Climate Change and Land Use Impacts on Ecosystems and Human Well-being in Desnianskyi Biosphere Reserve

Situation Analysis for Ecosystem-based Adaptation

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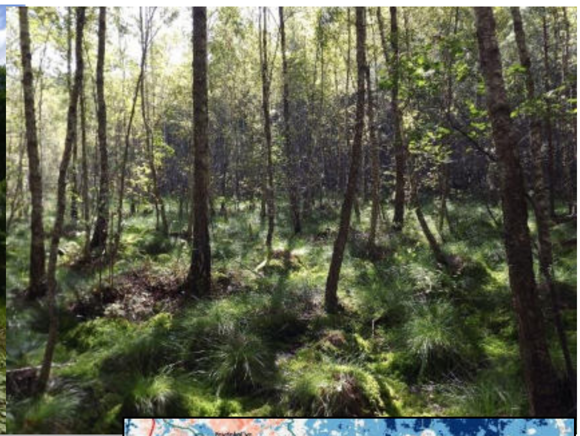

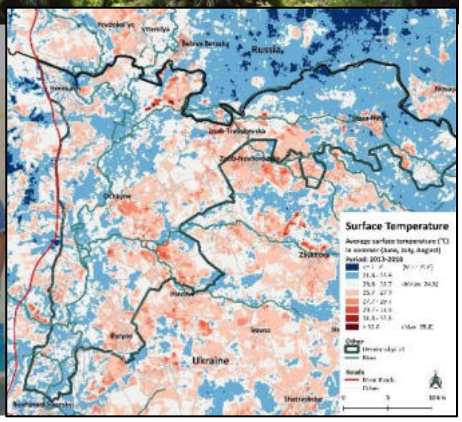

in the frame of the project:

"Ecosystem-based Adaptation to Climate Change and Regional Sustainable Development by Empowerment of Ukrainian Biosphere Reserves"

Implemented by:

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Eberswalde and Greifswald, 2021

International Project:

"Ecosystem-based Adaptation to Climate Change and Regional Sustainable Development by Empowerment of Ukrainian Biosphere Reserves"

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Contents

1 Introduction

This document provides a summary of the situation analysis and the diagnosis. It is the cumulative result of the findings, discussions, and excursions during a. the citizen workshops[1] b. GIS-based analysis and mapping c. MARISCO (adaptive **MA**nagement of vulnerability and **RIS**k at **CO**nservation sites) expert workshops[2] d. EbA training[3] and recent developments since these events.

The aim is to highlight socio-ecological system components, their functions and services, and their vulnerabilities, especially connected to climate change-related impacts and anthropogenic drivers.

The two coupled and integrated ecosystem-based management approaches of Ecosystem-based Adaptation to climate change (EbA) and the MARISCO method and toolbox are powerful tools to:

1. Analyze the situation, vulnerability, and potentials of the respective socio-ecological system on a holistic and systemic level, permitting a better understanding and visualization of cause-effect chains, feedback loops and for the identification of leverage points to facilitate the right choice of strategic entry points.

2. Guarantee participation of the local and regional population, stakeholders, land-users, experts, professionals, and decision-makers, thus striving for a holistic approach (diverse sectors and points of view) and understanding of diverse necessities, limitations, and framework conditions. EbA can be successful and applied in the long run if it is structurally rooted in the regional and local administrations, decision-making, and land users' mental models, awareness, and knowledge systems.

Applying an adaptive management approach to climate change adaptation – please note!

Due to the complexity and variability of ecosystem processes and functions, which is even increased by the interaction with social systems and constructs, the here applied approach to Ecosystem-based Adaptation is adaptive by nature.

The approach is itself a learning process, helping to adapt methodologies and practices according to how the relevant systems are being managed and monitored. The aim is to reach workable preliminary conclusions based on the best available and accessible data (which is mostly not peer-reviewed and site-specific). Based on such conclusions the most fitting strategy and implementation programs can be designed, yet in ways to always allow for adjustment to the unexpected, contrary to making rigid assumptions and taking steps based on the false belief of certainties. Such flexibility is also necessary for policymaking and implementation because long-term inflexible decisions are likely to become outdated, inadequate, or even detrimental for the system.

At both spatial and temporal scales climate change impacts, biodiversity loss, and ecosystem malfunctioning become evident to local stakeholders. Irrespective of scale, it is important that people are considered as part of, rather than actors external to the ecosystem. It is crucial to recognize the diversity of social and cultural factors affecting natural resource use. Thus, the concept of the '*socio-ecological system'* is used throughout the document. It requires considering the specialties and uniqueness of local and traditional knowledge, regional expertise and combining and triangulating these knowledge systems with available scientific studies and research on the local, regional, and wider spatial scales.

Thus, ecosystem management and the here applied approaches, need to be envisioned as a long-term experiment that builds on its results as it progresses, a 'learning-by-doing, a source of information and a shared gaining of knowledge and progress towards mutually agreed goals.

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[1] The *citizen workshops* took place in November 2018 and involved a variety of local participants of different age, gender and background.
[2] The MARISCO expert workshops were conducted in May 2019 in Sumy.
[3] The training on *Ecosystem-based Adaptation to Climate Change* with 28 Ukrainian and German participants took place in December 2019, Eberswalde, Germany.

2 Situation Analysis

One central component of the situation analysis is the MARISCO method. Its output is a comprehensive diagnostic of the area, including ecological stresses diminishing ecosystem functionality and their drivers such as climate change and anthropogenic factors. Both human affectedness and stake in such processes were analyzed and depicted systemically. Besides, a basic portfolio of potential ecosystem-based strategies for adaptation to climate change was developed.

A short introduction to the MARISCO method in frame of the EbA Ukraine project
MARISCO method is an approach and toolbox to adaptive ecosystem-based management. It facilitates the integration of dynamic risk and vulnerability perspectives into the management of conservation projects and sites[4].

To gather existing and new knowledge and to analyze the complex socio-ecological system of Desnianskyi BR, the project team applies this method, a stepwise process to identify and map both essential and strategically relevant elements of the system. The involvement and active participation of diverse groups of stakeholders, local and regional citizens, land users, professionals, and scientists were ensured to make the model and analysis as site-specific and robust as possible. The findings are being substantiated and strengthened excursions, spatial analyses, and desktop research.

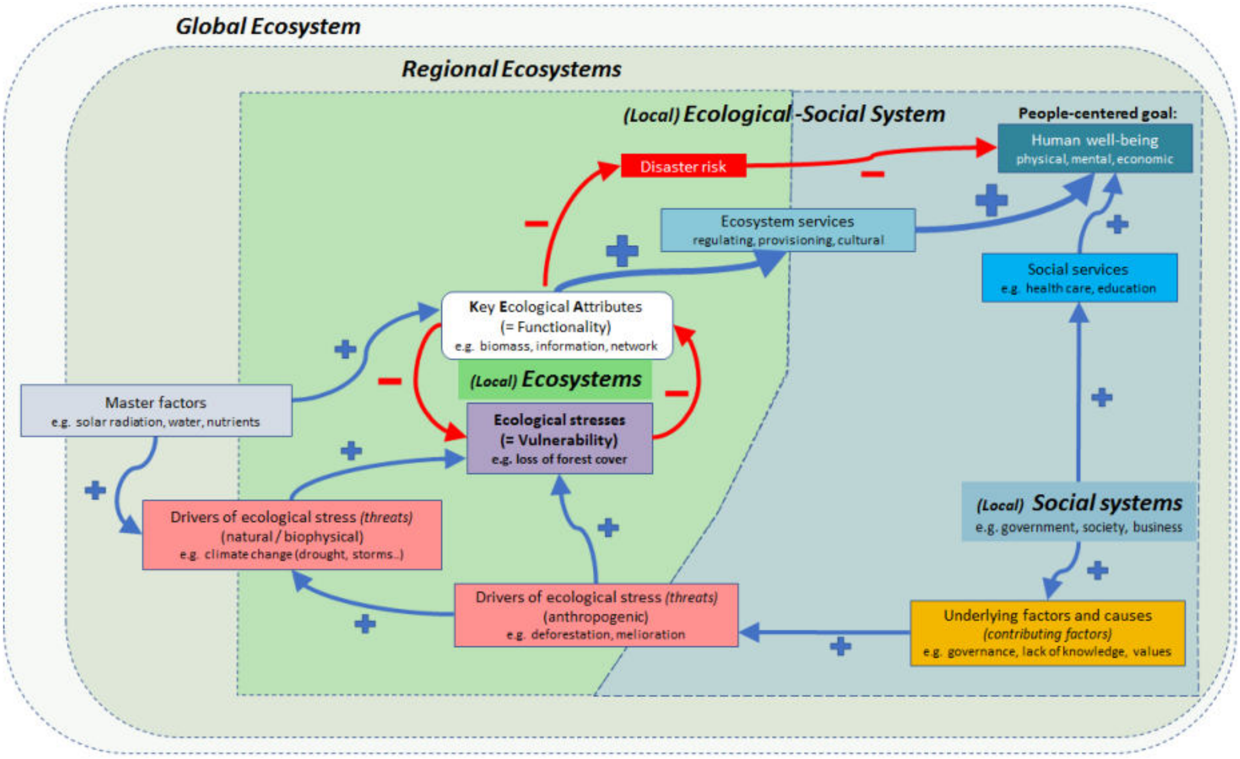

Figure 1 Conceptual model for the MARISCO approach; Illustration by K.Mack

This situation analysis comprises the **ecosystems of the biosphere reserve areas**, their respective **key ecological attributes (KEA),** and the **ecosystem services (ES)** they provide to people. A high functionality (availability of KEAs) of the ecosystems secures the quality and quantity of ecosystem services, thus contributing to **human well-being in the Biosphere Reserve and beyond**. The **ecological stresses** (e.g. loss of forest cover) describe degraded or even destroyed KEAs (biomass, information, and network), thus indicating the increased vulnerability of the ecosystems. The **drivers of such ecological stresses** can both be of natural/biophysical (e.g. climate change) and anthropogenic origin (e.g. deforestation, melioration). Nowadays, such drivers of stress mostly stem from human **underlying factors and causes** (e.g. governance, lack of knowledge, values), which are driven by the government, societal, economic, and other sectors, constituting the **social systems**. The social systems also contribute (or not) to human well-being via the so-called **social services** (e.g. health care, education).

[4] MARISCO (**MA**nagement of vulnerability and **RIS**k at **CO**nservation sites), Source: https://www.marisco.training/

2.1 Ecosystems, their Functions, and Services

Nature is the basis of all life. Ecosystems, i.e., the habitats and organisms inhabiting them, are the natural structures in which the various components interact particularly intensively and perform different services. They consist of complex, dynamically interacting functional units with emergent properties. From a functional point of view, ecosystems are self-organizing bioreactors through the interaction of their living components, in which energy is captured, passed on, converted, stored, and above all, used to perform work.

Thus, ecosystems are complex systems that use energy and perform work in the physical sense. They result from the fact that living organisms interact as system components with each other and with inanimate resources and thereby develop emergent properties, such as temperature regulation. This guarantees or promotes their continued existence.

Main ecosystem classes of the Desnianskyi Biosphere Reserve

The following images show the four general ecosystem classes selected for the Desnianskyi BR.

Forest ecosystems

Water ecosystems

Wetland ecosystems

***Agro- and Settlement ecosystems** (incl. Grasslands)*

Images by - Top left: Desnianskyi BR / Top right: Desnianskyi BR / Bottom left: A. Miskov / Bottom right: J. Kloiber

Ecosystem map with ecotope classes

The existing functional ecosystem classes in the Desnianskyi BR were identified and defined during the MARISCO workshop and in course of the spatial analysis commissioned by the project group.

The map includes data based on landcover classification made within the framework of this project using current sentinel satellite images and manually mapped hydrological and other physiotope conditions, including publicly available data.

The ecosystem map (based on ecotope classes) is **attached to this document series in printed A1 format** and can be accessed online via the project website: https://www.eba-ukraine.net/maps.html

2.1.1 Ecosystem classes and their functions

Results of ecosystems performing work include all physical, chemical, and biological processes and interactions that take place in the various ecosystems. For example, ecosystems produce biomass, filter, and store water, ensure the pollination of plants and thus their survival (also in agriculture), convert and decompose organic and inorganic substances and thus maintain soil fertility. Emergent properties of these systems are for example temperature regulation, which is a precondition for the survival and well-being of many species, including humans. Thus, ecosystems fulfill several important functions and significantly influence many of the life-enabling processes.

Ecosystem functionality

The functionality of an ecosystem describes a certain state of an ecosystem. It is characterized by inherent structures, ecological functions, and dynamics, the so-called **Key Ecological Attributes** that provide an ecosystem with the following conditions:

- The necessary (energetic, material, and hydric) efficiency
- The flexibility to demonstrate the development of resilience without abrupt changes in system properties and geographical distribution, and to respond flexibly to external change.
- The adaptive capacity to adapt to perturbations and shocks (e.g. caused by climate change)

Thus, the decisive criteria include the nativeness or naturalness of the respective ecosystem, the degree of self-regulation, the amount and type of vegetation or plant biomass, the complexity and diversity, and the proportion of the unsealed area.

The following table introduces the semi-quantitative ranking (levels) of (self-) regulating capacity to reduce climate change vulnerability and risk according to the availability of functional ecological structures and processes.

Level of (self-) regulating capacity based on ecosystem functionality		**Definition**
1	Very high	The ecosystem is **in a (near-) natural state, almost undisturbed** such that **all functional ecological structures and (self-) regulating capacity** are **fully available and maximal**. The conditions are highly beneficial for local and regional climate regulation and buffering.
2	High	The ecosystem is in a **largely natural state** and **negligibly impaired** such that many **functional ecological structures and (self-) regulating capacity** are **available to a high degree**. The conditions are beneficial for local and regional climate regulation and buffering.
3	Rather high	The ecosystem is **partly artificial** and **relevantly impaired** such that **some functional ecological structures and (self-) regulating capacity** are available to **a moderate degree**. The conditions are somewhat beneficial for local and regional climate regulation and buffering.
4	Rather low	The ecosystem is **mostly artificial**, **impaired, and disturbed** such that **functional ecological structures and (self-) regulating capacity are limited**. The conditions are marginally beneficial for local and regional climate regulation and buffering.
5	Low	The ecosystem is **highly artificial**, **significantly impaired, and disturbed** such that **functional ecological structures and (self-) regulating capacity are low**. The conditions are not beneficial or even detrimental for local and regional climate regulation and buffering.
6	Very low	The ecosystem is **completely artificial, heavily impaired, and disturbed** such that **functional ecological structures and (self-) regulating capacity are minimal**. The conditions are harmful to local and regional climate regulation and buffering.

The following tables (2.1.1.1-2.1.1.4) describe the ecosystems´ functional classes according to their general site conditions and ranked level of ecological functionality.

2.1.1.1 Forest Ecosystems

Category	Site condition	Description	Approx. Area Size in ha (% of total territory)	Ranked level of functionality (Scale 1: highest – 6: lowest)
Broadleaved and mixed			5713.6 (7.85%)	
	On river terraces (hygric-mesic)		4,879.60 (6.70%)	
	On wavy plains and slopes (mesic)		834.03 (1.15%)	
		Natural and near-natural (Conservation and protected forests) Including: • Some virgin oak forests • Old-growth, near-natural mixed forests (no thinning) • Oak-pine forests • Natural forest on past agricultural land		1
		Artificial (Plantations and intensively exploited) Including: • Birch and oak forests (local hollows) • Other moderately site-specific forests		3
Needle-leaf (coniferous)			18337.4 (25.18%)	
	On river terraces		17,498.08 (24.03%)	
	On wavy plains		839.34 (1.15%)	
		Natural and near-natural (Conservation and protected forests) • Few old, quasi-virgin pine forests		2
		Artificial (Plantations and intensively exploited) • Location-typical pine forests (moderately and intensively exploited)		4

Functionality of forests at Desnianskyi BR

The area encompasses various forest ecosystems that are differently limited in their functional capacity (Map 11-14: Cooling capacity map as an indicator of the level of regulating functionality). Depending on the degree of use and change, the different forest ecosystems show more or less (self-) regulating capacity. In the overall forest area, a share of about 76% is dominated by pure and mixed pine stands. The remaining, significantly smaller share consists of the broad-leaved and mixed broad-leaved forests, such as pure oak or oak-pine, or birch-oak forest.

The near-natural broad-leaved and mixed broad-leaved stands with native main tree species, which also include bog and fen forests, and forests with the main tree species beech, birch, oak, or alder, with and without mixed and secondary tree species, have a very high functional capacity. Anthropogenic influence, i.e. ecosystem stresses directly caused by humans, are comparatively low. Due to the high diversity of species and structures and the high proportion of native broad-leaved trees, these stands have sufficient (self-) regulating capacity that climate change impacts are buffered, and climate change-induced stresses can occur rarely or only in a weak form.

Mixed pine-broad-leaved stands are older stands with common pine as the main tree species and broad-leaved trees such as oak or birch or late blossoming secondary tree species. Due to the mixture of species and age classes as well as the comparatively high proportion of broad-leaved trees, the functional efficiency can be classified as high, although not very high, since these stands were mostly established or actively influenced by humans.

Pure pine stands, mixed pine-needle stands, and other coniferous stands are relatively unnatural forest ecosystems with conifers such as the common pine, the common spruce, or the Douglas fir from North America as main tree species with or without mixed and secondary tree species, whose functional efficiency can be classified as medium to low. Permanent human interventions characterize these ecosystems; self-regulation can hardly take place. Many essential ecosystem structures and processes are missing in these forests, which also makes them vulnerable to climate change impacts in the long term.

Clearcut areas, pioneer forests, and young forests exist due to human activities. These include young afforestations, bare areas, clearings, and patches with overstory on dry sites. Often these areas undergo further maintenance and development interventions such as weeding, planting, and later thinning. However, these highly transformative ecosystems have a high potential to build ecological functioning if allowed to develop in a primarily self-regulated manner in the future. They have intermediate functional capacity.

