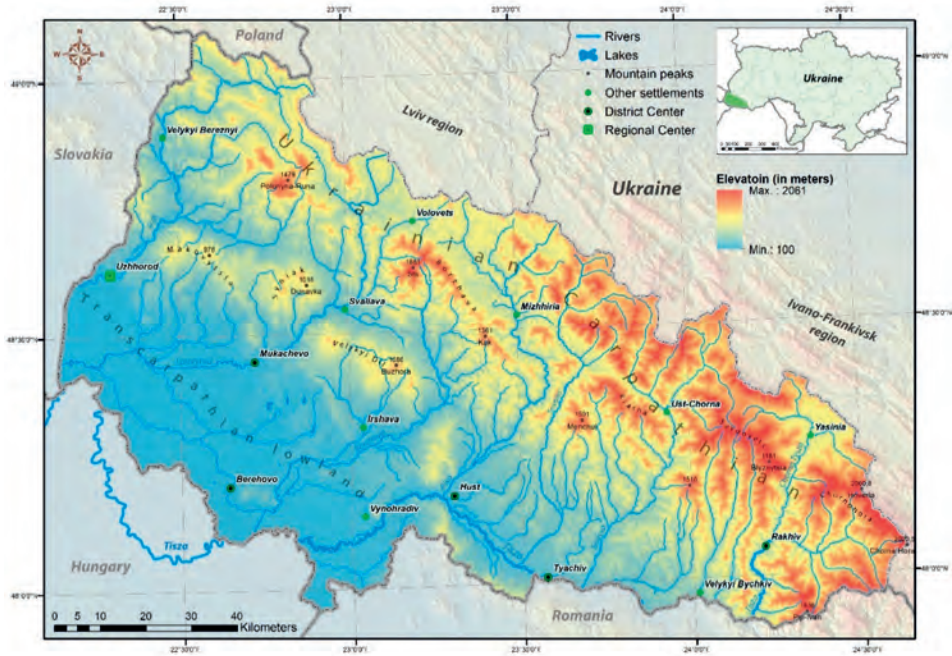


Fig. 1.7.1. Hypsometric Map of Zakarpattia Region (prepared by the author)

The landscapes of mountainous areas differ significantly from those of plain areas in the level and nature of the landscape organization. Therefore, an important aspect of our research is the use of the genetic approach in exploring the current state and development of the landscapes of Zakarpattia Region, which makes it possible to determine the spatial features of forming and locating geocomplexes of different genesis, as well as to analyze the contemporary landscape structure. In general, the landscape approach of the research involves the analysis of a continuous-discrete geographic envelope, via the prism of natural complexes of different ranks, which are directly located in a holistic landscape system, uniting natural territorial complexes of lower orders while simultaneously being a constituent part of the landscape unit of higher order (Melnyk, 1999; Hrodzynskiy, 2005).

Contemporary manifestations of global changes in the climate of the Ukrainian Carpathians have been repeatedly corroborated (Karabiniuk, Shuber, 2019; Karabiniuk, Markanych, 2020) and are relevant in view of studying the landscape organization of the cross-border territory of Zakarpattia Region. Changes in climatic conditions affect all dynamic processes and functioning of landscape complexes, circulation of substances, development of physical and geographical processes, etc. To the main manifestations of changes in the climate of mountainous regions belong changes

in the features of altitudinal belting and disruption of landscape layering, which is one of the main geographical patterns of landscape differentiation of mountain systems (Karabiniuk, 2020).

There is no unanimous and clear understanding or interpretation of the notions of *landscape tiering* and *landscape tiers* in geographical science. According to H. Miller et al. (2002), landscape tiering manifests itself both at the regional level of landscape differentiation – through the layered arrangement of mountain landscapes, their referring to separate parts of a certain (low-mountain, medium-mountain or high-mountain) tier of the mountainous country, with which the formation of physical and geographical or landscape areas in the mountains is associated, as well as at the local, or intra-landscape level – through the differentiation of landscapes into morphological units (landscape layering within the landscape is shown via high altitude areas).

