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PROBLEMS OF BIOTIC AND LANDSCAPE DIVERSITY CONSERVATION IN THE UKRAINIAN CARPATHIANS HIGHLANDS

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Introduction. The highlands of the Ukrainian Carpathians belong to the territories with the highest concentration of rare species and coenotic diversity in Ukraine. Due to highland ecosystem transformation, a large number of populations and communities of rare species are under the threat of degradation and elimination.

Climate change. At present, effective growth and development of plants begins 2–3 weeks earlier compared to the 1980–90s. Sharp seasonal distribution of precipitation causes negative changes in the highland water-body hydrology regime affecting freshwater populations of plankton crustaceans and amphibians.

Demutative successions. During the first 10–20 years of the succession its influence on the structure and vitality of the majority of rare species populations is mostly positive, but 30–40 year-long demutations usually cause negative dynamics. Overgrowing results in the simplification of spatial structure and fragmentation, as well as decreasing of population density, disappearing of rare species from the community structure. Active protection measures should be locally implemented in protected territories: traditional type of grazing, mowing, and shrub or tree cutting in the cases of protection of extremely rare phytocoenoses and populations.

Anthropogenic impact. Intensive recreation pressure causes digressive changes in numerous communities, which are located along the popular tourist paths to the glacial lakes, mountain summits etc. Unfortunately, the systematic violation of the protection regime in the highland zone of the Ukrainian Carpathians is obvious nowadays. Gathering medicinal and ornamental species poses a serious threat. Uncontrolled increase in the number of recreants in the highland areas for the last 5 years has destroyed its aquatic ecosystems more than in the previous 30–40 years. Usage of

vehicles for recreation purposes (4×4, quads and motorcycles) refers to significant destructive factors for highland ecosystems.

Protection measures. Population conservation and revival of communities is usually possible under the condition of moderate and short-term anthropogenic pressure. The visiting regime of the most popular highland sites must be put under control immediately, while mass ascensions must be completely forbidden.

Keywords: biodiversity loss, highland ecosystems, climate change, demutative successions, anthropogenic impact, the Carpathians

INTRODUCTION

Highlands of the Ukrainian Carpathians belong to the territories with the highest concentration of rare species and coenotic diversity in Ukraine (Didukh, 2009; Akimov, 2009). However, natural systems of alpine and sub-alpine zones are very vulnerable to different impacts, and their revival takes long time (Kyyak, 2004; Malynovskyi, Kyyak, & Bilonoha, 2004). Recently, rare biota of the highlands has been significantly affected by a number of negative natural and anthropogenic changes, e.g. climate change, demutation, recreation, harvesting, etc. Because of highland ecosystem transformation, the large number of populations and communities of rare species are under the threat of degradation and elimination (Holubets & Tsaryk, 2004; Tsaryk, 2009b; Kyyak *et al.*, 2015; Kobiv, 2017; Kyyak, 2018). The mentioned problems have been aggravated during the last years and new threats appear in addition. Thus, it is necessary to bring these issues forward for discussion by the scientific and conservation community (Angelstam *et al.*, 2013; Sobala, 2020).

Our research was done in alpine and sub-alpine zones of the Ukrainian Carpathians. The lower alpine limit here is situated between 1750–1800 m a.s.l. Sub-snow zone communities appear on the northern snowy slopes between 1800–2000 m a.s.l. Low temperatures, high air humidity and cloudiness, intensive wind regime and sharp contrast of ecological factors within different sites are typical climate conditions. Sites without snow and seasonal permafrost alternate with deep snow cover sites in winter. Soils are usually poor, thin and stony. Plant communities have simplified vertical and horizontal structures. Microphyto-climate is almost absent in alpine communities. Permanent and temporary lentic water-bodies in the highlands are characterized by low water mineralization. The values for glacial lakes are between 18 and 130 mg/L. Water supply is almost fully supported by rainfall and snow melting (Mykitchak, 2014). All of the mentioned factors predetermine low buffer ability and high vulnerability of highland species, as well as populations and ecosystems to exogenous transformations (Alberton *et al.*, 2017).

Spatial distribution rates of plants under the conditions of alpine zone are very slow. Significant changes are noticeable on the scale of decades and centuries (Kyyak, 2004). The slowest rates for flowering plants occur at pioneer stages of their distribution. Low survival percentage at early life stages is also typical of them. Colonization rates accelerate only after the plants reach their ability to spread in vegetative way. Vegetative reproduction, which is important for new sites colonization, local distribution and self-maintenance, dominates over seed reproduction (Tsaryk, Kyyak, Dmytrakh, & Bilonoha, 2004; Tsaryk, 2014).