2.1.1.2 Water Ecosystems

Category	Description	Approx. Area Size in ha (% of total territory)	Ranked level of functionality (Scale 1: highest – 6: lowest)
Running waters and waterbodies			
Rivers	Undisturbed and natural, protected	**Sum of all:** 1,517.53 (2.08 %)	1
	(Near-) natural and modified with transversal and longitudinal shoring, intensely used		2
Small streams	e.g. Desna river tributaries (incl. drying out)		2
Lakes	Natural and undisturbed		1
	Highly frequented, intensively used, and artificial		2
Small water objects	Ponds and puddles (natural) (incl. drying out)		3
Drainage Systems /Channels			6

Functional classes of water ecosystems

In this classification, water bodies include continuously flowing freshwater bodies above ground (such as Desna River) and smaller tributaries as well as still waters (e.g. small lakes, puddles, or ponds). These have grown and developed naturally, but can also be artificially created (e.g. ponds or pools in the settlement area or for agricultural or forestry use). Ponds or pools are not bound to a specific section of the landscape in any characteristic way. Due to their ability to absorb, supply, and evaporate water, they play a significant role in ecosystem-based adaptation to climate change.

Flowing waters include primarily the Desna River and its tributaries, including piped streams and small creeks. While Desna River is for the most part a naturally meandering river with a wide riverbed and floodplain, smaller flowing waters are in part strongly influenced by humans. This includes not only the many changes in river courses caused over centuries and the construction of flowing waters but more recently also measures of renaturation and revitalization. Locally, these effects manifest themselves in part very differently and are often also spatially displaced. Similar to still waters, streams are central to ecosystem-based adaptation to climate change because of their ability to absorb, store, remove, and evaporate water. Their spatial dispersal and connectivity are particularly important to the networking between different ecosystems.

The **hydrography map** (based on ecosystem data) is **attached to this document series in printed A1 format** and can be accessed online via the project website: https://www.eba-ukraine.net/maps.html

2.1.1.3 Wetland Ecosystems

Category	Site condition	with … vegetation	Approx. Area Size in ha (% of total territory)	Ranked level of functionality (Scale 1: highest – 6: lowest)
Wetlands	Including: Swamps, swampy meadows, eutrophic bogs (forest-, shrub-, grassy-…), mesotrophic bogs (sedge-sphagnum), marshy forests (sphagnum)			
	on river floodplains … (hydric-hygric)			
		… with coniferous forest	979.15 (1.34%)	1
		… with broadleaved / mixed forest	3,250.61 (4.46%)	2
		… with grassland/agricultural use	13,912.29 (19.11%)	2

The availability of especially floodplain and forest swamps, bogs, and marshes is relevant in the Desna area. These ecosystems play a significant role as they represent a transitional form between water bodies and terrestrial habitats. The use and alteration of sites where wetlands are present vary greatly, which also has different effects on their functional capacity. Only (semi-)natural swamps, bogs, fens, and marshes have a very high ecological functional capacity. As semi-terrestrial sites, they combine the water storage capacity of water bodies with the ability of terrestrial systems to produce plant biomass that additionally stores and evaporates water. Farmed and degraded wetlands, on the other hand, tend to match their environment in functional capacity. For example, used bog and fen sites by agriculture and livestock grazing have intermediate to low functional capacity. They are often significantly altered and cannot provide the full spectrum of ecological functions and services.

The **hydrography map** (based on ecosystem data) is **attached to this document series in printed A1 format** and can be accessed online via the project website: https://www.eba-ukraine.net/maps.html

2.1.1.4 Agro- and Settlement Ecosystems (incl. Grasslands)

Category	Site condition	Functional classes	Approx. Area Size in ha (% of total territory)	Ranked level of functionality (Scale 1: highest – 6: lowest)
Agricultural land	On river terraces		12,099.58 (16.62%)	
	On wavy plains		2,638.21 (3.62%)	
		Orchards		3
		Treelines		3
		Forest breeding and reproduction centers		4
		Private gardens		4
		Cropland (extensively used)		4
		Cropland (intensively used)		5
Grasslands				
	On river terraces		8,218.93 (11.29%)	
	On wavy plains		1,902.04 (2.61%)	
		Natural and undisturbed		2
		Hayland and meadows		3
		Pastures		4
Settlements			4,248.18 (5.83%)	
		Cemeteries		4
		Parks and green spaces		4
		Allotment gardens		4
		Settlement (housing) areas (Buildings with yards)		5
		Waste polygons		6
		Sewage and waste pits		6
		Technical infrastructure & facilities		6
		Roads		6

2.1.2 Ecosystem services

Ecosystems are not only 'nature' out there, beautiful, and simply given. For us humans they are also the indispensable basis of our well-being and economic activity: they provide food, clean water, living space, and a source of income. They also provide recreation and a sense of home. These ecosystem services are essential for human well-being. In addition to these more obvious provisioning and cultural services we receive from ecosystems, they also regulate water balance and water quality, influence air quality, and local climate, protect against soil loss or degrade pollutants. These regulating services are seemingly inexhaustible and free for everyone to use which is why they are often neglected in economic and development considerations.

According to the *Common Classification of Ecosystem Services* (CICES) developed by Haines-Young & Potschin, these services obtained from ecosystems for human benefits can be ordered into the following three classes:

Regulating Ecosystem Services

In current times of accelerating climate change, regulating ecosystem services are coming to the fore. They are the key services when it comes to adaptation to climate change. These include services that result from the fact that the work of ecosystems positively influences the quality of the environment such as air and water purification, pollination, fertile soils, flood prevention (e.g. through soil- and plant water retention), and climate regulation. Further examples are the storage of greenhouse gas carbon dioxide or biological control of pest infestation.

The regulating services can be understood as fundamental services, themselves guaranteeing a sufficient and qualitative provision of material and cultural services.

Provisioning Ecosystem Services

Provisioning ecosystem services are the goods (biomass and genetic materials) that are produced by ecosystems and used by humans. For example, food (such as fish, fruit, and vegetables), drinking water, timber (e.g. as construction material), and fuel materials (firewood, peat) are provided by ecosystems.

Cultural Ecosystem Services

Cultural ecosystem services are of high relevance, especially in modern, technology-oriented societies. Varied and semi-natural landscapes offer high recreational, educational, and adventure value. The typical features and the condition of ecosystems have a complex effect on the human psyche. In this way, they also create an identity and contribute to people feeling connected to their habitat.

On the following page, a non-exhaustive list of ecosystem services of the Desnianskyi BR is depicted. They were partly identified and discussed by a group of local citizens, experts, and stakeholders.

**Images by: Top: Desnianskyi BR / Middle: J. Kloiber / Bottom: A. Miskov, Desnianskyi BR*

Regulating Ecosystem Services

Regulation of physical, chemical, biological conditions

Regulation of baseline flows and extreme events

- Wind erosion reduction and prevention
- Hydrological cycle and water flow regulation (Including flood control)
  - Regulation of surface water level and runoff
  - Regulation of groundwater level
- Water accumulation and retention (incl. flood protection)*
- Protection from soil erosion*
- Reduction of wind speed; wind protection*
- Fire protection*

Lifecycle maintenance, habitat, and gene pool protection

- Pollination*
- Seed dispersal*
- Maintaining nursery populations and habitats*
- Biotic production

Pest and disease control

- Pest control and reduction of the spread of invasive species*
- Prevention and reduction of diseases*

Regulation of soil quality

- Soil formation*
- Soil purification and fertility*
- Soil moisture regulation*
- Mediation of weathering processes*
- Decomposition and fixing processes*

Regulation of water quality

- Regulation of the chemical and physical quality of freshwater in surface waters (standing and flowing)
  - Water purification
- Regulation of the chemical and physical quality of groundwater

Regulation of air/atmosphere quality and climate regulation

- Microclimate regulation (e.g. cooling)
- Filtration and purification of air
- Air humidity regulation
- Carbon sequestration (reduction of anthropogenic CO2 emissions)
- Oxygen production

Transformation of biochemical or physical inputs

Mediation of wastes or toxic substances of anthropogenic origin

- Bioremediation/cleaning by (micro-) organisms*
- Filtration, accumulation, storage by (micro-) organisms*

Mediation of nuisances of anthropogenic origin

- Smell reduction*
- Noise attenuation*
- Visual screening*

Provisioning Ecosystem Services

Biomass

Nutritional use

- Diversity of food (e.g. fish, mushrooms)
- Non-timber forest products (berries, mushrooms, medical herbs, nuts) for both private and commercial use
- Hunting and fishing resources
- Birch juice
- Organic products
- Honey (beekeeping)
- Agricultural produces (crops/grains/vegetables)
- Meat and dairy products by livestock breeding
- Site-specific plants and animals

Materials

- Building and construction materials (reed, straw etc.)
- Construction wood
- Timber
- Hay
- Fur
- Gardening and horticulture products
- Flowers and plants

Energetic use

- Fuelwood / Firewood
- Biofuels

Fundamental goods

- Fresh and clean air
- Fresh and clean (drinking) water

Genetic material from all types of organisms*

- Seeds, spores, and other plant materials collected for maintaining or establishing a population*
- Individual plants used to breed new strains or varieties*
- Individual genes extracted from plants for the design and construction of new biological entities*
- Animal material collected to maintain or establish a population*
- Wild animals (whole organisms) used to breed new strains or varieties*
- Individual genes extracted from organisms for the design and construction of new biological entities*

Cultural Ecosystem Services

Direct outdoor interactions with living/ecological systems in their natural setting

Physical and intellectual interactions with biota, ecosystems, and landscapes

- Place for living
- (Green) tourism
- Hunting and fishing
- Recreation (e.g. in the forest) and sports (swimming etc.)
- Ecological education and scientific research
  - Possibility to observe ecosystems in virgin states
  - Dendrochronology
- Bird/animal watching
- Source/Place of inspiration
- Nature filming
- Arts (photography/painting)

Spiritual, symbolic, and other interactions with biota, ecosystem, and landscapes

- Aesthetic value*
- Spiritual value*
- Traditional and cultural value*
- Ethnic, traditional crafts

Table 1: Desnianskyi BR Ecosystem Services; Classification based on CICES, Haines-Young & Potschin (2017), contents by workshop participants

*added by the author based on CICES

2.2 Ecosystem Vulnerability, Risks, and Human Affectedness

In the Millennium Ecosystem Assessment, vulnerability is defined as:

> *Exposure to contingencies and stress and the difficulty in coping with them. Three major dimensions of vulnerability are involved: **exposure** to stresses, perturbations, and shocks; the **sensitivity** to the stress or perturbation, including their capacity to anticipate and cope with the stress; and the **resilience** of the exposed ecosystems in terms of their capacity to absorb shocks and perturbations while maintaining function.*[5]

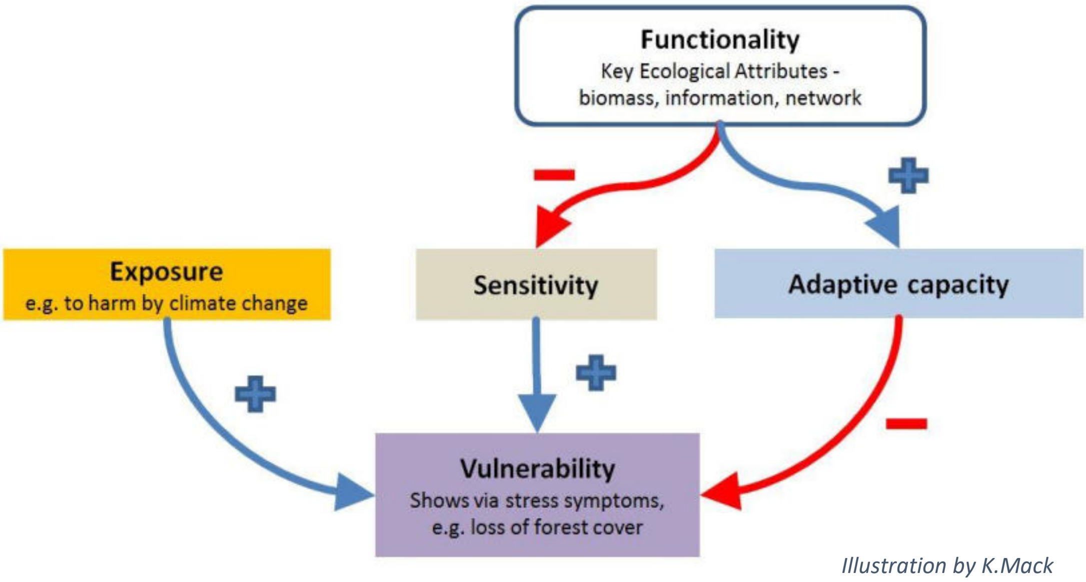

Illustration by K.Mack

Exposure to e.g. climate change causes stress in the ecosystems (e.g. by extreme temperatures or absent precipitation), indicating the increased overall vulnerability.

The **ecological stresses** are the visible symptoms and manifestations of the degradation of key ecological attributes. They indicate how stressed, i.e. vulnerable an ecosystem is. This includes the loss of minimum levels of biomass (e.g. trees, mosses, flowers, fungi, dead matter, etc.), information (gene pool, nutrient uptake, nutrient provision, etc.), and network (e.g. mycorrhizal symbiosis, nutrient exchange, etc.) due to insufficient availability or quality of master factors (e.g. energy input, moisture, temperature, nutrients, etc.)

The result is that, under certain conditions, the ecological attributes begin to degrade, which then impacts the resilience, adaptive capacity, and efficiency of biodiversity elements, such as species or ecosystems. If stress (or a mix of stresses) is sustained, shifts or changes in the ecosystem occur. Ecological stresses are **caused by the "drivers of ecological stress"** (as explained in chapter 2).[6]

The drivers of the ecological stress (also *threats*) can be natural events, for example, droughts and tornados, as well as anthropogenic activities such as deforestation or draining of landscapes. These threats damage and degrade the Key Ecological Attributes, i.e. decrease functionality, and increase vulnerability. The underlying factors and causes (also *contributing factors*) originate both from direct and indirect natural/biophysical processes as well as from anthropogenic origins.

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[5] Adapted from Millennium Ecosystem Assessment (2005), p. 605

[6] Ibisch P. L. and Hobson P. R. (eds.), *MARISCO: Adaptive MAnagement of vulnerability and RISk at COnservation sites: A guidebook for risk-robust, adaptive and ecosystem-based conservation of biodiversity* (Eberswalde: Centre for Econics and Ecosystem Management, 2014).

2.2.1 Exposure to climate change in Desnianskyi Biosphere Reserve

The Desnianskyi Biosphere Reserve represents the far north-eastern part of the Polissia ecoregion, which is also called Novgorod-Siverske Polissia in terms of climatic and other environmental conditions. Since it lies at the frontier of mixed forest and forest-steppe zones and contains the Desna River valley within its boundaries, microclimate settings tend to have substantial spatial variations. It is characterized by a warm and humid summer, a winter with snow cover, and no significant difference in precipitation between seasons.

There are no facilities for the regular collection of climatological data within the biosphere reserve. The closest weather station that provides information on climate conditions of the area is situated in Druzhba town (Sumy oblast), which is about 25 km southeast of the Desnianskyi BR.

Changes in air temperature

During the climatic normal period between 1961 and 1990 (standard reference) the average annual air temperature was about 5.8 °C. It reached a maximum of 7.8 °C in 1975 and 1989. In the last 28 years (1991-2018) the mean annual temperature increased to 6.9 °C, i.e. by 1.1 °C. It has been particularly high since 2007 with a peak of 8.1 °C in 2015. The mean monthly temperature of the coldest and hottest months (i.e. January and July) in the periods of 1961-1990 and 1991-2018 were -8.2 vs -5.4 °C and 17.5 vs 19.7 °C respectively.

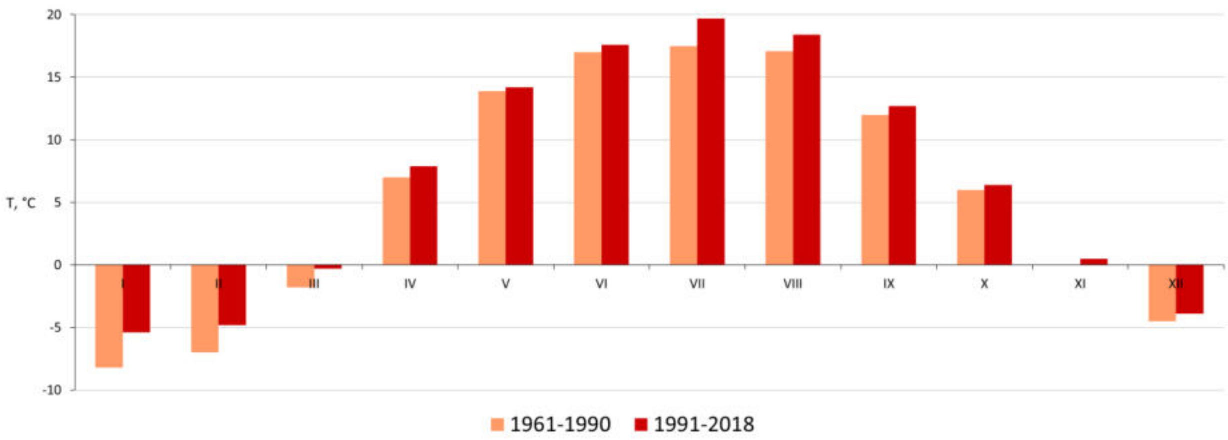


Figure 2 Monthly average temperatures for periods 1961-1990 and 1991-2018; Graph by A. Smaliychuk