The study of the vertical differentiation of the landscapes of the Ukrainian Carpathians and Zakarpattia Region, in particular, testifies to the complex essence of landscape tiering, which expresses the altitudinal change of natural components and integral landscape complexes. Taking into account the complex features of the landscape tiering, it is clear that in different parts of the mountain system, there is the differentiation of individual natural components (relief, vegetation, climate, etc.) and their altitudinal limits are not always correlated (The Nature of the Ukrainian Carpathians, 1968; The Nature of Zakarpattia Region, 1981). In the academic literature, it is also noted that there are no clear altitudinal limits between landscape tiers, since they depend on a number of factors – the peculiarities of the geographical location and the complex of regional physical and geographical features (Karabiniuk, 2020). For example, the distribution of nival and glacial-exarational forms of the relief – corries, cirques, glacial troughs, nival niches, etc. is also an identifying feature of the highland landscape tier in the Ukrainian Carpathians (Kravchuk, 2006, 2008; Melnyk, Karabiniuk, 2018; Karabiniuk, 2020).

The regional understanding of the landscape tier is based on the study and analysis of the landscape organization of mountain systems, their regional division. Therefore, the regional-level landscape tier is a separate landscape area (low-mountain, medium-mountain, or high-mountain), which is formed by a group of landscapes of the corresponding low-mountain, medium-mountain, or high-mountain types (Karabiniuk, 2020). The hypsometric position and relative heights are considered the main criteria for determining whether landscapes belong to one or another landscape tier. According to H. Miller and O. Fedirko (1990), the foothills include the landscapes with maximum relative elevations above the river valleys of up to 150 m. This figure is up to 1 300 m for the mid-mountain landscape.

The highest relative elevations are characteristic of high mountain landscapes – up to 1 500 m. (Miller, Fedirko, 1990).

According to the landscape map of H. Miller and O. Fedirko (1990), three landscape tiers are distinguished in the Ukrainian Carpathians: high-mountain, medium-mountain and low-mountain ones. Within Zakarpattia Region, at the hypsometrically highest levels, the *landscapes of the high-mountain tier* are located, which are represented by paleoglacial-high meadow flysch (Chornohora, Svydovets, etc.) and paleoglacial-high meadow crystalline (Marmarosh landscape) types. The largest mountainous part of the territory of Zakarpattia Region from the urban-type village Velyky Berezny to Rakhiv is occupied by forested and steep-sided sloping *landscapes of the mid-mountain tier*, which stretch in strips from the northwest to the southeast. They are represented by the middle mountain-meadow and middle mountain-paleovolcanic types. In contrast, in the intermount basins (Yasinia basin, Mizhhiria basin, etc.) and in the hump foothill and lowland areas (Solotvyn plain, etc.) landscapes of low-mountain tier were formed, they are represented by three types: intermount-upland, low mountain-cliff and hump mountain-basin ones (Miller, Fedirko, 1990).

Based on the research conducted by us (in co-authorship) it was established that in the Ukrainian Carpathians it is appropriate to distinguish two levels of landscape tiers, the research and mapping of which is carried out at different scales and requires the use of special methodical approaches. Landscape tiers of *the regional level* are distinguished within the complete mountain system. Within individual mountain landscapes, their morphological structure and properties of landscape complexes change with elevation, which causes a consistent change in landscape tiers *at the local (intra-landscape) level* (Karabiniuk, 2020). Thus, in the local sense, the mountain landscape layer within the landscape manifests altitudinal differentiation of the morphological structure and features of natural complexes of different genesis, peculiarities of functioning and development (Karabiniuk, 2020). The best expression of such altitudinal change of landscape complexes is high terrain, which in mountain systems are located at different hypsometric levels depending on the manifestation of the principal factor of their formation – glacial exaration, denudation, erosion, etc.

