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Development of Interactive Climate Change Maps for Protected Natural Areas in the Volyn Region

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SUMMARY

The study and analysis of regional manifestations of climate change require the visualisation of the results obtained, with cartographic representation being the most effective means of such visualisation.This study presents the results of a long-term investigation into the dynamics of climatic processes over recent decades in the four largest and most valuable nature conservation areas in the Volyn Oblast: Shatsk National Nature Park, Cheremsky Nature Reserve, Kivertsi National Nature Park 'Tsumanska Pushcha', and the 'Prypiat–Stohid' National Nature Park. The research has resulted in the development of two interactive maps: the map 'Climate Change in the Cheremsky Nature Reserve' and the map 'Climate Change in the National Nature Parks of Volyn. These online tools allow users to assess the dynamics of climate change at these sites over the past decade. They provide a comprehensive set of data on changes in key climate indicators, presented in both numerical and graphical forms, as well as information on the potential impact of climate change on biota. The maps developed will be updated with the latest data and will help to monitor the dynamics of climate change in nature conservation areas in the coming years. They can be used as an educational and awareness-raising resource, form the basis of a geoportal on climate change in Ukraine's nature conservation areas, and serve as a platform for bringing together researchers in this field.

Keywords: Climate change, Online map, Shatsk National Nature Park, Cheremsky Nature Reserve, Kivertsi National Park 'Tsumanska Pushcha', 'Pripyat-Stokhid' National Nature Park.

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Introduction

Climate change is already having a significant impact on the natural complexes and biota of nature conservation areas in the Polissya region, and over time, according to current climate change scenarios, this impact will only increase (Loboda N., Serbova Z., Bozhok V. (2014)). It is therefore important to investigate the regional manifestations of such changes, analyse long-term trends in climatic characteristics, and assess their potential impact on biota and landscape complexes. For the nature conservation areas of the Volyn Oblast, the authors began studying aspects of contemporary climate change in the works of Fedoniuk V., Zhadko O., Vovk O., Fedoniuk M., Ivantsiv V. (2023) and Fedoniuk V., Ivantsiv Ya., Ivantsiv V., Zhadko O. (2026); the online maps were developed as a result of synthesising and visualising the findings. The authors drew on in-depth studies of the manifestations of climate change within nature conservation areas in both Ukraine and other regions of the world, as presented in the works of Voevoda V., Sovhira S., Darmofal E. (2025), Lybskyi M., Khyzhniak A., Orlenko T. (2024), Ranius T., Widenfalk L. A. et al. (2023), and Duncanson L., Liang M., et al. (2023). An assessment of the current geographical and ecological status of sites within the Nature Reserve Fund (hereinafter 'NRF') of the Volyn region, including sites in the Emerald Network (hereinafter 'EN'), was carried out based on research by Petlin V.M., Fesyuk V.O., Karpyuk Z. K. (2021) and Fesyuk V., Fedonyuk M., Moroz I., Fedonyuk V. (2026).

The aim of this study is to visualise and map the regional manifestations of climate change within the largest nature conservation areas of the Volyn region, based on an analysis of archived climate data for the period 2014–2024.

Method and Theory

The source data for the numerical analysis of the dynamics of climatic indicators, which were visualised on maps, were obtained from the open-access digital archive of the European Meteorological Agency (European Meteorological Agency... (2025)). Climate change in four nature conservation areas in the Volyn region was assessed using data from the meteorological station closest to each: the Manevychi station for the Cheremsky Nature Reserve, the Lubeshiv for the 'Pripyat–Stokhid' National Nature Park (hereinafter referred to as NNP), the Lutsk station for the Kivertsi NNP 'Tsumanska Pushcha', and the Svitiaz station for the Shatsk NNP. The interactive maps were developed using Google Maps (Google Earth). This application was chosen as it is accessible, free, easy to use and equipped with a wide range of practical tools. Familiarisation with the methodologies for developing maps of this type and purpose was carried out using the methodological guidelines from «Sustainable innovative development...» (2021) and Kostyuk V., Petrukha N., Petrukha S. (2026). Standard statistical methods, automated within Excel, were used to calculate and plot the graphs and diagrams of the climatic indicators presented on the maps.

Results

Figure 1 shows the interface of the electronic maps developed and their QR codes. The maps were populated using data from an 11-year analysis. All identified trends in the dynamics of climatic indicators were analysed in detail by Fedoniuk V., Ivantsiv Ya., Ivantsiv V. and Zhadko O. (2026). The main stages of map development included: creating a cartographic base by superimposing the boundaries of the Cheremsky Nature Reserve and the Volyn National Nature Park onto the original landscape map; marking the main landscape features (for example, for the Cheremsky Nature Reserve, these are the Cheremsky Marsh, Lakes Cheremske and Redychi, the nature trail and its main points; for the Shatsk National Nature Park – the park's main lake complexes; for the 'Pripyat–Stohid' National Nature Park – floodplain complexes in the valleys of the Pripyat and Stohid rivers; and for the Kivertsi National Nature Park 'Tsumanska Pushcha' – primeval forests. Two thematic map layers were developed in sequence: 'Dynamics of climatic indicators' and 'Potential impact of climate change on the rare component of biodiversity': a labelling system was selected for the visualisation of diagrams, graphs, tables and their accompanying explanations. The graphical elements were designed to be intuitive for the user (for example, the active markers placed around the perimeter of the nature