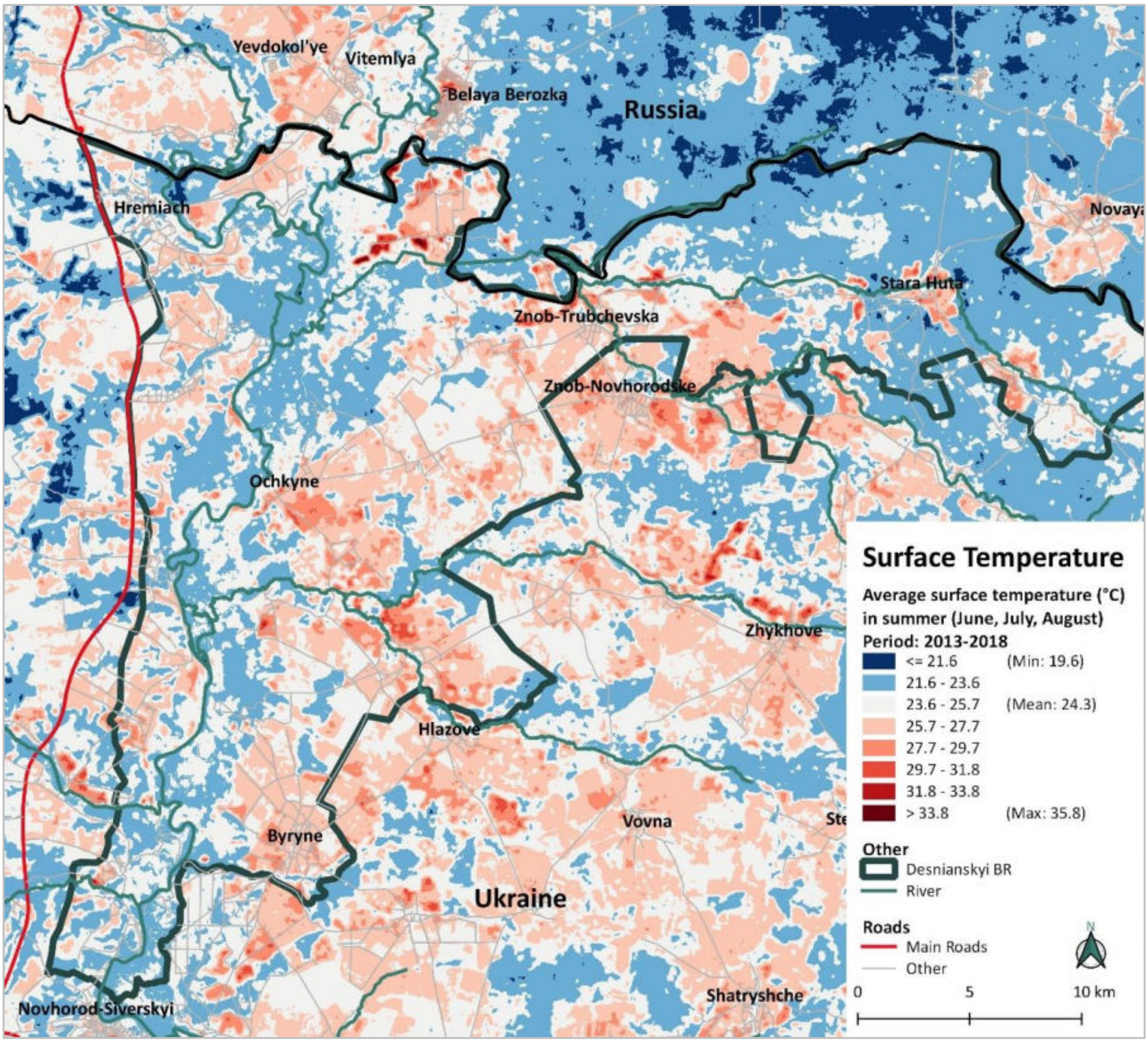
The highest increase in mean monthly temperatures in comparison to the climatic normal was observed for the winter and summer periods along with March (Figure 3). Moreover, this trend has accelerated in the recent five years (2014-2018) when the highest temperature rise was calculated as more than 3 °C for February and March. It was particularly hot in July of 2014, 2016, and 2018, when the average air temperature exceeded 20 °C, which corresponds to the past long-term average of Central Ukraine (e.g., Dnipro city). In 2017 and 2018 the summer days (maximum daily temperature exceeds 25 °C) were observed as earliest as in April, which is additional evidence of the recent climate change in the region.

Also, the local population and land users observe and confirm a significant increase in average daily temperature, especially in the winter and summer months. Additionally, the longer duration of heat and drought periods is highlighted among the participants of the expert workshops.

Projections for the future

According to the most probable climate development scenario for the Desnianskyi region (A1B scenario of IPCC), the mean annual temperature is expected to increase by 2.5 °C by the end of the 21st century in comparison to 2000-2010 average. It also indicates an increasing variability of the amount of precipitation, which might be challenging for the development of sustainable and adapted agriculture and forestry in the region.

Satellite-based remote sensing data for the reflection of heat radiation now makes it possible to assess surface temperatures on a global, regional, and local scale. The surface temperature map (cf. figure 4) shows average surface temperature (°C) patterns in the summer months (June, July, August; day-time) at Desnianskyi BR and adjacent regions. They were recorded by the Landsat 8 satellite every two weeks from 2013 till 2018 with a spatial resolution of 30 m. Compared with the ecosystem map on page 6, it appears that settlement and arable land show the warmest (red) areas and the large areas of forest, wetlands, and water bodies the coolest areas (light and dark blue) of the region.



Map 1 Surface temperature map, Sources: Landsat 8 OLI & TIRS: US Geological Survey, Roads & settlements: OSM 2019; Data processing and analysis by S. Kriewald (PIK); Map by A. Dichte

Hence, the map also allows interpretations about the work capacity of different ecosystem types, their functional state, and regulating capacity to handle increased incoming energy (solar radiation), buffer and transform it, and thereby cool themselves and surrounding areas. This (micro-) climate regulating capacity of the different ecosystem types refers to chapter 2.1.1 and is partly included in the rankings of ecosystem functionality.

[7]Rising temperatures are one of the most dangerous consequences of climate change, threatening socio-economic systems (Chen et al. 2020), ecosystem functions (Fisher et al. 2017), and human health (Vicedo-Cabrera et al. 2021, Luber & McGeehin 2008; Mora et al. 2017). These findings increase the importance of regulating ecosystem services, such as mitigating local temperatures and temperature peaks. While the positive influence of forests and wetlands or water bodies on (micro)climate is widely known and acknowledged (e.g. Blumröder et al. 2021, Alkama and Cescatti 2016, Bonan, 2008, Bright et al. 2017, Frenne et al. 2019; Zellweger et al., 2019), their concrete contribution to regional landscape cooling has not been accurately assessed so far. For a study in north-eastern Germany, a satellite-based method was developed to quantify the effect of different land use types on surface temperatures in the landscape (Gohr et al. 2021).

An area of about 11,000 km2 in the northeast German lowlands was chosen for the analyses. The area encompasses a land use gradient that includes the metropolis of Berlin in the south and the Mecklenburg Lake District in the north, thus covering various forest ecosystems of different sizes, water bodies, but also agricultural areas as well as other urban areas in more rural regions.

When considering the hottest days (days with daily maximum temperature ≥ 30 °C in the study period, for the years 2002-2020), temperatures in forests were on average almost 4 °C below temperatures in urban areas and on average about 3 °C below temperatures in agricultural areas. Modeling a theoretical conversion of 10% of the agricultural land in the study area into 'average forest' showed that the average temperature on heat days would be reduced by 0.9 °C.

Furthermore, a clear correlation between the vitality of the vegetation and the cooling effect could be established. The more vital a forest ecosystem is, the more pronounced its cooling capacity, with effective cooling, in turn, helping to mitigate heat stress under extreme summer temperatures, which can thus have a positive effect on vegetation vitality. Thus, climate change effects can be counteracted at the local level. Risks associated with them are reduced.

The study of Gohr et al. (2021) shows that landscape temperature depends on the composition of land use types. The cooling function of forests and water bodies in the landscape on hot days can be explained by their ecohydrological functions, which support the uptake, processing, and storage of water in ecosystems (Ellison et al. 2017). Evaporation, transpiration, and shade (in forests) ensure local cooling during the day (Ellison et al. 2017, Maes et al. 2011, Shen et al. 2020). However, reduced soil moisture due to heat extremes can impair temperature regulation functions (Teuling et al. 2010). In summary, the temperature regulation of forests and water bodies in the landscape depends on different local and regional factors such as evaporation, albedo, and energy conversion, as well as on supra-regional functions such as land use type composition and clouds (Wu et al. 2021, Shen et al. 2020, Bright et al. 2017, Zeng et al. 2017, Bonan 2008, Benayas et al. 2008, Zaitchik et al. 2006, Schneider & Kay, 1994). The thermal effects of forests and water bodies can be understood as a potential for ecosystem-based adaptation to climate change-induced heat stress (e.g. Kupika et al. 2019, Nanfuka et al. 2020). The relevant ecosystem functions need to be integrated into landscape management target systems. Targets and incentives should be created to support these functions (Lusiana et al. 2017). The quantification of landscape cooling with satellite-based surface temperature data can be readily adopted for analyses in temperate landscapes.

For the description of the used datasets and method, please refer to the Toolbox document in frame of this publication series.

[7] The following paragraphs have been extracted and translated from the document: *Pierre L. Ibisch, Charlotte Gohr, Deepika Mann & Jeanette S. Blumröder (2021). Der Wald in Deutschland auf dem Weg in die Heißzeit. Vitalität, Schädigung und Erwärmung in den Extremsommern 2018-2020. Centre for Econics and Ecosystem Management an der Hochschule für nachhaltige Entwicklung Eberswalde für Greenpeace. Eberswalde* (in German language).

Changes in precipitation quantity and patterns

The average annual amount of precipitation in the region of the biosphere reserve compared to the reference period and the last three decades remained almost the same – 634 and 632 mm. However, in three out of five years between 2014 and 2018, there was less than 500 mm of precipitation. Most precipitation still falls during the summer season, but there are some changes in volume throughout the year. Between 1991 and 2018, a substantial decrease in the amount of rainwater was recorded for June and August 14 and 13 mm respectively, compared to the climatic normal. The only month which showed a considerable increase in precipitation was October with 17 mm of surplus.

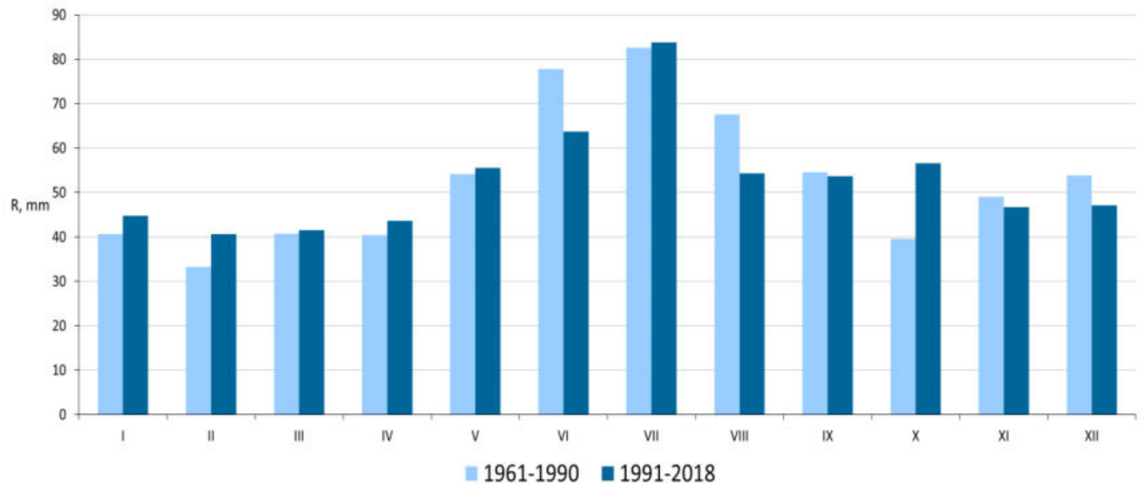


Figure 3 Monthly average sum of precipitation during the periods 1961-1990 and 1991-2018, Graph by A. Smaliychuk

During the last five years, the average duration of a dry period was 12 days per month, with the longest being between August and November (16-17 days). The highest one-day precipitation usually falls from May to July with an average of 20-30 mm over 24 hours. Its absolute maximum was recorded in July 2018 with 56 mm/day, which was 60 % of the entire rainwater that month. The period between May and July is also characterized by the most frequent heavy and extremely heavy rains. Due to the air temperature developments, particularly in the winter season, in recent years more and more precipitation rather occurred as snow, which has impacted the flooding regime in spring.

Experts among the biosphere reserve staff, the local population, land users, especially farmers and foresters confirm the above-observed developments from the station located outside the BR territory. They noticed changes in precipitation intensity, distribution, and location, highlighting that:

- The distribution of precipitation in summer is quite uneven in time and location. In most cases, the amount of precipitation over larger areas was low while small areas experienced high amounts.
- The total amount of precipitation for most months has not changed much, yet June and August are getting increasingly dryer.
- Dryer periods without precipitation occur in spring, summer, and autumn.
- Rainfall periods are shorter and more intense.
  - In the past, the amount of precipitation that fell in two weeks now pours down in a day or two.
  - These short-term heavy, torrential rains lead to flooding, crop damage, erosion, and contribute to processes of waterlogging.

Thus, the climatic conditions of the Desnianskyi Biosphere Reserve are developing towards the conditions of the arid steppe zone

Changes of seasons

In Desnianskyi BR, the following changes in seasons have been observed:

- Changes in the timing of meteorological spring and winter
- For several years in a row, the winter has become milder and shorter by a few weeks, frequently without frost and a stable snow layer.
- Warmer and dryer summers and autumns for several years in a row.
- Anomalies in phenomena such as the repeated blossoming of flowers, individual trees, and bushes are occurring more frequently.

2.2.2 Climate change-related impacts, disasters, and human risks

The above described altered temperatures and drought periods, precipitation patterns, and seasonal shifts cause high levels of stress for the ecosystems and make the need for adaptation palpable. For humans, being embedded and forming an active part of these systems, this need for adaptation to climate change becomes drastically visible through the related natural disasters posing direct and indirect risks to human well-being.

The **human well-being in Desnianskyi BR** can be defined by a multi-dimensional interrelation of:

- Physical well-being factors such as physical health, sufficient and good nutrition as well as safety from environmental and human harm.
- Mental well-being factors such as mental health, personal fulfillment, sense of belonging, freedom of choice and action, knowledge, spirituality, and social relations.
- Economic well-being, including secured income, and material livelihood.

In the face of climate change, these aspects are threatened, as essential regulating functions and ecosystem services are at stake and might be insufficiently supplied by ecosystems.

Anthropogenically driven harm and destruction of ecosystems are further strengthening these effects. This includes examples as forest clear-cutting, inadequate land management, pressure from uncontrolled recreation, and low ecological awareness of the local population.

Several climate change-related risks affecting the ecosystems´ and human well-being both directly and indirectly have been identified as relevant for Desnianskyi BR:

Changes in the hydrological regime

Increasing average temperatures and longer drought periods drive higher levels of physical evaporation from waterbodies and transpiration leading to a decrease in soil moisture. Combined with changing precipitation patterns, unsustainable water use by the agricultural sector, and local population causing, inter alia, higher surface water runoff affect the water balance and hydrological regime. At Desnianskyi BR, the following developments are observed:

- Shallowing and drying of Desna River tributaries: As a result, parts of the riverbed transformed into a swamp, which is subsequently transforming into meadows.
- Desna River shallowing
- Lake and pond shallowing
- Drying of forests
- Drying and overgrowing of swamps and other wetlands
- Water level decrease causes drying of meadows, trees, and shrubs

Shallowed River Bobrik; Image by Desnianskyi BR

A decrease in groundwater level and subsequent shallowing of wells and reduced drinking water quality complicates and worsens the qualitative and quantitative water supply of local inhabitants. Especially in the countryside they mostly rely on a non-centralized water supply, which makes these risks more imminent. This will have an effect on the health and well-being of the local population as well as on ecological sustainability and the biological productivity of natural ecosystems.

As the average temperature in winter increases, a lack of sustainable snow cover in winter is noticed, impacting the hydrological balance and thus flora and fauna. For example, it has led to a breach of the flood regime, causing a disruption of fish-spawning and greatly affecting the species composition and number.

Increasing number and risk of meadow-, peat bog-, and forest fires

Due to the increasingly dry conditions, groundwater decrease, and periodical absence of precipitation, especially in spring, there is an increased risk and occurrence of forest-, peat bog- and swamp-, and meadow fires.

Monoculture plantation after forest fire; Image by Desnianskyi BR

Changes in flora and fauna

Higher temperatures, changing hydrological conditions, and anthropogenic drivers of ecological stresses (such as clear-cutting of forests, ecosystem fragmentation, land conversion, and pollution) cause changes in wildlife and plant populations and habitats. They also enable the appearance of alien species while the living conditions of native species of plants and animals are deteriorating.

Pests, diseases, and insect calamities

The increasing temperature-, heat-, and drought stress besides other relevant anthropogenic drivers enable and accelerate the occurrence and spread of (new kinds of) pests including diseases, insect calamities, weeds, and abiotic factors. This is observed mostly in forest and agricultural ecosystems.

There is an increasing population of insects that destroy trees, starting from the treetop. This is mostly observed in large arid arrays. Monoculture pine forests are very vulnerable, such that the bark beetle has now become uncontrollable and aggressive in these stands.

However, here a **fundamental rethink is necessary**. From an ecosystem perspective, bark beetle infestations also support the “restoration” of a damaged system. The beetle, disease, or plague is a symptom that indicates the level of stress, for example, that a monoculture forest is not healthy and functional. Such a structurally weakened forest is not able to fight the “disease” by its defense mechanisms. To protect the forest from so-called “bark beetle infestations” would necessitate a natural decay and regrowth cycle with as little human influence as possible.

Extreme and hazardous weather events

In the Desnianskyi BR, climate change also drives a sharp increase in the number of dangerous weather phenomena, such as:

- **Heat:** The number and duration of hot days (>30°C) has increased. Heat stress occurs in the summer months with for the region abnormal heat in which the temperature rises to 32 degrees, and sometimes to 38-40 degrees. Consequences of increasing heat and heat stress are for example raised levels of mortality of flora and fauna and soil degradation processes. The extinction of certain species may occur at an accelerated pace. Heat also drives elevated evaporation rates leading to faster drying of water bodies and wetlands.

- **Frequent droughts** provoking an increase in the number of forest-, peat bog- and meadow fires, leading to the destruction of regional and local ecosystems and endangering the local population.
- **Heavy, short torrential rainfall** with precipitation amounts that sometimes equal the average monthly precipitation. This causes flooding, crop loss, and damage to infrastructure and buildings.
- **Strong winds and storms** causing:
    - Windbreak and windthrow in forests
    - Damage to human infrastructure and buildings
    - Erosion of topsoil and thus deterioration of fertile lands
- **Hailstorms** of abnormal intensity for the region
- **Sandstorms** in spring, summer, and autumn
- **Floods in spring**
- **Frosts and icing** occur in spring (still in May) causing damage to blossoming gardens, flourishing warm-season vegetation, tree branches, and crops.

All the described climate-change-related contingencies and risks have a significant influence on the diverse ecosystems and the whole network within the Desnianskyi BR. Thus, humans are directly and unsparingly affected by these developments, physically, mentally, and economically.

Affectedness of economic well-being

Diverse economic sectors relevant to the Desnianskyi BR region, such as forestry, agriculture, fishery, and tourism are facing increasing challenges due to climate change impacts.