Re-colonization rates in the sites with disturbed vegetation cover are very slow as well. Vegetation cover revival in most of the coenoses under the conditions of alpine zone usually takes more than 20 years even in small sites (0.25–0.5 sq. m). More than

100 years is needed for the revival for *Saxifraga, Salix, Poa, Cerastium, Loiseleuria* species in rocky sites on mountain summits, stony bluffs and slopes, and in the sites with long-lasting snow cover. Relatively quick revival is observed in tall-grass communities. About 70 years of secondary succession is needed to restore the vegetation cover with the domination of *Juncus trifidus, Festuca airoides, Calamagrostis villosa* to the natural stage in flat sites with good soil conditions (Kyyak, 2004).

Under the conditions of current short-term changes induced primarily by recreation, highly specialized plankton species disappear in the composition of highland communities of aquatic invertebrates. Thus, vacant ecological niches are occupied by eurytopic species increasing the upper limits of their distribution. Permanent revival of the gene pool of plankton eurytopic species is usually supported by the vehicle translocation of their diapause developmental stages. Thus, atypical hydrocoenoses appear in the locations that are typical of specific sub-alpine aquatic communities. For example, the disappearance of such mountain endemic and ultra-specific species as *Mixodiaptomus tatricus, Daphnia obtuse, Daphnia rosea, Streblocerus serricaudatus* leads to the appearance of trivial lowland species in the first place; they are as follows: *Simocephalus veturlus, Scapholeberis mucronata* (glacial lakes of the Svydovets). In such cases, ubiquist species, which are present both in highlands and lowlands: *Asplanchna priodonta, Keratella cochlearis, Brachionus calyciflorus, Chydorus sphaericus, Acanthocyclops vernalis, Eudiaptomus* sp., *Cyclops* sp., begin to play the main role in terms of number and biomass of plankton communities (Mykitchak, 2014, 2016, 2017). A similar tendency is observed for highland amphibian communities. Common Frog (*Rana temporaria*) and Common Toad (*Bufo bufo*) have become more and more numerous and common species in the composition of highland communities due to the intensification of recreational impact on highland waterbodies. Consequently, such mountain endemic newt species as Carpathian Newt (*Lissotriton montandoni*) and Alpine Newt (*Ichthyosaura alpestris*) do not have enough adaptation ability to compete for their transformed habitats at the population or sub-population levels (Reshetylo, 2013; Tsaryk, 2016; Kyyak, 2018; Kyyak et al., 2019).

CLIMATE CHANGE

Climate change is one of the most obvious natural factors influencing highland biota. First of all, it is climate warming. At present time, effective growth and development of plants begins 2–3 weeks earlier compared to the 1980–90s. In the case of chionophilous communities this difference is even more impressive due to faster snow melting – 4–6 weeks. The rest of the phenophases, in particular blooming and fruitage ones have been noticed to start earlier as well. The difference of effective temperatures at the end of the vegetation season is over 200 °C, which indicates an increase in average day air temperature by approximately 1.3 °C. If the existing climate change tendency persists, the upper limit of forests will rise up by 200 m totally eliminating alpine zone in the Ukrainian Carpathians (Kyyak, Shtupun, & Bilonoha, 2016) (**Fig. 1**).

Due to the extention of vegetation period, effective temperature sum increase, faster snow melting, a decrease in the amount of winter precipitation, and as a result soil humidity decrease, we can observe habitat and biotope transformations that cause the displacement of eco-phytocoenotic optima and overlapping of ecological niches. Therefore, the increasing inter-species competition accompanied by shrub and trivial grass species invasion eliminates rare heliophyte species which are usually uncompetitive.

Fig. 1. Alpine meadows formerly extending above 1750 m a.s.l. in the Chornohora Ridge have been overgrown by shrub and tree vegetation (green color in the photo), SE slope of Mt. Breskul, 1910 m a.s.l.

Рис. 1. Альпійські луки, які були поширені на Чорногірському хребті вище 1750 м н.р.м., заростають деревно-чагарниковою рослинністю (на фото – зеленої барви), г. Брескул, пд.-сх. схил, 1910 м н.р.м.