Analyzing the features of natural conditions and the landscape structure of the mountainous part of Zakarpattia Region, it is also possible to distinguish three landscape tiers at the local level – low-mountain, medium-mountain and high-mountain tiers (Fig. 1.7.2). They consistently change with elevation and are characterized by significant differences. *The low-mountain landscape tier* is characterized by the dominance of geomor-

plexes of erosive and accumulative origin, as it is limited to the bottoms of river valleys and extensive intermountain basins (Fig. 1.7.3). The undulating erosion relief and the leveled surfaces of the terraces of the river valleys are covered mainly by secondary grassland vegetation with fragments of beech and spruce forests, alder and other deciduous species (Miller, Fedirko, 1990; Melnyk, 1999).

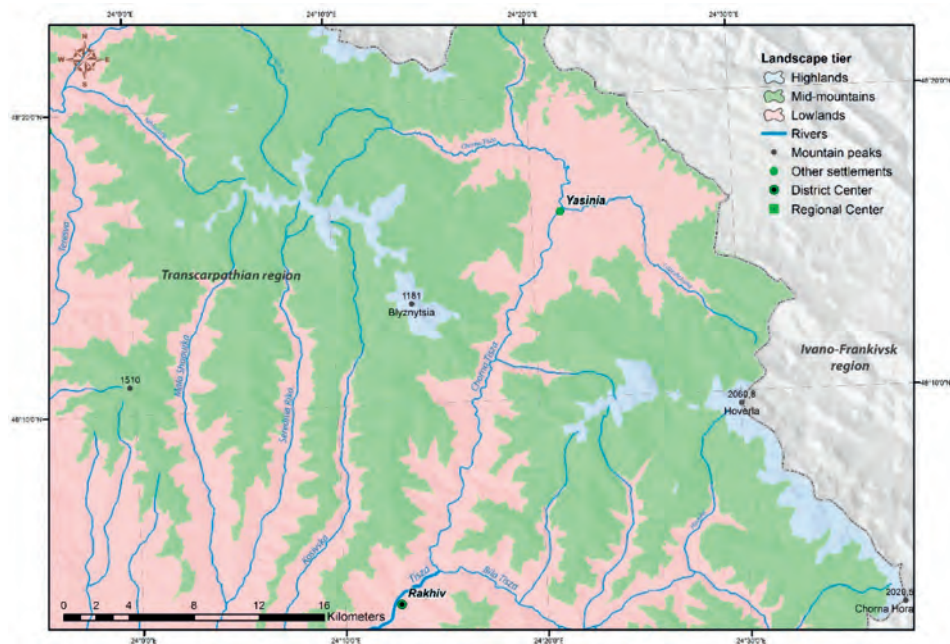


Fig. 1.7.2. Landscape tiers in the central part of the Ukrainian Carpathians in the upper reaches of the Tysa river basin (Zakarpattia Region) (prepared by the author)

The middle-mountain landscape tier covers the largest area and altitudinal range of the mountainous area of Zakarpattia Region and the Ukrainian Carpathians in general. It is represented by landscape complexes of mainly erosional and erosional-denudation origin, which are characterized by the predominance of steep slopes (over 15°) and dismembered spurs of mountain ridges with the dominance of coniferous, less often – deciduous forests on medium-thick brown soil (Melnyk, 1999; Karabiniuk et al., 2017; Melnyk et al., 2018). On well-moistened slopes, erosion processes are actively developing under the influence of permanent and temporary watercourses, which diversify the morphological structure of the landscapes of the middle mountains (Fig. 1.7.4).



a)



b)

Fig. 1.7.3. Low-mountain landscape tier within Yasinia landscape during summer (a) and winter (b) periods (photo by Yana Karabiniuk)