Agricultural sector

The Biosphere Reserve and surrounding regions are sparsely populated and no industrial centers are nearby. In the past, there was some glass and carbonization industry, which was mainly based on the available forest resources of the region. Thus, the sectors of forestry and agriculture are the most developed in the area. Today, there is an intensive development of agriculture by large corporations within the BR territory.

Substantial changes in climate and increasing occurrence of extreme weather events cause:

- Early warming, activating the vegetation of plants which is then again negatively affected by spring frosts (especially in May).
- Increasing average monthly temperatures, warmer summers and winters, dry springs and winters (frostless, with little or no snowfall), and changing precipitation patterns cause a reduction of humidity and groundwater level and a decrease of air humidity. This all results in deficit water for agriculture and impacts the agricultural sector significantly.
- Because of low soil moisture and dry, strong winds, the erosion of fertile lands is occurring.
- The beginning of spring fieldwork is significantly shifting, impacting all agricultural works and production.
- Heavy, short-term rains with large amounts of water are causing flooding and waterlogging and lead to processes of washing out of the topsoil.
- Hail causes direct damage to crops, farming infrastructure, and puts farmers themselves in danger.
- Nowadays, the climatic conditions of the Desnianskyi Biosphere Reserve are ever more developing into the conditions of the arid steppe zone.
- Decrease of fertile land for agriculture and livestock breeding drives losses of jobs and income for farmers and local households.

This non-exhaustive overview of climate change impacts provides examples of why there is a general decrease in agricultural productivity, both ongoing and to be expected in the coming years.

The farmers located within the territory of the biosphere reserve primarily face the challenges to retain water in the soil, preventing erosion by strong winds, flooding, and waterlogging. It requires different farming practice approaches such as crop rotation, avoidance of soil compacting, and use of intermediate crops and green manure to preserve soil fertility and increase humus content. This is possible if the topsoil layer is not overheating or eroded by intense precipitation of the surface fertile layer.

Forestry sector

A large area of the Desnianskyi Biosphere Reserve features forest plantations, which do not correspond to the composition and age structure of natural forests. In the past, intensive agriculture was carried out on the sites of felled broad-leaved forests driving a decrease in soil fertility. The forest plantations which grow on these formerly arable lands, due to low humus content, have reduced biological stability and are more vulnerable and susceptible to pests, diseases, and storms.

Under such conditions, artificial even-aged, pure stands (forest plantations), the area of which in the Starogutskiy forest according to forest taxation in 2009 was 4957 hectares, are the most vulnerable to stress.

Thus, these anthropogenically altered forests, plantations, and transformed lands increasingly suffer from climate change. It is disrupting the links between the components of forest ecosystems. Forest phytocoenosis is depending on the structure, composition, and shape structure and thus is impacted and reacts differently to critical climatic and anthropogenic factors.

Changes in weather and climatic conditions lead to deterioration of growth conditions, reduction of biological stability of stands, weakening, and death of individual trees and whole stands. For example:

- Excessive drought periods stress forests and lead to the death of artificial spruce and pine stands.
- Changes in precipitation amount and patterns, as well as groundwater level decrease, are altering the hydrodynamic regime and water balance of rivers relevant for the tree stands in the river basin and on terraces.
- Hundreds of hectares of forest have been damaged and destroyed by storms in the Desnyanskiy BR in recent years.
- Forest fires have devastated forest stands within the BR area and the fire risk is increasing.

Windthrow after storm in forest plantation; Image by Desnianskyi BR

- The forests´ resistance to pests and diseases has decreased, and the frequency and the area of fires (especially in the coniferous stands) have increased
  - After the dry years of 2010-2011, mass reproduction of the bark beetle (Ips typographus) and drying of the European spruce monoculture took place in the Desnianskyi BR. In 2017, the drying of pine stands began, and primarily weakened monocultures were damaged by the engraver beetle (Ips acuminatus).
- A general decrease in biodiversity is the result of such developments.
  - The number of plant species is decreasing
  - Changes in forest fauna composition are occurring
- Soil degradation and changes in the species composition of soil flora and fauna
- Flooding and waterlogging cause damages to vulnerable stands

The Biosphere Reserve staff observes that in (near-) natural plantations, most consistent with the native forests, outbreaks of pests and diseases occur much less.

Fishery sector

For the Desnianskyi BR, the fishery is a relevant sector, as the local population makes both private and commercial use of this ecosystem service. Additionally, the touristic attractiveness of the region is driven by sport fishing at Desna River and its tributaries.

However, the Desna River and its tributaries are shallowing due to the warmer and changed hydrological conditions. Rising water temperatures, missing precipitation, changes in the hydrological regime, and groundwater level decrease are just a few examples of how the fishery sector is and will be negatively affected by climate change and its manifold direct and indirect consequences.

Tourism sector

The value of the Desnianskyi Biosphere Reserve in touristic terms is its natural richness and beauty. Undisturbed and functional ecosystems are providing the basis for the manifold cultural and provisioning ecosystem services which mostly attract tourists, also from more remote areas.

Especially the Desna River, floodplain, and terraces are of inestimable value for recreation, sports, and nature-based tourism. Furthermore, the vast forests and meadows provide other scenic highlights and produce the local goods and services tourists cherish.

The above-described climate change-related challenges Desna BR and its ecosystems face are endangering the provision of these services, and thus will negatively affect the tourist attractiveness of the region in the years to come.

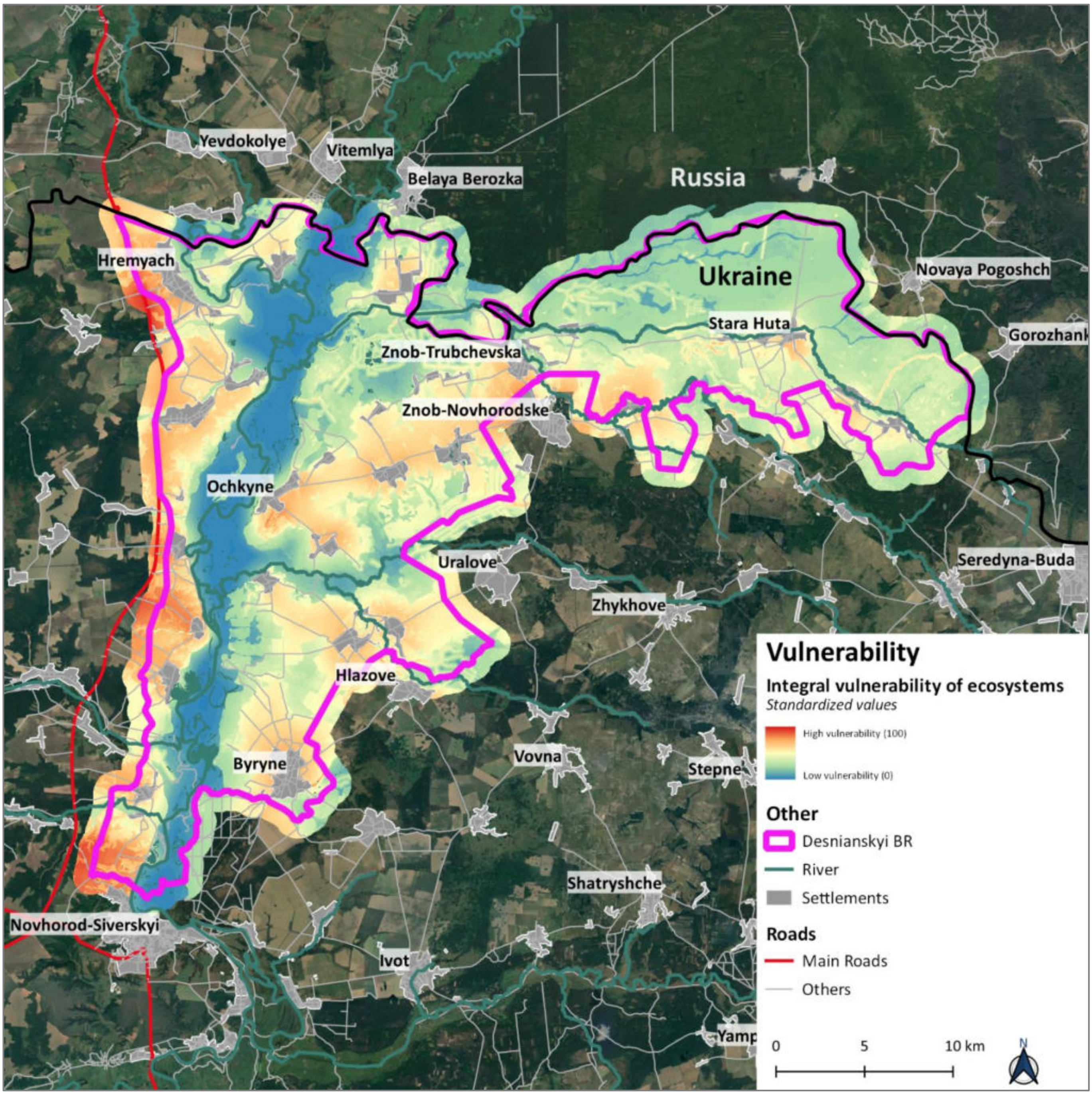
2.2.3 Vulnerability

The following sections present the ecological stresses, their drivers, underlying factors, and causes that were identified during the MARISCO stakeholder and expert workshops.

Map 2 depicts the vulnerability of ecosystems based on the following stress indicators:

Forest ecosystems a. Management intensity (expressed in structural and species composition) – coniferous/broad-leaved, freshly logged, recently gained + forest change data b. Logging intensity or forest loss intensity (% of the logged area) – expressed in a generalized 1 km grid c. Fragmentation by roads and other transport infrastructure, differentiated by impact, expressed in a buffer size d. Patch metric indicators (size, connectivity, edge density, neighbor analysis (e.g., forest-field, forest-wetland) e. Soil parameters (water retention capacity, etc.) – taken from ecosystem map as a site moisture index f. Artificial drainage – continuous buffers along artificial canals g. Human population density – as a chance of human impact on the forest (related to the settlement population and distance)	**Wetland ecosystems** a. Artificial drainage b. Peat extraction sites c. Human population density d. Fragmentation by roads and other transport infrastructure e. Patch metric indicators (size, connectivity, edge density, neighbor analysis) **Lake ecosystems** a. Buffer around the shoreline to analyze its structure and impact on the lake (incl. patch metrics) b. Population density c. Size (area, form) d. Depth (bathymetry)	**Grassland ecosystems** a. Patch metric indicators (size, connectivity, edge density, neighbor analysis e.g., wetland-field, forest-wetland) b. Population density c. Fragmentation by roads d. Soil parameters (water retention capacity, etc) e. Artificial drainage **Arable/Cropland ecosystems** (same criteria as grassland) a. Size can indicate management mode (e.g., machinery, chemicals)

The outcomes of this analysis were used to make evaluations for separate ecosystem types. Then they were harmonized and weighted with the evaluation results. Only afterward, the neighborhood analysis was applied. For a detailed method description, please consult the Toolbox document, chapter *Spatial Analysis and Mapping – Part I*.



Map 2 Map of ecosystem vulnerability in the region of the Desnianskyi Biosphere Reserve (area of the BR + 1 km buffer)
Sources: Data processing and analysis by I. Kruhlov;
Base map: Google Satellite 2016;
Roads, settlements, water bodies: OSM 2020; Produced by A. Dichte

2.2.3.1 Relevant ecological stresses in Desnianskyi BR

The rating scale is from 1 (dark green) – low strategic relevance to 4 (red) – high strategic relevance.

Sphere	Ecological stress	Ecosystem affected (direct)				
		Forest	Waterbody	Wetland	Agricultural and Settlements (+ Grasslands)	Strategic relevance (based on criticality ratings)
Energy input	Changed solar radiation intensity*	X	X	X	X	?[8]
Atmospheric	Changed CO_2 balance	X		X	X	2
	Changed precipitation patterns	X	X	X	X	?
	Changed (micro-)climatic conditions*	X	X	X	X	?
Hydrosphere	Drying of rivers/disappearance of small rivers and ponds	X	X	X	X	4
	Drying of wells				X	4
	Surface water pollution	X	X	X	X	4
	Groundwater pollution	X	X	X	X	4
	Changed flood regime pattern (shorter intervals, higher water level)	X	X	X	X	3
	Decrease in water level	X	X	X	X	3
	Low water level of Desna River	X	X	X	X	3
	Decrease of river/floodplain area	X	X	X	X	3
	Reduced groundwater level	X	X	X	X	2
	Drying swamps	X	X	X		2
	Mineralization of peat bogs		X	X		2
	Increased water temperature		X			1
	Silting		X			1
	Unstable snow layer	X	X	X	X	?
Lithosphere	Increasing area with low productive and degraded soils	X		X	X	4
	Soil compaction	X		X	X	4
	Eroded soils			X	X	3
	Changed water retention capacity of soils (due to humus loss)	X		X	X	?
	Salination		X			?
Matter cycles	…					?

[8] The boxes marked with a '**?**' are issues which were not completed, rated, and prioritized by the participants during the situation analysis workshops.
Elements marked with '*****' added by author based on indication outside of MARISCO expert workshop

Sphere	Ecological stress	Ecosystem affected (direct) Forest	Waterbody	Wetland	Agricultural and Settlements (+ Grasslands)	Strategic relevance (based on criticality ratings)
Biomass	Decrease in yield	X			X	4
	Decrease in growth	X			X	4
	Reduced extent of natural ecosystems	X	X	X		?
	Loss of forest cover*	X				?
Information	Disappearance of species (flora/fauna)	X	X	X	X	2
	Disappearance of certain types of flora and fauna	X	X	X	X	2
Network	Changed species composition (e.g. new insects like spiders)	X			X	3
	Overgrowing of meadows with trees			X	X	3
	(Overgrowing) spreading of trees and shrubs			X	X	3
	Aggression of new insects to local tree species	X				3
	Changed number of migrating birds	X	X	X	X	2
	Succession in wetlands (trees growing)			X		2
	Spread of macrophytes on lake surfaces / artificial lakes		X			2
	Biotopes changing after wildfires	X		X	X	2
	Algae blooming		X	X		1
	Changed trophic chain	X	X	X	X	1
	Suppression of native species	X	X	X	X	1
	Damage of tree structure	X				1
	Changed vegetation composition	X		X	X	?
	Weed spreading	X		X	X	?
	Internal fragmentation of stands*	X				?
	Canopy gaps*	X				?
	Edge effects*	X	X	X	X	?
	Dissection of mushroom and root plants*	X		X	X	?

Sphere	Ecological stress	Ecosystem affected (direct) Forest	Waterbody	Wetland	Agricultural and Settlements (+ Grasslands)	Strategic relevance (based on criticality ratings)
Species-specific factors	Drying of trees	X				3
	Harm from insects	X			X	3
	Drying of plant (vegetation) layer			X	X	2
	Tree weakness	X				1
	Drying of trees in riparian forest	X		X		1
	Windthrow	X			X	1
	Increased fish mortality		X			1
	Massive bee mortality	X			X	?
	Snow and ice - tree collapse	X				?
Energy, matter, and water efficiency	Increased frequency of fires (wildfires)			X		3
	Increased evapotranspiration of landscape	X	X	X	X	?
Resilience and resistance	Impaired forest recovery in monocultures*	X				1

Ecological stresses of forests

Especially in the northeastern part, Desnianskyi Biosphere Reserve has a relatively large, predominantly contiguous forest area, with minor fragmentation. In the western and south-western parts, forests are highly fragmented mainly due to cropland and settlements. On the left bank of the Desna river, a relatively narrow forest strip is present. In addition, broad-leaved and mixed broad-leaved forests occupy only small and fragmented areas, which thus show increasing edge effects.

The mosaic of different types of use (including settlement areas, traffic routes, energy lines) causes fragmentation and islanding of forest areas that would naturally be contiguous. Resulting forest ecosystem fragments are increasingly separated from each other and limited in their functional capacity. Increased fragmentation leads to downsizing and islanding of populations, genetic impoverishment, and possibly local disappearance of species. Abrupt transitions between forests and other areas without functional forest edges increase edge effects; among other things, it is easier for substances foreign to the ecosystem to enter, e.g. through emissions from road traffic or agriculture.

Due to agricultural use and construction projects, there may be a further loss of forest area. Access roads cause additional internal fragmentation and microclimatic changes. Additional disturbances are caused by the development and operation of forestry areas. Not only the construction and driving of forest roads and trails but also of so-called skid trails for the corresponding machines, result in the loss of areas for tree growth and thus in biomass losses. Linear forest aisles lead to sharp forest edges in the middle of the forest and thus change light and climate conditions.

Stands potentially become thinner, warmer, and drier. Originally non-native species may invade the forest along trails and in disturbed areas, sometimes displacing other species and contributing to further homogenization. Soil is compacted, at least around logging roads; underground, fungal root networks important for water and nutrient uptake (mycorrhizae) may be disrupted. Soil and regrowth vegetation on the skid trails (and beyond) are often damaged during timber harvesting. With heavier logging and lowering of the stocking level, more or less large gaps are created in the canopy. This, together with biomass removal, affects the microclimate. Among other things, biomass in the forest also stores water and cools. Trees that stand more freely are also moved more during storms and may be more susceptible to windthrow. The wind susceptibility of trees is high for a certain period if larger protective trees have previously been removed from a stand.

Particularly problematic in heavily used forests is the poverty of dead and old wood. Dead wood is, for example, a habitat for many species and a substrate for regeneration. It is a nutrient and water reservoir, protects the soil from drying out, and has a favorable effect on soil formation.

The intensive management of coniferous forests and woodlands that are not in their natural state has the effect of severely limiting the age and decay phases, as less old and dead wood is found in these areas. As with all ecosystem uses and any human infrastructural or industrial activities, forestry activities result in the degradation of ecosystems and their ability to function at all stages of operation. Fundamental choices are made when establishing forests and selecting the tree species that will be allowed to grow.

The selection of few species (compared to natural succession) and the cultivation of predominantly even-aged trees results in the severe simplification of stands, loss of biodiversity at all levels, and reduced self-regulation. Among other things, pests can more easily establish themselves and cause economically relevant damage. The risk for windthrow and forest fires may increase. If non-native trees are planted on a larger scale, fewer resources may be available for native species. Certain tree species have an unfavorable effect on the soil in monoculture (e.g., acidification by needle litter, reduction of soil microorganisms, and available nutrients by red oak, for example). Furthermore, in coniferous forests, evaporation is increased even in the recently more frequent mild winters and groundwater recharge is greatly reduced.