Negative climatogenic dynamics characterizes populations of many petrophyte and chionophilous species included into the Red Data Book of Ukraine: *Leontopodium alpinum*, *Erigeron atticus*, *E. alpinus, Saussurea alpina, Achillea oxyloba* subsp. *schurii, Saxifraga androsacea, S. carpatica, Minuartia zarecznyi, Astragalus australis* subsp. *krajinae, Aconitum anthora* subsp. *jacquinii, Primula halleri, Ranunculus thora, Dichodon cerastoides* etc. (Didukh, 2009). The populations of alpine and arcto-alpine chionophobic species, which are the components of summit communities, are threatened as well (*Oreochloa disticha, Carex curvula, Dryas octopetala* etc.). They show a decrease in the number and vitality of their populations (Kobiv, 2009; Kyyak & Bilonoha, 2016; Kobiv, 2017; Kyyak, 2018).

Climate change, especially sharp seasonal distribution of precipitation, causes negative changes of small water-body hydrology regime (glacial lakes, highland puddles, swamps, wet locations, springs etc.). In recent years, there have been no appropriate conditions for a successful annual reproduction of populations of stenobiont invertebrates in small highland water-bodies (less than 1 m deep). The number of habitats of *Mixodiaptomus tatricus* in the Chornohora highlands has decreased sharply for the last 20 years: of about 100 permanent habitats of the species at the beginning of the 21st century only 1/3 are still inhabited according to a 5-year record (Mykitchak, 2017). Similar changes of aquatic ecosystems under the influence of climate change have been recorded in other mountainous regions of Europe (Kiesel *et al.*, 2019).

Summing up, climate changes of the last decade have led to drastic negative changes in population viability, moreover, to a complete elimination of some of them.

DEMUTATIVE SUCCESSIONS

Demutative succession influence at its final stages is a natural threat factor for rare species populations. During the first 10–20 years of succession, its influence on the structure and vitality of the majority of rare species populations, particularly uncompetitive heliophytes, is mostly positive. But 30–40 year-long demutations usually cause negative dynamics. The increased shading and vegetation cover compaction due to the

distribution of highly competitive species further contribute to negative changes. As a result, short-stem rare species are displaced (Kyyak, 2018).

Populations and phytocoenoses within the protected territories are subject to the greatest impact. Climatogenic changes are further aggravated here by demutative successions. Negative dynamics of population range areas and specimen numbers is characteristic of *Pulsatilla alba*, *Gentiana acaulis*, *G. punctata*, *Heracleum carpaticum, Anemone narcissifolia, Erigeron alpinus* etc. Some population loci or metapopulation fragments of the mentioned species have already disappeared (Kyyak, 2018).

Accelerated degradation is typical of many rare petrophyte phytocoenoses on the slopes of Petrosul, Hoverliana, Dantser, Turkul, Rebra, Berbeneska Mts (the Chornohora), Komyn and Rebro Mts (the Svydovets), Neneska Mt (Marmaros) due to overgrowing by shrubs (*Juniperus communis* subsp. *alpina*, *Alnus viridis*, *Pinus mugo*) and some trees (*Picea abies*, *Salix* sp., *Sorbus* sp.). Overgrowing by shrubs and trees results in the simplification of spatial structure and fragmentation, as well as a decrease in population density, disappearing of rare species from the community structure, and causes the impoverishment of its floristic composition in total (Voloshchuk, 2016; Kyyak, 2018).

Overgrowing of water surface and shorelines of small water-bodies by tall grasses and shrubs (*Alnus viridis*, first of all) causes shading of water mirror and water temperature decrease, which is critically important for the development of phytoplankton and phytoperiphyton. They are known as primary diet components of food chains in highland freshwater ecosystems.

Thus, demutative processes resulting from an absolute protection do not always contribute to the revival of populations of primary communities, and sometimes can even pose a serious threat.

Population conservation and self-renewal of its structure and function is usually possible under the condition of moderate and short-term anthropogenic pressure. Such influences which induce fragmental dilution of vegetation and weaken species competition facilitate higher viability of many rare highland species of the Ukrainian Carpathians, in particular uncompetitive short-stem heliophytes. The conditions of absolute protection for these species are favorable only at the primary demutation stages.

Active protection measures can slow down population degradation of rare species due to long-term demutation and climate changes. They should be locally used in protected territories: traditional type of grazing, mowing, and shrub or tree cutting in the cases of protection of extremely rare phytocoenoses and populations (Kyyak, 2018).