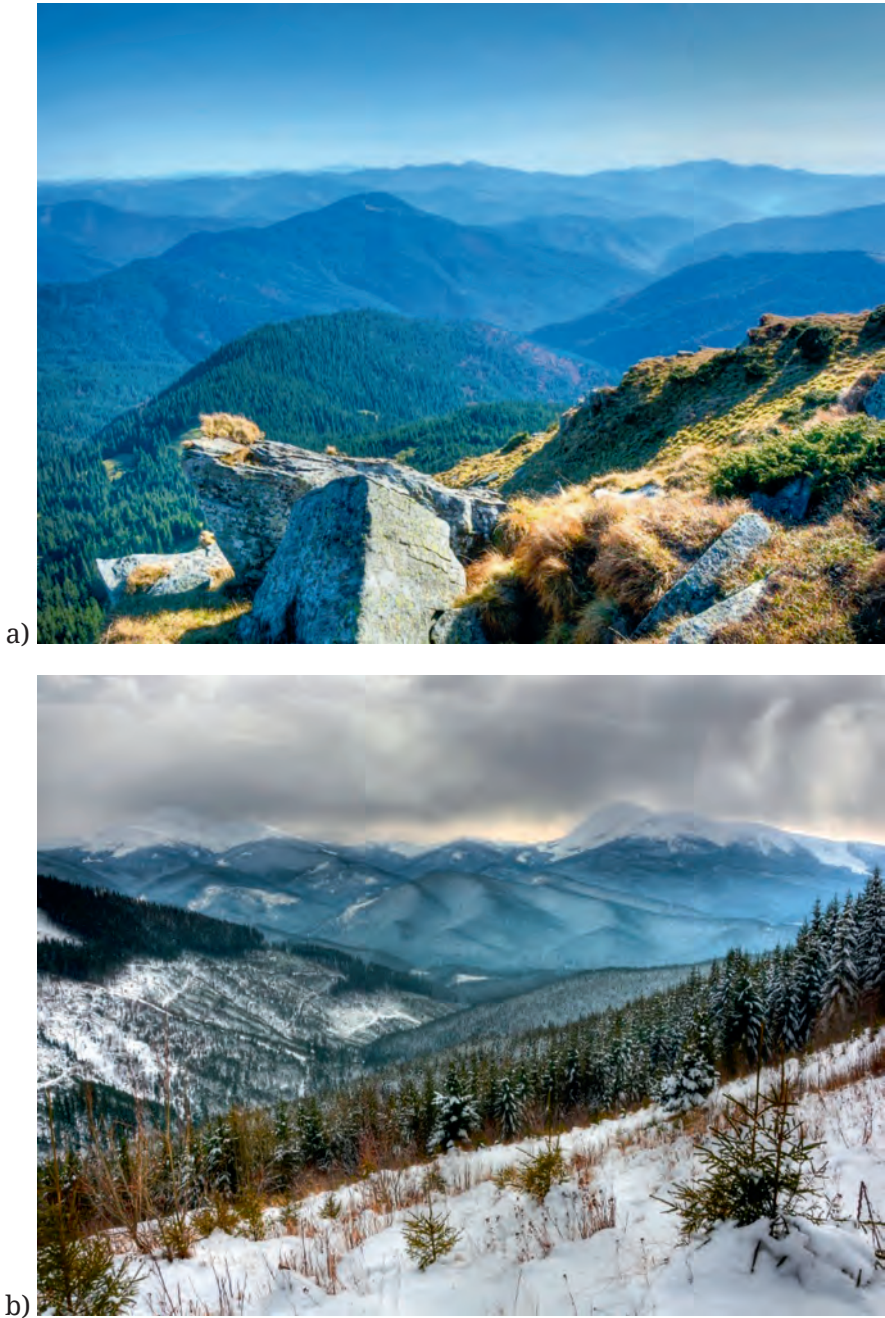


Fig. 1.7.4. Middle-mountain landscape tier of the Ukrainian Carpathians in Rakhiv district of Zakarpattia Region in summer (a) and winter (b) periods (photo by Viacheslav Yahodzynskyi)

The development of powerful water collection funnels and the deepening of dissection in the mid-mountain landscape tier contribute to the overall evolution of the landscape structure of the territory, which depends on the amount of precipitation and petrographic and lithological features of bedrock deposits. As a result, the morphological structure and properties of the geocomplexes of the mid-mountain landscape layer in different parts of Zakarpattia Region can differ significantly depending on the above factors. A characteristic feature of the mid-mountain landscape tier is also a significant anthropogenic load from economic activity, the forest industry and agriculture, in particular, cattle breeding are actively developing (Fig. 1.7.5).