Decades and centuries of settlement and use of the former and remaining forest areas, including the loss of predators such as wolves, have increased the population density of, in particular, cloven-hoofed game to such an extent that this disturbs the forest in its development and regeneration.If the functional capacity of forests is reduced, they become significantly more susceptible to climate change impacts. In heavily modified stands, mainly in those where pine dominates and the understory is very sparse, there is also a changed forest interior climate, which is far from the typical balancing microclimate of a mixed broad-leaved forest. Lower evaporation and stronger or unrestrained solar radiation lead to lower humidity and higher temperatures on hot days. Soils dry out and trees suffer drought and heat stress, which can lead to higher mortality rates. Higher temperatures and less moisture in the forest coupled with highly flammable tree species such as pine also increase the risk of wildfire. Higher winter temperatures also favor the reproduction of insects and other creatures that live in and on wood. Trees are increasingly weakened by pathogens and insect calamities, and mortality rates are increasing. Aisles, sparse stands, and abrupt forest edges promote the effects of wind or storms, which can lead to an individual to areal injury and toppling of trees. The resulting clearings increase edge effects in the forest and provide new targets for storms and strong solar radiation.

2.2.3.2 Relevant natural and anthropogenic drivers of ecological stress in Desnianskyi BR ecosystems

Sphere	Drivers of ecological stress	Strategic Relevance (based on criticality ratings)
Climate change and severe weather	Lowering of water level of Desna river	2
	Drought	1
	Increase of mean annual temperature*	?
	Shorter winter periods	?
	Warmer (snowless) winter	?
	Unfavorable weather conditions	?
	Increasing occurrence of heavy rains	?
	(Short) heavy rainfalls	?
	Spring floods (e.g. 2018)	?
	Extreme temperature events	?
	Snowmelt in winter	?
	Storms and strong winds	?
	Spring frosts (e.g. in May)	?
	Frostbite in spring	?
	Icing - frost	?
	Heavy snow	?
	Increase in water temperature	?
Energy production and mining	?	
Agriculture and aquaculture	Abandoned land (degraded)	1
	Conversion of natural ecosystems to agricultural lands	?
	Decrease of humus content due to non-organic agriculture	?
	Increased water use by agriculture	?
	Increased water loss by evapotranspiration (by agriculture)	?
	Use of pesticides	?
	Uncontrolled use of herbicides and pesticides	
Biological resource use	Clear cutting of forests	?
	Overlogging	?
	Forestry	?
Human intrusions and disturbances	?	
Natural system modification	Drainage	?
	Forest fires	?
	Peat and swamp fires	?
	Meadow fires	?
	Uncontrolled use of resources	?
	Absence of tree plantations (orchards)	?
Invasive and other problematic species	Forest pests	?
Pollution	Pollution of the natural surrounding	?
	Chemical pollution	?
	Soil erosion	?

Hydro-Geological events	?
Transportation and service corridors	?
Residential and commercial development	?

Climate change and biological resource use by forestry

Climate conditions currently perceived as "extreme" (Büntgen et al., 2021) could be considered "normal" in the near future (Hari et al., 2020; Scharnweber et al., 2020). It is therefore of great interest to what extent forest management (especially thinning and thinning of forest stands) has the potential to increase the negative effects of heat waves in forest stands[9].

It has been partly concluded from recent studies that thinning can reduce the impacts of drought (Ameztegui et al. 2017, D'Amato et al. 2013, DelRío et al. 2017, Gebhardt et al. 2014, Giuggiola et al. 2013, 2016, Ma et al. 2010, Primicia et al. 2013, Simonin et al. 2007, Sohn et al. 2016). However, the corresponding findings are by no means as clear-cut as sometimes presented. The benefits of thinning depend on local climatic conditions and cannot be generalized (Ameztegui et al. 2017). It needs to be reflected more critically in times of frequently recurring dry and hot years, namely when rainfall is absent for prolonged droughts. Then, potential advantages of thinning can turn into a disadvantage, because higher water losses through evaporation become the decisive stressor in forests exposed to more intense heat. It is also known that forest openings and clearings increase ambient and ground temperatures, which in turn negatively affect water availability, especially during periods of low precipitation (Redding et al. 2003). The larger the canopy openings, the higher the air and soil temperatures (Latif & Blackburn, 2010). At forest edges, soil moisture can be similar to that in open areas (Erdős et al., 2019).

The microclimatic regulation capacity of forests is therefore of central importance. This is mainly a matter of mitigating peak summer temperatures, lowering average temperatures, and buffering temperature fluctuations. An open question was to what extent forest properties that are directly influenced by forest management (e.g. thinning, timber harvesting intensity, and nature conservation) affect microclimatic regulation under extreme climatic conditions in exceptionally hot periods. To this end, a study in northern Germany (Blumröder et al. 2021) investigated temperature indicators in the two extremely hot and dry summers of 2018 and 2019 (see e.g. Buras et al. 2020, Kornhuber et al. 2019, Vogel et al. 2019) in forests of northern Germany. In addition, temperature measurements were collected and analyzed in pine and beech forests along a utilization gradient.

In both years, the highest maximum temperatures were measured near the ground and at a height of 1.3 m in a pine stand with a relatively low supply (177 m3 ha-1). At the same time, maximum temperatures were 9 °C lower in a beech stand with a relatively high stock (>565 m3 ha-1). In 2019, when data on crown closure were also included in the analysis, crown closure was also a significant factor influencing maximum temperature, as was the number of felled trees. Across both study years and all sample plots, the temperature increased by 0.21-0.34 °C near the ground and by 0.09-0.17 °C at 1.3 m per 100 trees per hectare felled in the past. In 2019, when crown closure was also considered in the analysis, it showed a significant influence on maximum temperature (in all datasets studied). Between forest stands differing in crown closure by 10%, there was a difference in maximum temperature of 0.46 °C (including pine and beech stands, measured at 1.3 m) and 0.35 °C (pine stands only, measured at 1.3 m). Near the ground, the maximum temperature was 0.53 °C (pine and beech stands) and 0.41 °C (in pine stands) higher.

[9] The following paragraphs have been extracted and translated from the document: *Pierre L. Ibisch, Charlotte Gohr, Deepika Mann & Jeanette S. Blumröder (2021). Der Wald in Deutschland auf dem Weg in die Heißzeit. Vitalität, Schädigung und Erwärmung in den Extremsommern 2018-2020. Centre for Econics and Ecosystem Management an der Hochschule für nachhaltige Entwicklung Eberswalde für Greenpeace. Eberswalde* (in German language).

The biomass stock also influences the temperature regime. Sample circles with a difference of 100 m³ less stock per hectare showed a 0.31-0.33 °C and 0.15-0.27 °C higher maximum temperature near the ground at 1.3 m (including all sample plots). In pure pine stands, it was found that the more densely stocked a forest stand, the lower the maximum temperature.

A closed forest has a better cooling capacity (preventing relatively high temperatures) and also greater buffering capacity (reducing temperature fluctuations). Considering all study plots (beech and pine stands), it was found that temperature fluctuations (at 1.3 m) were higher than average when the crown closure was below 65 %.

Forest management has a significant influence on the ability of forests to mitigate temperature peaks, average temperatures, and temperature fluctuations. For the mitigation of maximum temperatures in the forest interior, the openness of the canopy is the decisive factor, but the amount of felled trees is also of great importance, and both variables are directly controlled by forest management (in terms of reducing timber harvesting activities and developing denser, multi-layered forest stands). Other studies also show that a reduction in canopy closure leads to an increase in forest internal temperature (e.g. Thom et al. 2020, Kong et al. 2014).

In the two record heat years of 2018 and 2019, denser and less thinned forests showed better microclimate regulation. Effective forest management aiming at continuous forest cover and more complex structures instead of homogeneous monocultures of the same age thus enables stabilization of microclimatic conditions inside the forest and counteracts extreme macroclimatic conditions that will occur more frequently in the course of climate change. The cooling property of forests contributes to climate regulation in the wider landscape and positively influences water and carbon cycles (Ellison et al. 2017). The regulation of microclimate can therefore mitigate climate change effects (Thom et al. 2020).

Based on the results, it is recommended to minimize warming and evaporation effects in the forest interior by reducing or avoiding the creation of artificial gaps in the canopy through silvicultural measures, including intensive thinning and clear-cutting, as well as the establishment of roads and skid trails. In this context, the fragmentation of forests by roads and infrastructure as well as the opening of the canopy by the construction or maintenance of skid trails and forest roads must be discussed. Regular and regular thinning or timber harvesting in German commercial forests usually takes place every 5 years, with skid trails being cut into the forest at a distance of 20-40 m from each other. The associated opening of the canopy creates internal forest edges and potential edge effects within a forest area, which can reduce microclimatic regulation capacity and increase the risk of heat and drought stress from the edges into the forest interior (Duncan et al. 2019, Reed et al. 1996). Road infrastructure causes higher air and canopy temperatures and saturation deficits (Delgado et al. 2007, Pohlman et al. 2007). Increased tree mortality at forest edges indicates higher stress levels in times of water scarcity and heat (Brun et al. 2020).

Adapting forest management to climate change primarily means reducing the sensitivity of trees to drought events as much as possible. Extremely low precipitation and high temperatures depleted soil moisture and increased evaporation was responsible for the recent spring droughts in Central Europe and are likely to persist in the long term due to climate change-induced atmospheric circulation phenomena (Ionita et al. 2020). According to the results of the study (von Blumröder et al. 2021), high stock and dense canopy provide insurance against heat and drought events. This is in contrast to promoting thinning as a management strategy to adapt forests to climate change and reduce the associated impacts of droughts.

Forest microclimate management, to produce cooler and less variable forest interior temperatures, is a critical element of ecosystem-based adaptation to climate change.

It is recommended to keep the canopy as dense as possible, at least at 80 % cover. This can be achieved through low intervention intensities, intermediate layers (e.g. native broad-leaved tree species in intermediate and understorey), with the aim of creating multi-layered, uneven-aged stands.

The trade-off between sufficient light availability for tree regeneration growth, which is necessary for the forest to develop into a more resilient ecosystem, and the need to maintain protective shade is increasingly evident under climate change conditions, especially in extremely hot and dry years. Of key importance is the risk that extreme heat, soil dryness, or even direct sunlight (which can lead to sunburn in exposed beech trees) can jeopardize the success of forest development.

The regulation of micro-and mesoclimate by forest ecosystems is an important function and service, which in turn influences other ecosystem services (Tuff et al. 2016). The socio-economic importance of forests goes far beyond timber production and is also highly relevant for human health and recreation. Therefore, forest management should assume greater responsibility for regulating the microclimate in order not to further exacerbate the negative impacts of the macroclimatic climate crisis, but to counteract it.

2.2.3.3 Relevant underlying factors and causes

Sphere	Underlying factor and cause	Strategic Relevance (based on criticality ratings)
Biophysical factors	Increased fire risk	2
	Global climate change[10]	1
	CO_2 emissions*	?
Institutional factors	Insufficient resources in the administration of the protected area (financial, staff, physical infrastructure)	
	Insufficient regulation/control of logging and forest use	
	Inadequate agricultural fire protection regulations and enforcement	
Governance-related factors	Inadequate legislation/ legal instruments concerning the BR Administration	1
	…?	
Socio-economic factors	Low standard of living; Lack of a regular income for the local population	?
	Economic stimulus/incentives for large industrial agro-complexes	
Socio-demographic factors	Rural depopulation	?
	?	
Infrastructure-related factors	Tourism	?
	No business areas	?
	Absence of places for waste collection	?
	Remnants of Soviet times	?
Socio-cultural factors	Lack of awareness	1
	Not following logging regulations	
	Agricultural fires	?
Spatial factors	Lack of transboundary cooperation	?
Scientific and technological factors	Forestry companies and administrations lack knowledge on sustainable harvesting and	?

[10] Itself natural and biophysical processes but today mostly driven by past and current anthropogenic activities

	processing of timber	
Industrial production-related factors	Low-quality fertilizers	?
	Low-quality pesticides	?
Natural resource-use related factors	Need for natural resources	?
	Forestry (e.g. monocultures)	?
	Demand for wood and timber	?
	Fires	?
	Different evapotranspiration of different crops	?
	(Global) deforestation	?
	(Global) greenhouse gas emissions	?

? - To be determined/assessed

2.3 Diagnosis

Desnianskyi Biosphere Reserve, its nature, and humans already are and increasingly will suffer a regime of climatic change and its related consequences. It is mostly perceived in rising mean annual and monthly temperatures, uneven precipitation patterns, seasonal shifts, and disbalance in the overall hydrological regime.

Milder and shorter, snowless winters and warmer springs and summers lead to changed flood regime patterns, decrease in surface and groundwater levels, the shallowing of Desna river, and drying of its tributaries. The drying of swamps, forests, and wells in urban areas is occurring at an accelerated pace, leading to overgrowing with grasses, shrubs, and trees and the transformation of wetland and grassland. Biodiversity loss, changes in species composition, and the increasing occurrence of alien species and pests significantly impact the local ecosystems.

There is a higher exposure to extreme weather events, including short-term heavy, torrential rainfalls that lead to flooding, crop damage, erosion, and contribute to processes of waterlogging. Heatwaves paired with longer and more frequent droughts raise the risk and number of forest-, peat bog- and meadow fires and stress both flora and fauna in manifold ways. Storms are causing windthrow in forests, erosion of topsoil, and damage to human infrastructure. Hailstorms, sandstorms, and spring frosts cause damage to fauna and human infrastructure.

At Desnianskyi BR, the main economic sectors and sources of income for the local population are agriculture, forestry, fishery, and tourism. They are already directly and indirectly affected by these climatic changes and extreme weather events. Crop loss on farmland and damage to forests is caused by heat, drought, fires, floods, storms, and pests. Water level lowering of Desna river, a decrease of soil fertility and water retention capacity, rising water temperatures and drop in groundwater level are just a few examples of how climate change has manifold consequences for human well-being.

Anthropogenic underlying factors and causes that drive the degradation of Key Ecological Attributes and thus increase the vulnerability of local ecosystems and risks include - demand for natural resources such as timber, agricultural produces, and water. This causes a variety of unsustainable land-use practices such as monoculture and clear-cutting forestry, agricultural practices leading to soil degradation, compaction, and desiccation. Both past and present melioration practices and draining of wetlands, soil sealing, and water pollution threaten the needed regulative capacity of the ecosystems. Hence, these practices and lifestyles raise the risks of direct climate change effects on human well-being, including the physical, mental, and economic spheres.

Taking into account all the above mentioned, the local population, land users, and stakeholders of the Desnianskyi BR are facing the urgent need to protect and restore (self-) regulating, functional ecosystems, while limiting harmful and destructive land use and behavior to a minimum extent. Only then there is a chance that their well-being and a qualitative and quantitative provision of ecosystem services can be guaranteed in the long term. This is also a vital requirement for sustainable regional development which is mainly based on natural resources and functional ecosystems. These are the core motivations of Ecosystem-based Adaptation to climate change.

The objectives to counter climate change and its negative impacts are based on the findings of the situation analysis and the necessity to protect and restore (near-)natural ecosystems.

These goals shall safeguard that the ecosystems of the Desnianskyi Biosphere Reserve:

- **maintain their ecological functionality** even under the influence of climate change including long-term local climatic changes and an increase in extreme weather events.
- can **buffer and reduce the effects of climate change on themselves** as much as possible.
- **continue to provide the ecosystem services needed for human well-being**, including most importantly the regulating services (e.g. local climate and water balance) mitigating negative effects of extreme events on humans, the provisioning services (e.g. food and energy), and the cultural services (such as recreation and cultural identity).
- **reduce climate change-related disaster risks to human well-being**.

Thus, the overarching aim is to **reduce Desnianskyi BR´s vulnerability to climate change**. Since vulnerability is caused at different levels (cf. chapter 2.2), these different levels must also be addressed to reduce vulnerability holistically.

For Desnianskyi BR, the following four climate change relevant and both ecosystem and human well-being centered goal-dimensions can be reached by EbA:

A. Cooling and buffering of temperature fluctuations
B. Water retention potential, water runoff- and flood regulation
C. Buffering of extreme and hazardous weather events
D. Pest and disease control

EbA measures have the potential and goal to proactively reduce the above-described risks by decreasing vulnerability and enhancing (self-) regulating capacity by restoring natural ecological structures and processes. For the EbA measures, please consult the separately printed *EbA measure and activity catalogs* annexed to this document series. The catalogs can also be accessed via the project website (https://www.eba-ukraine.net/Publications.html). The map "Priority Areas for Ecosystem-based Adaptation" provides a spatially explicit orientation of where what kind of action is primarily needed.

2.4 Spatial Analysis and Maps

In preparation for the local citizens' workshops and the MARISCO workshops, GIS experts carried out spatial analyses of the Biosphere Reserves Desnianskyi, Roztochya, and Shatskyi as well as their surroundings. Innovative maps were produced that take the ecosystem-based approach into account and incorporated first information on climate change impacts as well as land use.

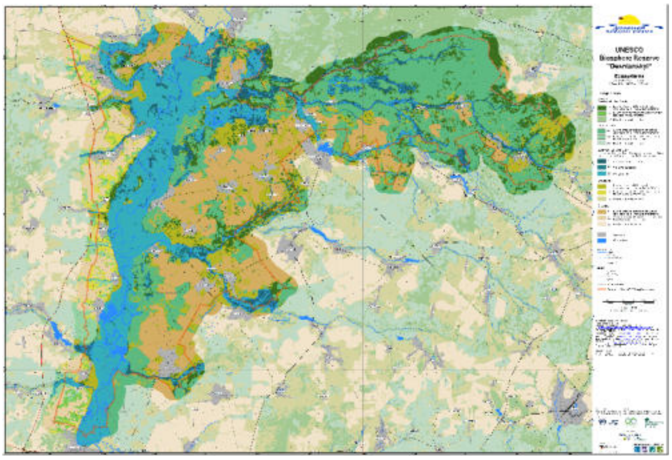
The spatial analysis enables statements to be made on the distribution and condition of relevant ecosystems and their services. Through citizen participation and stakeholder workshops, existing knowledge of the participants and their wishes and ideas are incorporated into the situation and target maps. They help to prioritize areas of conservation value and to localize EbA measures.

2.4.1 Situation Maps

The situation maps included: Ecosystems, Hydrography, Threats, Vulnerability, and Thermo

For more information on the method and geodatasets used for the production of these maps, please refer to the Toolbox document and project website.