reserve are graphical symbols representing the relevant climatic indicators and weather phenomena, and the information they convey: temperature – the 'thermometer' symbol; precipitation – the 'cloud' symbol; and so on). The colour of the labels is also significant: it indicates both the type of indicator (precipitation – blue) and whether we are looking at the average, minimum or maximum value, and so on. The system of symbols is standardised across both maps. The climatic indicators on the maps are presented in tables for each of the 11 years (2014–2024), whilst the averages and trend charts for individual indicators cover a 10-year period (2014–2023). The averaged indicators can be updated every 5 or 10 years. At the same time, it is planned to add a summary table of average annual climate indicators each subsequent year.

Figure 1. *The interface and QR codes for the digital maps «Climate Change in the Cheremsky Nature Reserve» and «Climate Change in the National Nature Parks of the Volyn Region»*

Climate change is already affecting the natural ecosystems and biota of protected areas in the region, and this impact will only increase over time. The potential impact of climate change on biodiversity was assessed by compiling comprehensive assessment tables for each species group (as shown on the maps). It is worth noting that many rare species are found and protected in all four major protected areas in the Volyn region.

There are three main ways in which biological species respond to climate change: migration, adaptation and extinction. Rare species, which are often poor migrants in the wild, may not have enough time to adapt – after all, adaptation is a lengthy evolutionary process, whereas modern climate change is occurring rapidly. Consequently, species that migrate little and are poorly adapted may face the threat of complete extinction. The main potential negative impacts identified include: the loss and degradation of the habitats of rare wetland species due to the encroachment of forest into wetlands; the risk of ecosystem impoverishment due to increasing aridity, which will encourage the spread of drought-tolerant invasive species; deterioration of the key characteristics of species' habitats; adverse phenological changes (for example, with a 2°C rise in average temperature—which is already being observed in the region—plants begin to flower 5–25 days earlier, when the threat of frost persists and pollinating insects are absent); possible changes in the distribution and ranges of species; the rapid spread of invasive species and the displacement of rare native species. A drier climate will contribute

to an increase in the number and likelihood of forest fires in protected areas (Fesyuk V., Fedonyuk M., Moroz I., Fedonyuk V. (2026)). For animals, birds, insects and amphibians, another potential threat is the depletion of their food supply and, as a result, a decline in their populations or migration.

However, climate change may also have a positive impact on biodiversity. The main identified potential positive impacts include: the acceleration of photosynthesis and other physiological processes, including biomass growth, as a result of rising average air temperatures, increased carbon dioxide levels in the atmosphere and increased amounts of photosynthetically active solar radiation; an increase in the duration of the active growing season due to a shift in the dates when temperatures cross the biologically significant thresholds of 0°, 5°, 10° and 15°C; and milder overwintering conditions for animals, birds, insects and amphibians as a result of a reduction in the duration of the frost period, as well as in the depth and duration of snow cover.

Looking ahead, amongst the main potential negative impacts of climate change on protected natural areas, the most serious threats are the potential shallowing and overgrowth of the Cheremskyi Marsh wetland complex, and the shallowing and overgrowth of the lakes in the Shatsk group, should the trend towards a drier climate continue. In that case, most populations of rare species and communities – which are not highly migratory and have poor adaptive capacity – could face degradation and extinction. The main positive effects of climate change include the intensification of photosynthesis and other physiological processes, milder overwintering conditions, a longer growing season, and an increase in the food supply due to intensive biomass growth.

Conclusions

Based on a comprehensive analysis of the dynamics of climatic indicators, two interactive maps have been developed which integrate quantitative characteristics, graphical data and information on the potential impact of climate change on natural complexes and biodiversity within the protected natural areas of the Volyn region. These resources provide a visual representation of the spatial and temporal dynamics of key climate characteristics, simplify the analysis of long-term trends and provide rapid access to up-to-date information on the climate conditions of the studied areas. A key advantage of the maps developed is their interactivity and the possibility of future updates, which will enable the establishment of a long-term system for monitoring climate change in Volyn's nature conservation areas.

The practical significance of this work lies in the possibility of using maps as a tool for providing information to support the management of protected natural areas, assessing the vulnerability of ecosystems, maintaining Nature Chronicles, planning nature conservation measures, developing regional strategies for adaptation to climate change, as well as during environmental monitoring, scientific research and the making of management decisions in the field of environmental protection.

The maps can be used by institutions within the Nature Reserve Fund, state and local government bodies, scientific institutions, higher education establishments and environmental non-governmental organisations. An important area of their practical application is the educational process, environmental education and the dissemination of knowledge about current manifestations of climate change. The proposed approach can be scaled up to other nature conservation areas in Ukraine, and the maps created could form part of a national geoportal on climate change in nature conservation areas, which would contribute to the development of a unified information environment for the collection and analysis of data on the regional impacts of climate change.

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