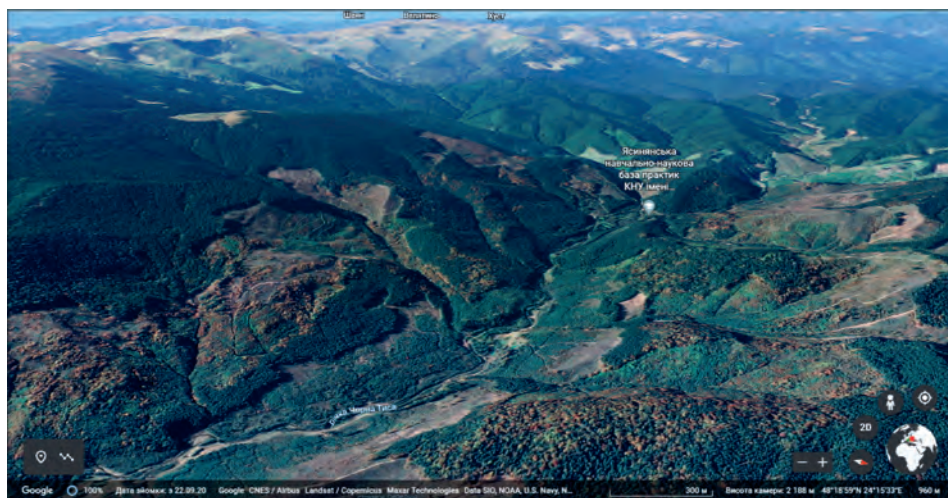


Fig. 1.7.5. Load from forest management operations (felling) on landscape complexes of the Upper Chorna Tysa river basin in Rakhiv district of Zakarpattia Region (a fragment of the space image from Google Earth)

Hypsometrically, the highest levels of the Ukrainian Carpathians are mainly occupied by denudation, glacial-exaration, and nival-erosion natural territorial complexes, which together form a *high-mountain landscape tier* (Fig. 1.7.6). In various mountain massifs (Chornohora, Svydovets, Marmarosh, etc.), the lower limit of the landscape layer varies between 1,450–1,600 m above sea level and often coincides with the contacts of the assises. For instance, within the landscape of Chornohora, on various sections, the lower limit of the highlands coincides with the contacts of the Chornohora and Yalove (Burkut and Yalove) assises, the whose lithological and petrographic differences also lead to a sharp contrast in relief forms and their morphometric features (steepness of slopes, exposure of slopes etc.) (Karabiniuk et al., 2017; Melnyk, Karabiniuk, 2018).



Fig. 1.7.6 High-mountain landscape tier of Chornohora massif of the Ukrainian Carpathians (Photo by the author)

A characteristic feature of the high-mountain landscape tier of the Ukrainian Carpathians is the dominance of massive relief forms with steep slopes and deeply incised glacial cirques, corries, nival niches and other geocomplexes. The landscape structure of the high mountains acquired its modern features during the ancient Pleistocene glaciations, and the modern development of landscape complexes occurs mainly under the influence of erosion and denudation (Karabiniuk, 2020). Subalpine and alpine vegetation is most common in the high mountains. The bottoms of corries, glacial troughs and lower parts of the massive slopes are covered with crooked forests of mountain pine, green alder and Siberian juniper. In the subalpine vegetation zone, there are also admixtures of fir-mountain pine groupings, which are sporadically distributed among continuous thickets of shrubs (Baitsar, 1994; Malynovskyi, 1980, 2003). At altitudes over 1850 m above sea level alpine meadow vegetation is widespread.