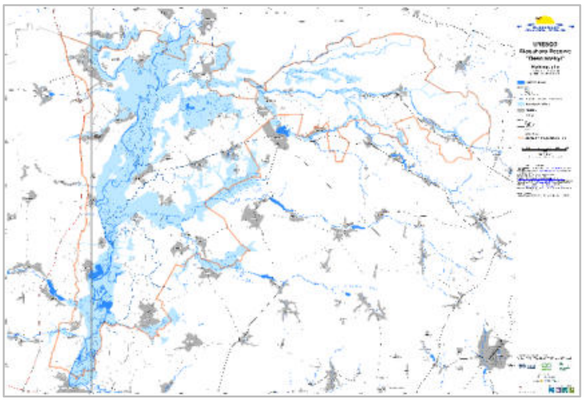
Ecosystems - Based on current satellite imagery, a land cover classification was developed, which depicts the ecosystem complexes of the region. In addition, information on topography, soil, and drainage was added manually (only inside the borders + 5 km buffer of the Biosphere Reserve areas).



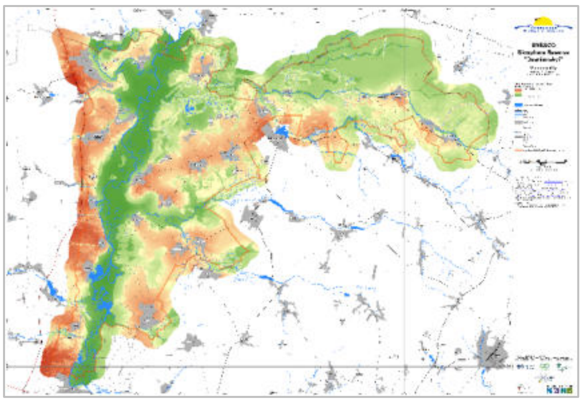
Map 3 Ecosystem Map of the Desnianskyi BR

The ecosystem maps represent relatively small and homogeneous ecosystems of a local geographical scale – ecotopes. An ecotope can be viewed as a combination of the two sets of ecological components: (1) a physiotope encompassing abiotic characteristics such as local landform, climate, hydrologic regime, and soil; (2) a biotope as a plant community with microorganisms and animals (biocenosis) within defined geographic boundaries.

The Hydrography maps focus on the representation of the hydrological regime including watersheds, surface waters, and wetlands. The Vulnerability maps show the spatial distribution of stress impacts in the ecosystems, based on an assessment of stress indicators carried out beforehand.



Map 5 Hydrography Map of the Desnianskyi BR



Map 4 Vulnerability Map for the Desnianskyi BR

The plotted maps were already handed out to the biosphere reserve administration and staff in the course of the MARISCO expert workshops in May and June 2019. All maps are included as A1 printouts to this document series and will be also downloadable from the project website.

2.4.2 Demand and Target Maps

Map types:

1) Deviation from Mean Surface Temperature
2) Ecosystem Cooling Capacity for the summer months 2002-2018

In the *mean surface temperature deviation maps*, geospatial distribution of temperature (T) deviations from mean for different weather conditions were calculated and visualized. In the *ecosystem cooling capacity maps,* zonal statistics were used to describe each ecotope class surface T values for the four weather conditions. Both sets of maps are annexed at the end of this document.

The method and steps for the creation of these maps are explained in more detail in the *Toolbox document*, chapter "Spatial Analysis and Mapping" – part II.

The four weather conditions cover:

1) Mean T for June-August

2) Mean T for cozy days (with max air T of 20 – 25 deg. C)

3) Mean T for summer days (with max air T of 25 – 30 deg. C)

4) Mean T for heat days (with max air T over 30 deg. C)

These four different conditions show one significant pattern over the entire study period (2002-2018). Water bodies with intact riparian zones, wetlands and the areas covered with forest as well as forest-shrub transition stages are the coldest areas in the study area. They sharply contrast with warmer agriculturally managed areas as well as urban and industrial areas. Sealed settlement or urban areas such as Znob-Novhorodske, Stara Huta, and the direct surroundings show the warmest areas. The difference in average surface temperatures between the coolest and forested areas and the warmest urban areas is over 10°C.

For example, on hot summer days with maximal air T > 30°C, the more functional and natural ecosystems, such as Desna River, its floodplain and riparian systems, as well as mixed and mostly unmanaged forest constitute the coolest areas with down to -4,6°C from the mean (cf. map 10). Their cooling potential (cf. map 14) is thus significantly higher than that of intensively managed or altered ecosystems such as agricultural and settlement (up to +11,4°C)

It becomes evident that different ecosystems and land use areas which are, for example, heavily modified, biomass-poor, drained, and sealed by humans, feature a significantly higher positive deviation from the mean temperature. Thus, temperatures differ significantly between the different ecosystems and land use classes.

2.4.3 Maps of Priority Areas for Ecosystem-based Adaptation Action

The project also aimed at indicating spatially explicit *Priority Areas for Ecosystem-based Adaptation Action.* To support targeted, urgent action and efforts to prevent and reduce climate change and its impacts, ecosystem degradation, and biodiversity loss, a map was elaborated with the following color gradient indicating:

1. Green - Conservation (mainly in (near) natural, i.e. rather functional, less stressed, and damaged ecosystems)
2. Yellow - Reduction of human influence/pressure (modified and (intensively) used and stressed ecosystems)
3. Red - Restoration (destroyed, heavily used, damaged, and stressed ecosystems)

It is important to note that the transitions of the three lines of action (conservation, reduction of human drivers of stress/pressure, restoration) are fluid, meaning that in areas of restoration (e.g. rewetting drained wetlands) also reduction of human influence (e.g. peat extraction, agricultural use) needs to be pursued, while conservation efforts are still relevant (e.g. preserving individual trees or tree communities that remained as functional structures). This applies to both directions of the gradient and is very site-specific. At this level of analysis, available data, and area section, the maps cannot provide further detail. Ground truthing and further research and monitoring are needed to clearly define the area, and which actions are most needed and efficient. For the selection of more concrete action, the EbA measure and activity catalogs can provide first guidance. They are attached to the document series and can be downloaded via the website.

For this map, thermal datasets standardized on the scale 0-100 were merged with integral vulnerability datasets for each BR, which also contain standardized values 0-100. The method is explained in more detail in the toolbox.

The maps are attached to this document in the annex (cf. map 7-14) and part of the printed materials within the series of documents.

3 Conclusion and Outlook

Desnianskyi Biosphere Reserve, its ecosystem, and social system complexes have been and increasingly will **face significant climatic changes** causing alterations in their physical, chemical, and biological conditions. This especially concerns the increase of air temperature, changes in precipitation patterns, and seasonal shifts, affecting all ecosystems and humans alike. These climatic developments cause **changes in the hydrological regime**, including a decrease in surface and groundwater levels leading to shallowing, drying, and transformation of rivers, forests, swamps, meadows, and wells. Meanwhile, the risk and number of meadow-, peat bog-, and forest fires are increasing. Climate change also prompts alterations in flora and fauna and drives the spread of pests and diseases.

A higher number of and **exposure to extreme and hazardous** weather events are observed, including short-term heavy, torrential rainfalls that lead to flooding, crop damage, erosion, and contribute to processes of waterlogging. Heatwaves paired with longer and more frequent droughts raise the risk and number of forest and wetland fires and stress both flora and fauna in manifold ways. Storms are causing windthrow in forests, erosion of topsoil, and damage to human infrastructure. Hailstorms, sandstorms, and spring frosts produce damage and disruption in ecological processes. Human well-being, including physical, mental, and economic spheres, is almost always directly and indirectly affected by such extreme events.

To **buffer and adapt to** these **climate change developments and impacts**, the **self-regulating and self-organizing functions of ecosystems**, and thus the guaranteeing of regulating ecosystem services, are fundamental. Degraded Key Ecological Attributes make the ecosystems more vulnerable and less resilient and resistant to exposure to climate change impacts. However, they are impaired, reduced, or partly lost due to a **variety of harmful anthropogenic activities**. Foremost, these include land-use practices, having their origins both in the past (e.g. land reclamation via draining of wetlands for grass- and cropland, monoculture forestry), and continue in the present (deforestation by clear-cutting, monocultures, surface sealing, artificial water abstraction, compacted and intensively used soil, and the like).

Thus, the adaptive management approach of Ecosystem-based Adaptation to climate change aims at:

- **Protection, maintenance, and restoration of ecological functionality** even under the influence of climate change.
- Maximal capacity of ecosystems to **buffer and reduce** climate change **effects on themselves.**
- **Continued provision of ecosystem services** needed for human well-being.
- **Reduction of climate change-related disaster risks** for humans.

For Desnianskyi BR, four climate change adaptation goal dimensions are proposed:

1. **Cooling and buffering** of temperature fluctuations
2. **Water retention** potential, water **runoff- and flood regulation**
3. **Buffering of extreme** and hazardous **weather events**
4. **Pest and disease control**

To achieve this, the EbA approach proposes four lines of action to increase ecosystem functionality and decrease vulnerability through heightened self-regulating and -organizing capacity. This will enable ecosystems to cope with the challenges and climatic uncertainties ahead:

I. **Conservation** of existing functional ecological structures and (self-) regulating capacity
II. **Reduction of human-made stresses and factors** that limit and disturb (self-) regulating capacity
III. **Restoration and targeted support** of (self-) regulating capacity
IV. **Development of enabling factors** supporting lines of action I – III

Outlook

The strategy development process played a central role in the continuation of the EbA and MARISCO approaches. The discussion of existing and additional strategies for each ecosystem complex and the ecosystem network of the Desnianskyi Biosphere Reserve led to the elaboration of five concrete work and monitoring plans. Both the spatial and temporal dimensions were addressed and considered in this process. These complementary strategies aim at filling strategic gaps and include relevant information for operationalization and implementation of the most viable EbA measures and actions. Based on these final results of the strategy development process, the strategies are included in the upcoming annual planning and discussed with regional and national decision-makers.

4 Annex

4.1 Workshop Series at Desnianskyi BR and Training in Eberswalde

Since the project started in August 2018, the team and partnering biosphere reserve staff conducted two multi-day workshops and excursions at each biosphere reserve. These workshops form part of the MARISCO adaptive management approach, described in the previous section.

The first visit during November 2018 aimed at familiarizing the German project team with the biosphere reserves, meeting with administration staff, local actors, and land users. With the involvement of the local population the question of “in which nature do we want to live?” was addressed. These so-called *citizen workshops* were designed to get a first-hand insight into the residents' relationship to their natural surroundings and allowed for the first assessment of Ecosystem Services.

The second journey to the Biosphere Reserves took place from May-June 2019 and aimed at a situation analysis based on the inputs of local and regional experts as well as excursions in the region. Furthermore, the insights of the citizen workshops were introduced and integrated into the considerations and systemic model.

Due to the COVID-19 pandemic, the third workshop trip to the Biosphere Reserves had to be canceled. Instead, a web-based process was developed and conducted to elaborate Ecosystem-based Adaptation strategies, measures, and activity catalogs, as well as working and monitoring plans.

4.1.1 Citizen Workshops

The citizen workshops included a series of three workshops within the area of each biosphere reserves, involving diverse actors from school children to foresters, land-users to administration staff. The participants exchanged knowledge and discussed views on the local ecosystems and their services.

Process

Firstly**,** the biosphere reserve introduces itself to the participants and gives some general insights into both work and purpose. Like this, the workshop also provides a platform to familiarize the audience with the biosphere reserve, its activities and to raise awareness.

The project staff introduces the citizen workshop. The “why” and “how” are explained to the audience. Smaller working groups of 4-6 people are formed.

Image 1 Desna River on 22.11.2018, Credit: K. Mack

Image 2 Results presentation after group work, Znob-Novhorodske, Desna BR
Credit: K.Mack

Session 1: Nature and humans

The previously formed groups work on a set of simple questions and write the answers on moderation cards. The concept of Ecosystem Services and ecosystem classification is explained. Afterward, they are presented by the groups and directly clustered into the scheme shown below. The guiding questions were:

- **How does nature contribute to your well-being?**
- **How do you use nature in the biosphere reserve, where?**

Services of nature (ecosystems)	**Forests** (Natural and managed)	**Water bodies and wetlands** (Lakes /rivers/mires etc.)	**Open land** (Agricultural land/ grassland etc.)	**Settlements and urban green areas**
Provisioning				
Regulating				
Cultural				

Session 2: Nature & (Climate) Change

What kind of changes and threats in nature do you perceive in the biosphere reserve?

- General changes are written down
- The group discusses for about 10 min.

Is climate change occurring?

The group adds more observed features of climate changes

If so, how is climate change affecting nature?

- Locate visible effects on the map
- Create small result ordered by the affected type of nature

Session 3: View to the future

How can nature and people be better prepared to deal with climatic changes?

- 3 main ideas are noted down

Image 3 Biosphere Reserve Staff workshop at Desnianskyi BR headquarter, Credit: K.Mack

How do you wish that the future landscape and its use in the biosphere reserve will look like? What should be changed where?

Finally, the participants received a certificate of participation.

Image 5 Group work at Citizen Workshop in Stara Huta, Credit: K.Mack

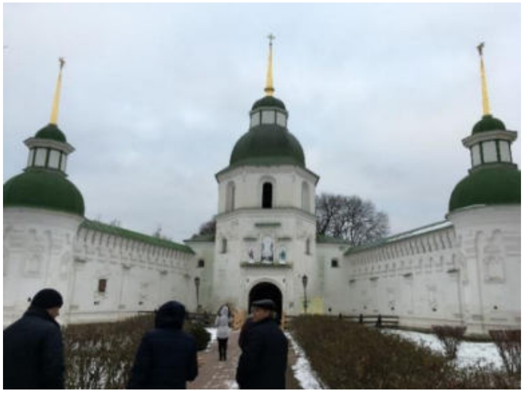
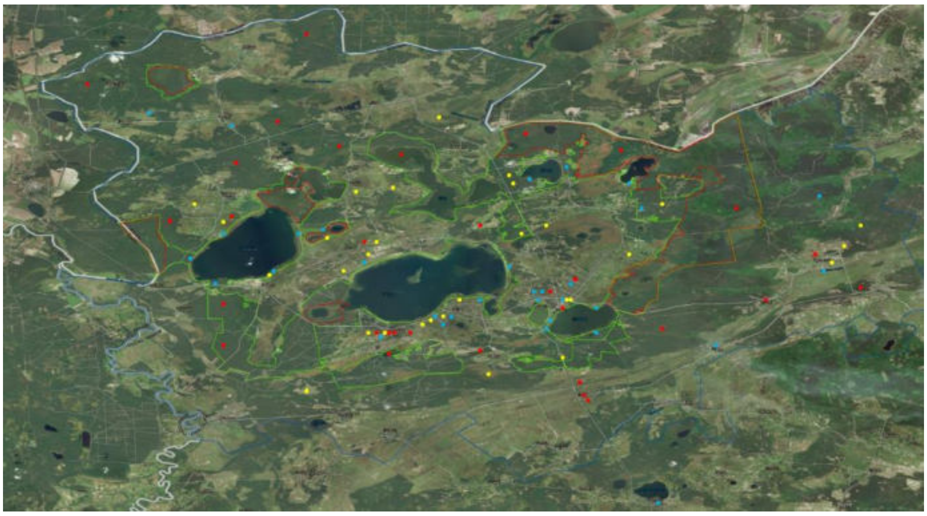


Image 4 Visit to cultural heritage site at Novhorod-Siverskyi, Credit: K.Mack

Results

During the citizen workshops, the participants considered a variety of ecosystem functions and services contributing to their wellbeing and livelihood. Ecological stresses, drivers of stress, and climate change impacts in the area were listed and indicated spatially explicitly (cf. map 6) on printed versions of the area´s satellite image provided during the workshops.



Map 6 Climate change-related events in the Shatskyi BR indicated by the workshop participants, Credit: CEEM

During the citizen workshop, a broad array of climate change-related impacts and threats was mentioned by the participants, including:

- Increase of mean annual temperature
- Temperature anomalies (e.g. extremely low temperatures in spring with frost)
- Seasonal changes of precipitation patterns
- Rainfall anomalies (torrential rain in short periods)
- Flooding
- Hailstorms
- Strong winds, storms, and tornados
- Drought
- Desertification
- Forest fires
- Peat-soil fires
- Soil erosion
- Increase of forest parasites

These results were taken into consideration during the MARISCO I stakeholder and expert workshops and helped complete the list of climate change stresses and impacts. The full list of the situation analysis results can be found in chapter 2.2.2.1

4.1.2 MARISCO I - Stakeholder and Expert Workshops

In May 2019, expert and land user workshops were held in Sumy. Here, the MARISCO method was applied to elaborate a first comprehensive diagnostic of the area. Both challenges to ecosystem functionality as imposed by climate change, as well as the first inventory of potential Ecosystem-based Adaptation strategies, were gathered. The results of the previous workshops were considered and further developed.

Desnianskyi Biosphere Reserve

The workshops started on 15.05.2019 with a session on ecosystems. Here, the previously elaborated maps were used to discuss the suggested scope, classification, and general state of the ecosystems in the region. Four groups were formed according to expertise, focusing on forests, grasslands, rivers and lakes, wetlands. The results were presented to the plenary. After a break, the Key Ecological Attributes (KEAs) were assessed in the same groups and the results were presented.

Image 6 Group work at MARISCO workshop in Sumy, Credit: P. Ibisch

The ecological stresses identified at the citizen workshop were introduced by the project team and discussed by all. For the identification of other, missing stresses, the four groups continued working. The rating of ecological stresses followed in two parts: I. Criticality (current as override, past, trend, and future) and II. Knowledge + manageability.

16.05.2019 – The second workshop day started with a recap and an introduction to necessary changes (clustering, merging) within the conceptual model by the moderators. Then, the drivers of ecological stress (threats) and the ecosystem services were assessed in the plenary. In continuation, groups elaborated on strategies for the identified stresses, drivers of stress, and contributing factors.
The strategies were pre-assessed using a color code according to their climate change adaptation potentials (cooling, buffering of temperature fluctuations, water retention, regulation of water runoff)
Then, each group was asked to define a key strategy according to a set of questions such as:

- If you had the money/resources etc., which strategy or measure would you implement to address the stress, threat, contributing factor most successfully?

In the plenary session, each group presented the identified strategies and the most promising in terms of climate change adaptation. Afterward, a narrowed stakeholder acceptance assessment was done, including the views of farmers, foresters, the tourist industry, and nature protection.