ANTHROPOGENIC IMPACT

Highland landscape refers to highly attractive territories for the recreation. The highest mountain summits and ridges, glacial lakes and rocks fascinate thousands of tourists by their unique beauty. The intensity of recreation in the Chornohora, Svydovets and other highland massifs grows every year. Unstoppable crowds of recreants flood the protected areas without any control violating the existing nature protection rules and regulations.

Intensive recreation pressure in the highlands causes digressive changes in numerous communities, which are located along the popular tourist paths to the glacial lakes, mountain summits, etc. There are several very attractive and at the same time very vulnerable objects in the highland landscape. First of all, it is Mt. Hoverla. The network of paths leading to the summit is permanently growing. So, the mountain top and the area around are degrading very quickly due to excessive trampling. Water and wind erosion become more usual processes here. Several thousand visitors ascend Hoverla's

summit daily in the summer. It caused the total disappearance or grass cover on the mountain top and surrounding areas. In some places the width of tourist routes reaches 50 m. Extremely fast widening of the routes occurs in rainy weather, when the surface of bare soil is over-moistured. The most destructive effect on plant cover and soil layer is visible during the ascensions of large groups of people.

Hundreds of recreants visit Nesamovyte Lake every day in the summer in the protected area of the Carpathian National Nature Park. Majority of them choose the tourist path starting from "Zarosliak" Sports base. Not only do they walk, but also put up tents or make bonfires along the route or around the lake. This is another example of the systematic violation of the protection regime in the highlands of the Ukrainian Carpathians.

The disturbance of grass cover and soil denudation during the erection of a traditional "tur" stone-pile on the summit of Mt. Turkul in the Chornohora as well as excessive trampling caused a total degradation of the unique *Oreochloa disticha* population which is the only one in Ukraine (**Fig. 2**). It is on the verge of extinction nowadays (Kyyak, 2013, 2018).

Fig. 2. A stone-pile "tur" on the summit of Mt. Turkul, 1933 m a.s.l.

Рис. 2. Тур на вершині г. Туркул, 1933 м н.р.м.

Collecting medicinal and ornamental species like *Rhodiola rosea, Gentiana lutea, G. punctata, Leontopodium alpinum, Cetraria islandica* etc. poses a serious threat as well. Harvesting of *Rhodiola rosea* is popular in the Chonohora and Svydovets highlands. Due to the excessive harvesting, populations of this Red Data Book species are seriously degraded having changed age, vitality and spatial structures. In the majority of their habitats, they are represented by only small groups of plants in the most inaccessible sites. Nevertheless, harvesting is still in progress: rhizomes of the species can be bought at the markets all over the Hutsul region like trivial medicinal plants. A similar situation is observed with *Gentiana lutea* and *G. punctata* which are also protected Red Data Book species of Ukraine. Besides, severe degradation affects all the populations of rare decorative species *Leontopodium alpinum* due to harvesting.

In 2021, there was a rapid increase in the cases of illegal *Cetraria islandica* harvesting mostly on the territory of the Chornohora within the Carpathian Biosphere Reserve. The exact harvesting sites are located between the following mountain summits: Petros and Hoverla, Breskul and Turkul, Berbeneska and Dzembronia (**Fig. 3**). Taking into account that *Cetraria islandica* is one of the main components of alpine phytocoenoses, its removal will cause the degradation of a number of primary plant communities.

Fig. 3. Illegal harvesting of *Cetraria islandica* on SE slope of Mt. Breskul, 1800 m a.s.l.

Рис. 3. Браконьєрська заготівля *Cetraria islandica* на г. Брескул, пд.-сх. схил, 1800 м н.р.м.

Blueberry *Vaccinium myrtillus* harvesting is another negative anthropogenic factor. This year it advances to a new "modern" type: the collecting centers receive not only ripe berries, but green ones as well. This fact caused the rapid increase in the numbers of harvesters who devastate large areas both outside and inside the protected territories.

Different forms of recreation are dangerous for highland ecosystems of the Svydovets massif. Permanent vehicle excursions from the recreational complex "Drahobrat" to Lake Hereshaska are common now in the Svydovets. The anthropogenic damage of unique petrophyte and hygrophyte phytocoenoses results in progressive degradation of the lake ecosystem and its surroundings. Motorcycles, quads and 4×4 vehicles have reached Lake Apshynets this year. The road network and their width in the Central Svydovets are growing year by year due to uncontrolled vehicle movement (**Fig. 4**).