In the Ukrainian Carpathians, the high-mountain landscape tier is best expressed at the highest hypsometric levels of the Chornohora, Svydovets, Marmarosh, and Borzhava mountain landscapes. The dominance of hard sandstones in the geological base and the long history of the development of the high-mountain layer under the influence of intensive mountain formation, glaciations and modern climate changes caused a high landscape diversity (The State Geological..., 2009; Karabiniuk, 2020). The convex and flat surfaces of the crests of the main ridges of the high mountain massifs preserve the features of ancient denudation, and are now covered with juncus-fescue meadows and juniper. On the steep slopes of the high-mountain landscape, avalanche and crumbling processes are quite common, avalanches and manifestations of other physical and geographical processes are recorded annually.

1.8. CONTEMPORARY LANDSCAPE STRUCTURE (*M. Karabiniuk*)

On the earth surface, under the influence of zonal and azonal factors, there were formed numerous geocomplexes of various ranks and sizes, of different genesis and complexity of internal organization, forming a clear hierarchical structure, from the smallest landscape unit of the local level (facies) to the largest natural territorial complexes of the global order (geographic shell). Landscapes occupy a special place in this hierarchical system. The landscape studies approach envisages the exploration of the object taking into account its location in this landscape system and the features of the internal structure (Melnyk, 1999).

Each landscape complex at the local level is a clearly defined element of the internal structure of the landscape. They formed historically and

E 45 Environmental Issues of Zakarpattia. Manual / N. Kablak, Ya. Hasynets, L. Felbaba-Klushyna, V. Mirutenko and others; Gen. Ed. prof. N. Kablak and prof. L. Felbaba-Klushyna. – Uzhhorod : RIK-U, 2023. – 324+356 p.
ISBN 978-617-8276-79-9

The manual contains scientific materials devoted to the coverage of contemporary environmental issues of Zakarpattia. Considerable attention is paid to the peculiarities of its natural conditions. Emphasis is placed on the preservation of biodiversity in the face of climate change. While devising this textbook, the authors resorted to the analysis of literary sources as well as the findings of their own research. It will benefit school teachers, students and postgraduates of higher educational institutions majoring in natural sciences, employees of the nature reserve fund, and representatives of the authorities.

This manual was produced with the financial support of the European Union within the project HUSKROUA/1901/6.1/0075 “Environment for the Future by Scientific Education” (EFFUSE) of ENI CBC Programme Hungary-Slovakia-Romania-Ukraine 2014-2020. Its contents are the sole responsibility of NGO “Institute of Development of Carpathian Region” and do not necessarily reflect the views of the European Union.

UDC 502+504(477.87)

ENVIRONMENTAL ISSUES OF ZAKARPATTIA

Manual

Team of authors:

N. Kablak, Ya. Hasynets, L. Felbaba-Klushyna, V. Mirutenko, M. Vakerych, M. Balazh, I. Besehanych, A. Hiurtler, V. Leta, I. Kalynych, M. Karabiniuk, R. Kish, V. Klushyn, N. Kryvtsova, F. Kurtiak, O. Mateleshko, L. Miklovsh, M. Nychvyd, R. Ozymko, H. Popovych, V. Sabadosh, M. Savenko, Yu. Shpontak, O. Stankevych-Volosianchuk, Ya. Syvokhop, D. Tomenchuk

Author's correction

Font: Noto Serif. Offset paper. Offset printing. Format: 70x100/16.
Conditional printed sheets: 55,3. Order: No 156K. Circulation: 1000 copies.

The original layout was made and printed
by RIK-U LLC, 88006, Uzhhorod, 36 Karpatskoyi Ukrainy st.
Certificate of the subject of the publishing business:
DK No. 5040 dated January 21, 2016.