Image 7 Participants in front of the conceptual model; Credit: CEEM

17.05.2019 – Due to organizational challenges, the third day consisted of the excursion, which optimally occurs on the first day for a better understanding of the region. Yet, in this order, the excursion allowed for ground-truthing of some assumptions made during the workshops. Different sites were visited, such as cropland, forests, swamps, the Desna floodplain, and settlements.

Image 8 Michael Succow participating during excursion in Desnianskyi BR; Credit: A. Schick

Feedback of workshop participants:

Pro:

- Gaining of and systemization of knowledge concerning the region, climate change, and adaptation
- Effective group brainstorming method for complex issues
- Good for understanding problems, threats, and driving factors
- Sharing of ideas and awareness-raising
- Productive and interesting system of information collection and processing for the development of the climate change adaptation strategy.
- The methodology of the seminar is very good as for the interdisciplinary approach.
- The thoughts of various specialists and scientists on one particular territory and being in one place is very important and good for the results.

Cons:

- Very theoretical, challenge to move to concrete implementation steps
- Complex approach – not enough time to proceed and discuss the complicated elements and problems sufficiently.
- Method (at this stage) neglects or underestimates resistance or obstacles of stakeholder or lobby groups when strategies come to an implementation level.
- The speed of the group work situations might lead to misunderstanding and overruling of crucial and essential impulses if they are not strongly promoted in due time
- Establish a closer link of elaborated strategies to ecosystem classes and maps
- Involve more local people knowing the region
- The applied approach for information gathering is quite subjective. It is hard to interpret and evaluate stresses, if they are mentioned by other teams (misinterpretation possible)

Results and conclusion:

- The participants gained more clarity of what kind of role, functions, and services ecosystems play in climate change.
- Understand systemically, where the problems and challenges lie, how human activity contributes to them, and how they can be overcome.
- An important goal was to gather first appropriate strategies for the region, which form a good base for the elaboration of strategies of Ecosystem-based Adaptation to climate change.

The participation of the biosphere reserve representatives was valuable, as this allowed for networking and learning together about climate change and adaptation options. Like this, the areas can inspire each other and share their solutions.

The project team would like to express its gratitude to all the workshop participants. The conceptual model represents walls full of “knowledge” and regional insight. The idea contest, as well as the implementation phase of the project, shall provide an opportunity for action on the local scale, to move from theory to practice, and implement parts of the Ecosystem-based Adaptation strategies and measures. It is very important to not only produce paper stacks but implement something, thereby inspiring people and making a change.
Biosphere Reserves are the right places for experimenting with such new approaches, strategies, and measures. The mission of BRs is to inquire, implement and monitor such people-centered and ecosystem-based approaches to changes in management, land use, and education. In this aspect, they can be the drivers of change and serve as role models.

Training and dialog in Eberswalde: Ecosystem-based Adaptation in Biosphere Reserves

From December 09-13, 2019, 15 representatives of 5 Ukrainian UNESCO Biosphere Reserves met in Eberswalde and initiated a dialogue to mutually support the understanding of Ecosystem-based Adaptation to climate change. The training was organized and conducted by the Centre for Econics and Ecosystem Management with the support of the Michael Succow Foundation.

Image 9 Group photo at Lower Oder Valley National Park, Credit: EbA Ukraine

The participants and organizers set out to mutually explore, discuss, and understand practical options for the implementation of corresponding measures.

Image 10 Workshop session at Eberswalde University for Sustainable Development, Credit: K. Mack

The training week comprised diverse formats – from lectures and excursions to workshop-like group work, the elaboration of a common statement paper, and the co-creation of own criteria for effective ecosystem-based measures in biosphere reserves.

Image 11 Guided excursion at Sernitz valley spring fen, Credit: K. Mack

Image 12 Guided excursion at Treuenbrietzen forest fire site; Credit: A. Dichte

December 9, 2019

Lecture day

After a welcome by the organizers, participating biosphere reserves, and a Ministry representative, presentations covered the topics of:

- The Biosphere Reserves Concept
- Adaptive Management under the Ecosystem Approach
- Participation and governance
- Climate change and developments in Ukraine
- Ecosystem-based Adaptation and Mitigation: Climate management with forest ecosystems
- Regional sustainable development and justice

Image 13 Uli Gräbener, head of the Biosphere Reserves Institute presenting the functional zonation concept; Credit: K. Mack

December 10, 2019

Forest ecosystems day

Excursion 1:

Glassy Forest Project,
Schorfheide-Chorin Biosphere Reserve
Gollin, Reiersdorf, Brandenburg

- Visiting the project site with a best practice approach from an EbA perspective
- Examples of measures positively affecting and securing regulating, provisioning, and cultural ecosystem services

Image 14 Dietrich Mehl (Brandenburg State Forestry Service), Pierre Ibisch, and Jeanette Blumröder (both Centre for Econics) guiding the excursion at Reiersdorf forest, Schorfheide-Chorin Biosphere Reserve; Credit: A. Dichte

Excursion 2:

CleverForest Project,
(**CL**imate-adaptive, **E**cosystem-based, **VE**rsatile and **R**esilient Forest)
Treuenbrietzen, Brandenburg

- Recent forest fire site
- Research on vulnerability and climate change impacts
- Project area with a new management approach
- Self-regulated and natural regeneration of the area

Image 15 Jeanette Blumröder and Pierre Ibisch (both CEEM/HNEE) guiding the excursion to the post-fire excursion site at Treuenbrietzen, Germany

December 11, 2019

Open land and settlement ecosystems day

Excursion 1:
Bernau – Project Bernau.Pro.Klima

Vulnerability and climate change impacts in semi-urban ecosystems and surrounding ecosystems

- Participatory adaptation approach for Bernau
- EbA best practice and management approaches including the topics of renaturation of a small river, urban greening, and surface unsealing

Image 16 Excursion to small river renaturation site - Panke, Bernau, Brandenburg; Credit: K. Mack

Excursion 2:
Ökodorf Brodowin, Schorfheide-Chorin BR
Ecological/Organic (Demeter certified) agriculture as an example of best practice approaches in agriculture and livestock breeding.

- Support of species and structural diversity
- Extensive forms of livestock breeding and agricultural production

Image 17 Ludolf v. Maltzan, CEO of the Ökodorf Brodowin explaining the concept, challenges, and benefits; Credit: A. Dichte

December 12, 2019

Water and wetland ecosystems day

Excursion 1: Lower Odra Valley National Park

- Vulnerability and climate change impacts on river and floodplain landscape
- EbA best practice approaches: Renaturation of Odra river meanders
- Support of structural landscape diversity
- Protection of biodiversity

Image 18 Dr Michael Tautenhahn, deputy director, guiding the excursion in the national park; Credit: A. Dichte

Excursion 2: **Sernitz marshland**

Schorfheide-Chorin Biosphere Reserve

Project: Revitalization of one of Northern Germany's largest spring bogs

- Options of Ecosystem-based Adaptation in land-use of wetlands (Paludiculture)
- Wetland nature protection activities
- Preservation and restoration of wildlife habitat

Image 19 Dr Benjamin Herold (Schorfheide-Chorin BR) and Andreas Haberl (Succow Foundation) guiding the excursion at Sernitz marshland; Credit: A. Dichte

December 13, 2019

Strategy and EbA criteria day

Elaboration of a **statement paper** concerning Ecosystem-based Adaptation and biosphere reserves.

Identification and selection of **criteria for Ecosystem-based Adaptation measures**

- for the planned idea contest
- for project proposals

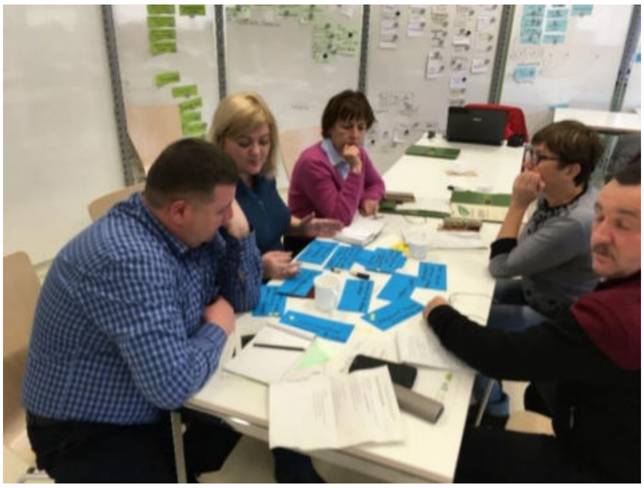


Image 20 Group work for the elaboration of the statement paper and criteria for EbA measures/projects. Credit: K. Mack

Results of the training:

- Improved understanding of the **concept and measures of Ecosystem-based Adaptation**
- **Networking** and **strengthening of the cooperation** between Ukrainian Biosphere Reserves and German partners.
- **Criteria** for the selection of EbA measures and projects
- Elaboration of a **statement paper** regarding Ecosystem-based Adaptation and biosphere reserves aimed at regional and state decision-makers.

4.1.3 MARISCO II – Strategy Development Process

The process consisted of different working steps, covering the identification of strategies, measures, and actions (SMA) relevant for restoring, increasing, and protecting ecosystem functions such as water retention and storage, filtration of solar radiation, and soil formation. These functions generate indispensable services urgently needed by humans to reduce climate-change-related threats like heat, drought, floodings, storms, forest- and wetland fires, etc. It furthermore provided an opportunity to assess and discuss the effectiveness and viability of strategies together with stakeholders to support the selection of key strategies for each of the BRs' upcoming work and monitoring plan development.

MARISCO and adaptive management expert Axel Schick guided through the process and, together with the whole project team and partners, took on the challenge to moderate all sessions via video-conferencing from Lima, Peru. Thus, the project operated on a global level, in different time zones, progressing amidst the challenges due to Covid-19-related travel and meeting restrictions. Positive side-effects were lower Greenhouse gas emissions, reduced travel time, and material use. The flipside of the adapted method was the missing possibility to further elaborate on and work with the conceptual model within the original group, the valuable in-person discussions, and the informal gatherings which used to complete the long working sessions in past on-site meetings in both Ukraine and Germany.

Part I: EbA Strategy identification and gap analysis

In Block A, the strategy identification was conducted for each biosphere reserve. Here, the task was to look through all existing strategies elaborated in the SMA catalog as well as in the available management plans of the BRs. Additionally, strategic gaps were identified based both on the participants´ expertise as well as the MARISCO conceptual model.

Table 1 Online sessions conducted for strategy identification and gap analysis

Date	Biosphere Reserve	Ecosystem considered
13.07.2020	Opening session / ceremony – 46 participants	
14.07.	Roztochya	Open land and settlement
16.07.	Shatskyi	Open land and settlement
17.07.	Roztochya	Forest
20.07.	Desnianskyi	Open land and settlement
21.07.	Roztochya	Grassland
22.07	Shatskyi	Forest
24.07	Roztochya	Water-& Wetland
28.07.	Desnianskyi	Forest
29.07.	Shatskyi	Wet-& Grassland
10.08.	Desnianskyi	Wetland
11.08.	Shatskyi	Waterbody
14.08.	Desnianskyi	Waterbody
26.08.	General summary and presentation of results	

The strategy process was met with great interest from a variety of participants. On 13.07.2020 up to 46 persons participated during the session ranging from biosphere reserves, local land users, universities, NGOs, to ministry representatives.

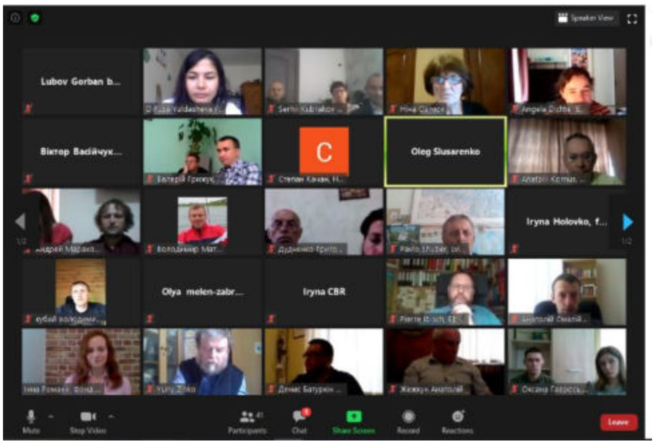


Image 21 Participants at the web-based opening session of the Strategy Development Process on 13.07.2020

As a result of the sessions shown in table *6, from **July to September 2020***, experts and staff of the three partner Biosphere Reserves together with the project team **developed an extensive Ecosystem-based Adaptation strategy portfolio.**

Part II: EbA Strategy evaluation, rating, and prioritization

03.09.2020

Face-to-face event for the rating and prioritization of pre-selected strategies.

- Most participants attending were also present at the online sessions.
- Participants include the BR, land users, and Sumy Oblast.

As an additional result of the ratings and prioritization, an official letter was sent to the department of Sumy Oblast.

Image 22 Strategy rating and prioritization session at Desnianskyi BR on 03.09.2020, Credit: Desnianskyi BR

09.09.2020

Presentation and discussion of the ranking results as well as of the final strategy selection by the Desnianskyi BR.

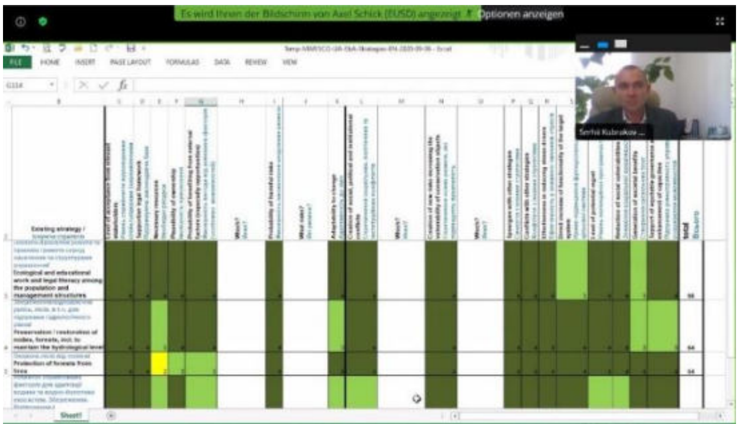


Image 23 Sergiy Kubrakov (Desna BR) presenting results in the revision/discussion session; Credit: K. Mack

15.09.

In the general summary and closing session, all biosphere reserves and the project team got together.

This didn´t mark the end of the whole process, but a milestone of having finished the SMA workshops for each ecosystem cluster, the offline workshops, and strategy ratings.

The process continued with the focus on the most viable and necessary goals, SMAs, and the development of concrete operational and monitoring plans

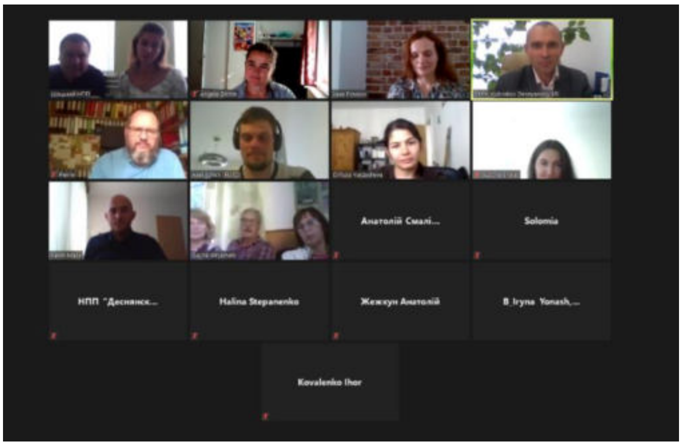


Image 24 Participants at the closing session on 15.09.2020, Credit: K. Mack

Conclusions and necessities:

- It is important to develop an Ecosystem-based Adaptation strategy on the national level.
- The 3 Biosphere Reserves are working at the forefront, doing groundbreaking work on these topics. So far, the BRs in general (also globally) haven´t stood up in favor of Ecosystem-based Adaptation.

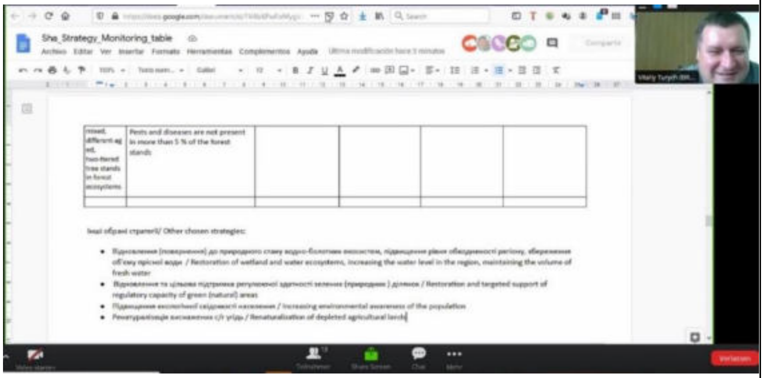
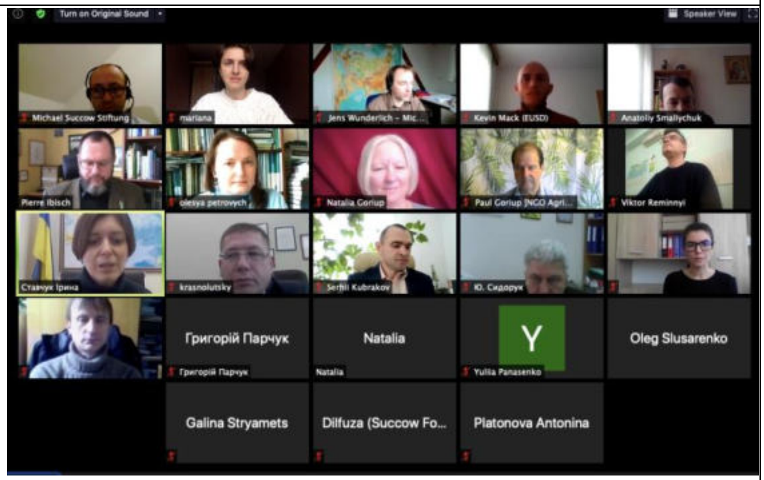
The development of a shared vision on EbA in biosphere reserves: Is both a big challenge and a chance for finding workable ways and answers to climate change.