Fig. 4. Off-road vehicles in the highlands of the Central Svydovets massif

Рис. 4. Високопрохідні автомобілі у високогір'ї масиву Центрального Свидовця

One of the main anthropogenic threats to the natural functioning of aquatic ecosystems in the highlands of the Ukrainian Carpathians is vegetation cover disturbance on the bottom of water-bodies and in their drainage basins as well. Uncontrolled increase in the number of recreants in the highlands for the last 5 years has destroyed its aquatic

ecosystems more than for the previous 30–40 years. Highland lakes (Nesamovyte, Brebenieska (Brebeneskul), Hereshaska (Dohiaska), Apshynets, Vorozheska, etc.) are among the most popular recreation sites in the Ukrainian Carpathians. The increased number of visitors of the mentioned aquatic objects is followed by large-scale trampling and devastating of vegetation cover. Irrespective of the protection status of the lake, the areas of totally destroyed vegetation cover around the highland lakes and in their drainage basins due to recreation activity have reached thousands of square meters since the beginning of the century. The number of bonfire places in the drainage basins of the glacial lakes is very indicative in this case, e.g. it has changed from 7 to over 120 since 2001 in the basin of Lake Nesamovyte (the Carpathian National Nature Park), and from 4 to 65 for the same period in the basin of Lake Brebenieska (the Carpathian Biosphere Reserve) (Mykitchak, 2014, 2017).

The usage of vehicles for recreation purposes causes a number of disturbance factors for the bird and mammal communities. Noise disturbance is one of the most dangerous in this case, especially in spring during the breeding season and in autumn during the food or fat storage process.

One more new factor of recreation influence on the highland ecosystem is usage of trekking poles for hiking. Trips with poles leave behind visible holes in the ground on the tourist routes causing the intensive soil layer wash off during the rain, storm, or snow melting, etc. As a result, the routes, especially on their steep sections, transform into stone debris preventing common hiking; recreants have to bypass difficult places trampling the vegetation and widening the existing routes. Vivid examples of such a type of erosion are the route on the slope of Mt. Turkul on the way to Lake Nesamovyte or numerous paths on the slopes of Mt. Hoverla

For the purpose of organizing tourist excursions, harvesting, religious tours, mass ascensions etc., local people usually provide vehicle transportation to the drainage basins of highland water-bodies. Sometimes brand new forest roads are made for that, e.g. a road to the upper part of the Chornohora from its Transcarpathian side.

PROTECTION MEASURES

Highland biota is characterized by the highest concentration of rare species in Ukraine. At the same time, it is the most vulnerable and needs urgent support from both the scientific community and nature protection institutions who should propose and implement new concepts and feasible plans for its conservation.

Population conservation and revival of the communities is usually possible under the condition of moderate and short-term anthropogenic pressure. Absolute protection regime for the numerous rare species is favorable only at the primary stages of demutation.

There is a critical need for expansion of territories under protection in the highlands for conservation of valuable localities of biotic and landscape diversity in Hutsul region. In particular, numerous habitats on the slopes of Petros, Shpytsi, Rebra, Hutyn-Tomnatyk, Berbeneska, Pip-Ivan Mts in the Chonohora need a higher protection status. The same refers to the Svydivets habitats protection (Hereshaska, Rebro, Vorozheska, Velykyi Kotel Mts) (Tsaryk, 2009a; Kyyak, 2018).

It is necessary to implement moderate anthropogenic pressure on a local scale including protection areas (grazing, moving, shrub and tree cutting) for the minimization of the negative climate change and demutation influences on the rare biodiversity.

It is important to elaborate and implement a complex of sustainable measures taking into account the recreation boom in the Chornohora and Svydovets highlands. First of

all, it is necessary to follow the nature protection rules and legislation on the protected territories. Efforts should be made to prevent the destruction of rare Red Data Book decorative and medicinal plant species. Ecological education concerning the vulnerability of natural high-mountain ecosystems, their slow revival after the disturbance, harmful influence of different recreation factors on the environment, like littering, making brand new bonfire places or stone-piles is very important and topical as well.

The visiting regime of the most popular highland sites, in particular Hoverla, Turkul, Drahobrat Mts summits and Lakes Nesamovyte, Berbeneska, Hereshaska must be put under control immediately; mass ascensions must be forbidden. Mt. Turkul summit must be protected from tourist visits to save and revive the unique population of *Oreochloa disticha*.

A considerable part of highlands of the Ukrainian Carpathians belongs to nature protection territories, particularly to the Carpathian Biosphere Reserve and the Carpathian National Nature Park. Nevertheless, the most powerful degradation of highland ecosystems takes place within their territories. Nature reserves and parks in the Ukrainian Carpathians actively promote their recreational potential highlighting attractive sites in their territories to increase the number of visitors. At the same time, the institutions do not control the buffer visitor numbers, they ignore the visitors' behavior and activity behind the check-points (i.e. ticket-desks). Thus, the direct devastation of unique highland ecosystems occurs due to the excessive recreation activity and the absence of its control. Moreover, nature protection activity in smaller areas, like natural monuments or habitat management areas is often completely neglected.

Currently, rapid environmental changes necessitate the creation of monitoring programs to provide observation over the populations of rare and endemic species in the highlands of the Ukrainian Carpathians with the aim of managing them under the influence of anthropogenic and natural factors (recreation, climate change, demutative successions). Hence, the urgent need of elaboration and implementation of modern approaches to highland nature conservation arises in the regard of serious threats induced by the mentioned factors.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Human Rights: This article does not contain any studies with human subjects performed by any of the authors.

Animal studies: All institutional, national and institutional guidelines for the care and use of laboratory animals were followed.

AUTHOR CONTRIBUTIONS

Conceptualization, [V.K., T.M., O.R.]; methodology, [V.K., T.M., O.R.]; validation, [V.K., T.M., O.R.]; formal analysis, [V.K., T.M., O.R.]; investigation, [V.K., T.M., O.R.]; resources, [V.K., T.M., O.R.]; data curation, [V.K., T.M., O.R.]; writing – original draft preparation, [V.K., T.M.]; writing – review and editing, [O.R.]; visualization, [V.K., T.M., O.R.]; supervision, [V.K.].

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ПРОБЛЕМИ ЗБЕРЕЖЕННЯ БІОТИЧНОГО ТА ЛАНДШАФТНОГО РІЗНОМАНІТТЯ У ВИСОКОГІР'Ї УКРАЇНСЬКИХ КАРПАТ

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Вступ. Високогір'я Українських Карпат належить до територій із найвищою концентрацією раритетного видового й ценотичного різноманіття в Україні. Унаслідок трансформації високогірних екосистем під загрозою деградації й вимирання опинилася велика кількість популяцій та угруповань рідкісних видів.

Кліматичні зміни. Початок ефективного росту і розвитку рослин в останні 20 років, порівняно з 80–90-ми роками минулого століття, пришвидшився на 2–3 тижні. Різкий сезонний розподіл кількості опадів призводить до порушення гідрологічного режиму високогірних водойм, негативно впливаючи на популяції планктонних ракоподібних і земноводних.

Демутаційні сукцесії. Протягом перших 10–20 років демутації мають переважно позитивний вплив і спричиняють відновлення структури та віталітету популяцій більшості раритетних видів, проте демутації тривалістю 30–40 років часто зумовлюють їхню негативну динаміку. Заростання спричиняє спрощення просторової структури і фрагментацію, зменшення щільності популяцій рідкісних видів, випадання їх зі структури угруповань. Потрібно локально вводити традиційні антропогенні навантаження – випасання, викошування, а для збереження особливо рідкісних фітоценозів і популяцій – вирубування чагарників і дерев.

Антропогенний вплив. Високе рекреаційне навантаження спричиняє дигресивні зміни численних угруповань, які розташовані вздовж туристичних шляхів на підходах до високогірних озер, хребтів, вершин тощо. Унаслідок стихійного відвідування заповідний режим зазнає систематичного порушення. Істотну загрозу становить збирання лікарських і декоративних видів рослин. Неконтрольоване збільшення потоку рекреантів за останні 3–5 років у високогір'ї призвело до набагато більших масштабів руйнувань високогірних гідроекосистем, ніж за попередні 3–4 десятиліття. Новітні види рекреаційної діяльності, до яких належать джипінг, квадроциклінг і мотокросинг спричиняють істотну деградацію високогірних екосистем.

Заходи збереження. Збереження й відновлення популяцій і угруповань забезпечуються переважно за умови помірних навантажень або нетривалих втручань антропогенного характеру. Режим відвідування найбільш популярних об'єктів високогір'я потребує термінового нормативного врегулювання, а масові сходження необхідно заборонити.

Ключові слова: втрата біорізноманіття, високогірні екосистеми, зміни клімату, демутаційні сукцесії, антропогенний вплив, Карпати

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