Part III: Elaboration of Work- and Monitoring Plans for 5 Key Strategies

From ***October to December 2020,*** **detailed work- and monitoring plans for strategies (five per BR) of Ecosystem-based Adaptation to climate change were prepared**. The strategies were developed during months of cooperation and 22 online workshops and meetings as well as regularly discussed, independent work on behalf of the Biosphere Reserves.

After the introduction session, the BRs were invited to elaborate in total 5 strategies which the BR will work on after the session:

The tasks for the BRs encompassed the following: 1. Define goals for each ecosystem (-cluster) 2. Select strategies most likely to achieve these goals 3. Take strategies & start to divide them into concrete tasks & actions a. Who is going to implement each task b. Define concrete timeline c. Define what resources are needed for implementation 4. Make use of the conceptual model to evaluate and conduct a plausibility check a. Do we achieve the change we want in the system? 5. Write concise work and monitoring plans	Further filtering and priority setting are required to advance to strategies that allow for adequate action. Here, two criteria are especially relevant: • Effectiveness (will the measure contribute to the goal?) • Feasibility (Will such a measure be accepted by the stakeholders?) • Socio-economically • Culturally appropriate • Financially viable (is there money to implement?) Further criteria had to be defined by the biosphere reserves and other participants

24.09.2020	*1st revision session for the working and monitoring plans*	
08.10.	*Goals and strategy revision*	
21.10	*2nd revision session for the working and monitoring plans*	
16.12.	*Closing event*	
		Image 25 Shatskyi BR´s Vitaliy Turych discussing the EbA work and monitoring plan - online session on 24.09.2020; Credit: K. Mack
02.03.2021	*Web-based presentation of updated results for the steering committee and Ministry of Environmental Protection and Natural Resources of Ukraine*	 *Image 26 Participants during the results presentation session Credit: K. Mack*

Based on the elaboration and collection of EbA strategies and measures (five catalogs per BR for the main ecosystem complexes), a criteria-based selection of 5 'key EbA-strategies' per region was completed. The work and monitoring plans for the strategies are ready for implementation. The results have already been presented to the project steering committee with the participation of Ukrainian ministry representatives and various documents have been distributed among the participants.

Results of the Strategy Development Process

1) An extensive portfolio of EbA measures and actions for the present ecosystem clusters of the biosphere reserves and regions was developed (SMA) (cf. attached catalogs in this documents series or via the project website: https://www.eba-ukraine.net/Publications.html).
2) Strategy evaluation and rating schemes were elaborated during offline work sessions by the BRs and partners by which the prioritization of strategies and final selection process was informed: The final selection of strategies was the following:

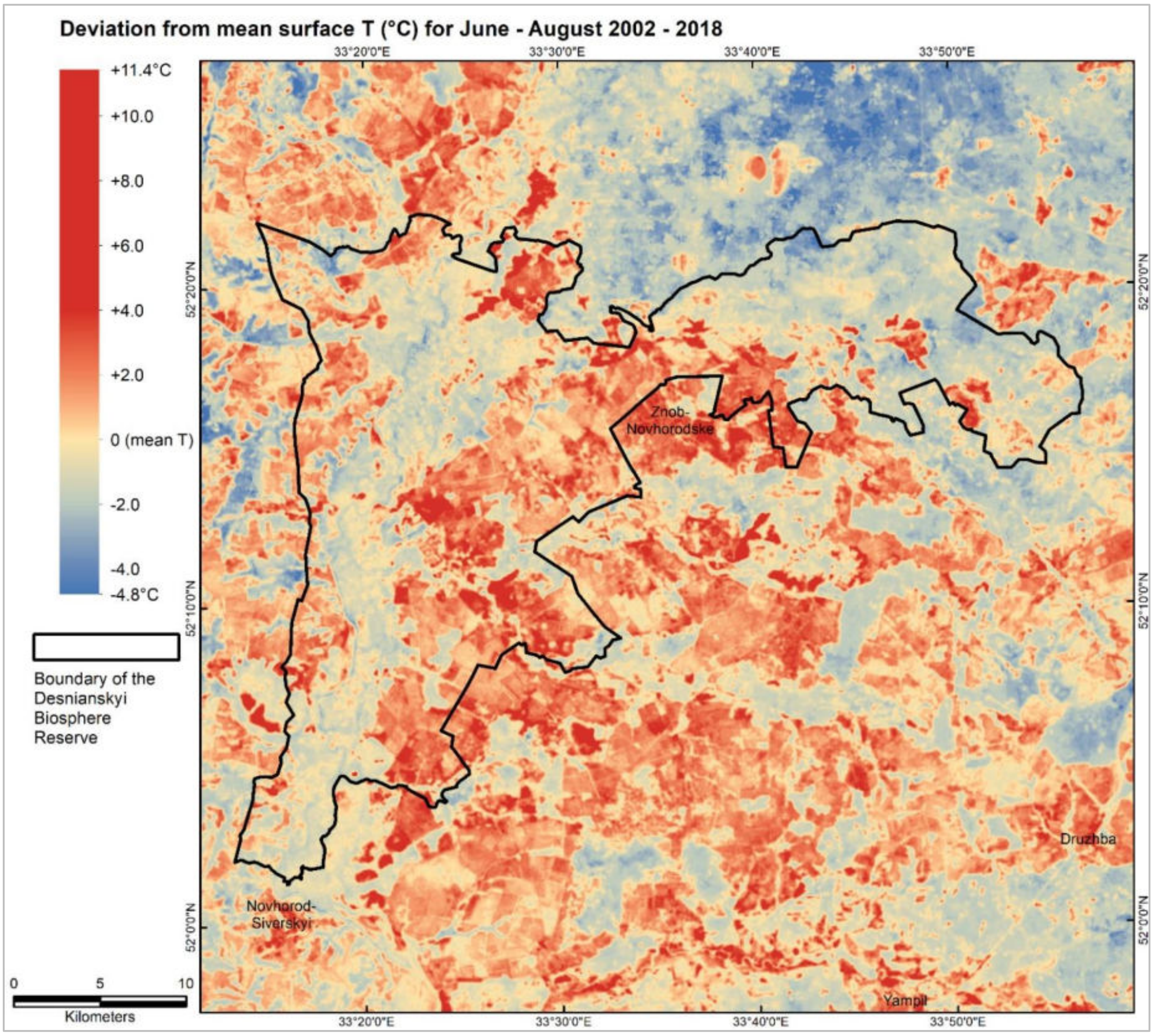
Desnianskyi BR (5 out of 20 strategies):

- Ecosystem-based forestry
- Transition to organic farming
- Increasing the area of (natural) green structures
- Increase of water retention in river basins and swamps
- Rational and sustainable use of agricultural lands

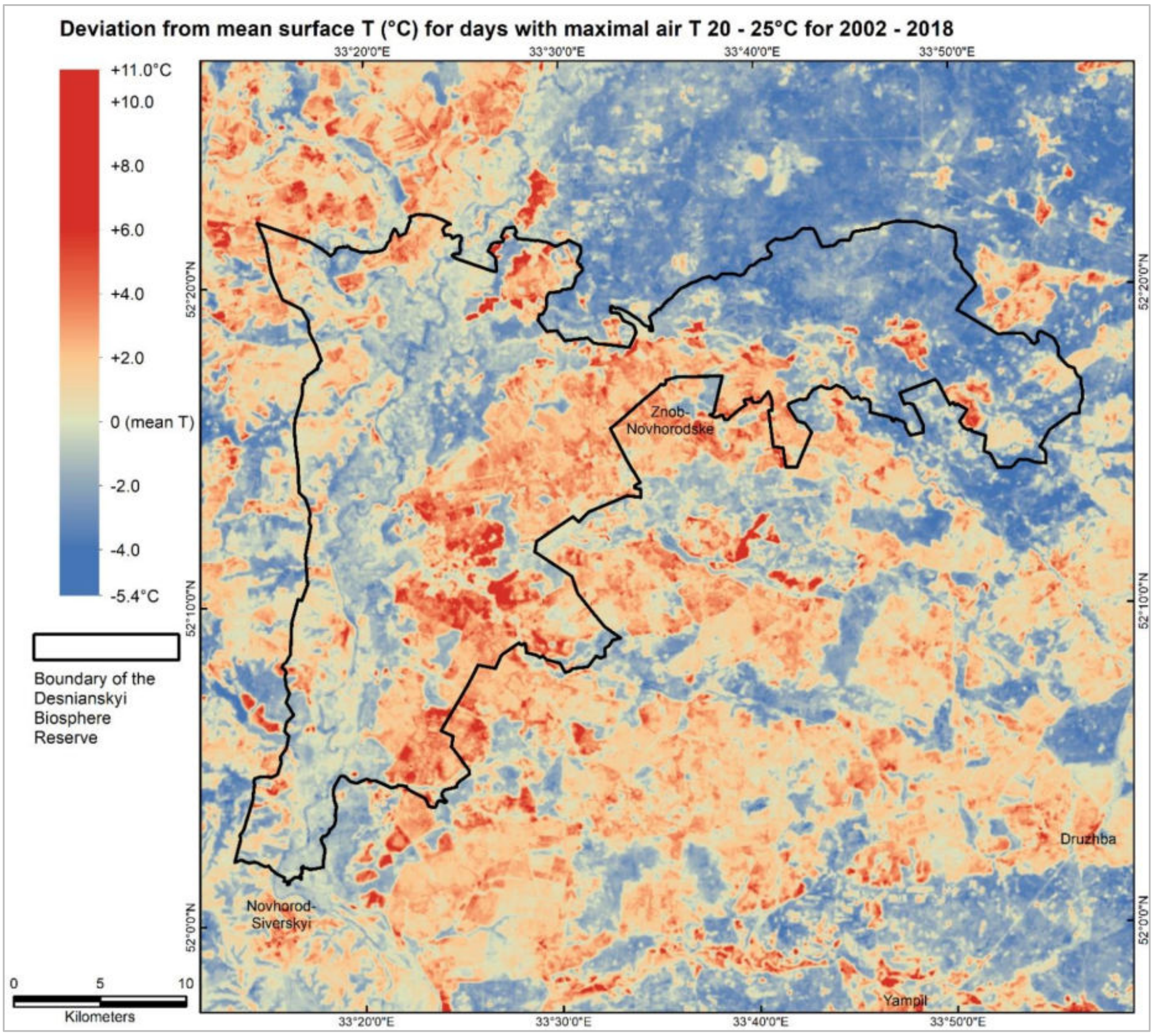
This process showed that Ecosystem-based Adaptation needs to address different levels of management:

- Direct protection and renaturation activities by the BR staff.
- Land-use changes with stakeholders in all zones of the biosphere reserves and beyond.
- Influence on regional and national strategies, policies, and laws.
- Showing presence and highlighting the importance of the UNESCO MAB program nationally and internationally.

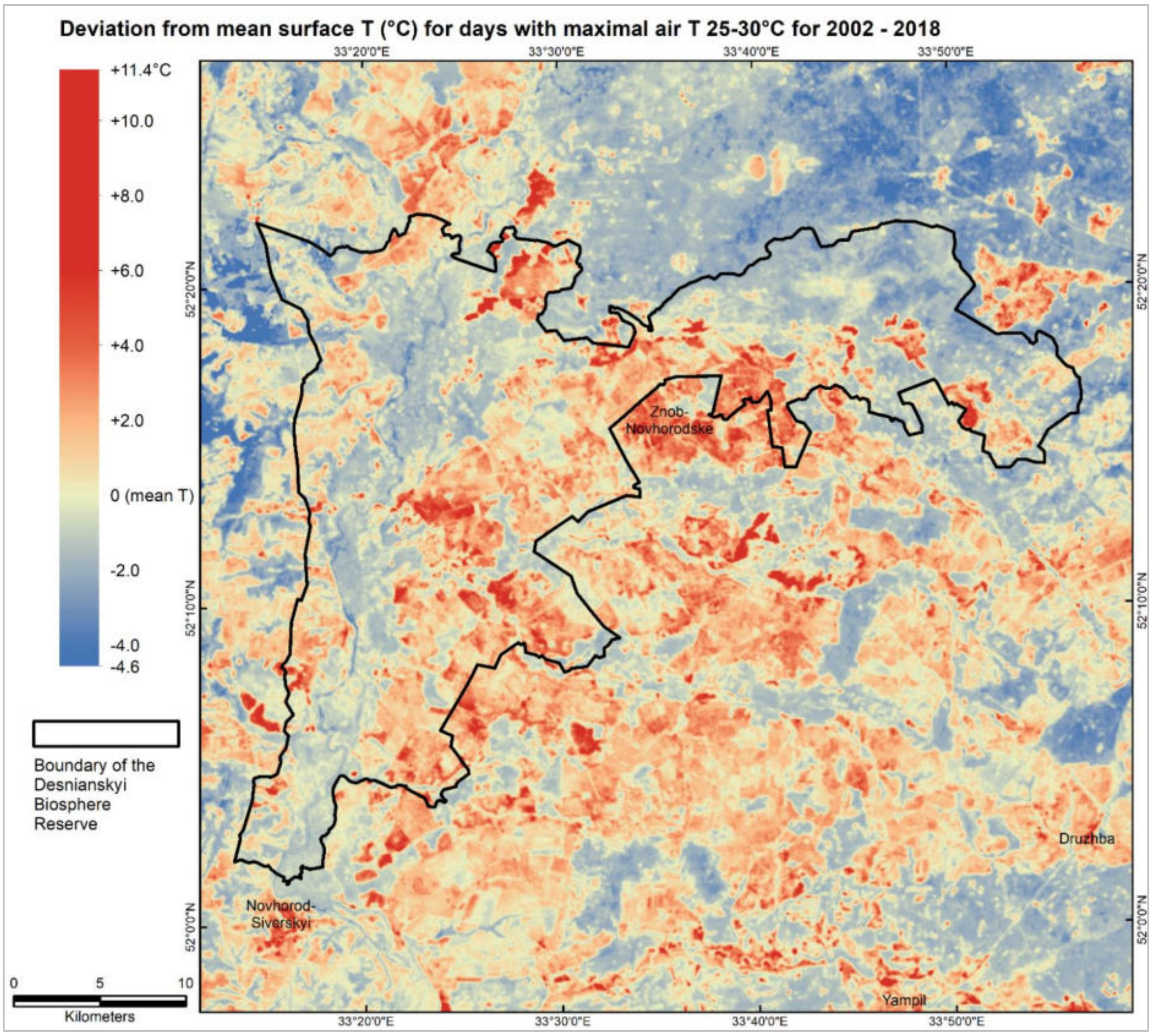
4.2 Maps: Deviation from Mean Surface Temperature - Summer Months 2002-2018



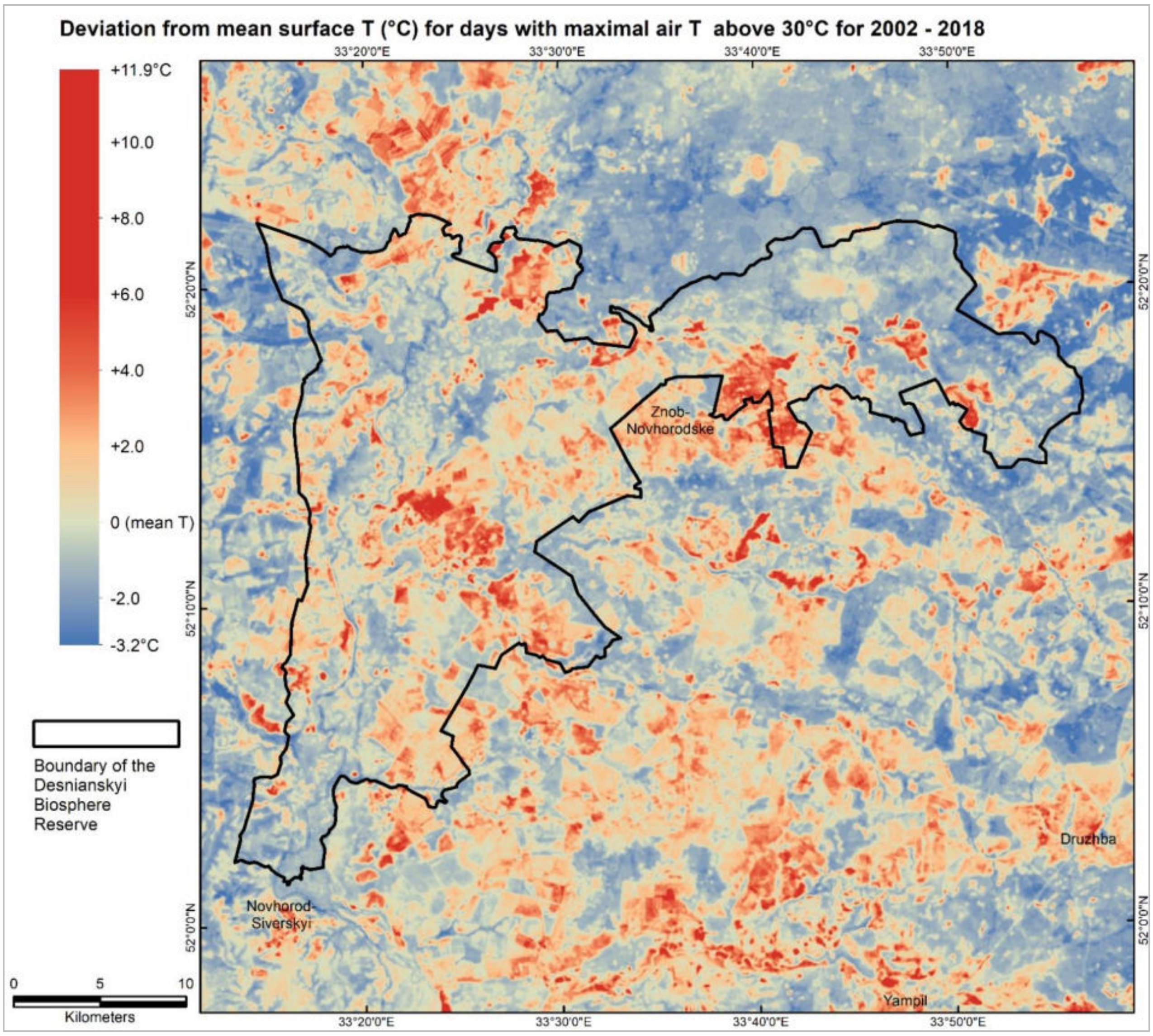
Map 7 Deviation from mean surface T (°C) for June-August (2002-2018)



Map 8 Deviation from mean surface T (°C) for June-August (2002-2018) - max air T 20-25°C

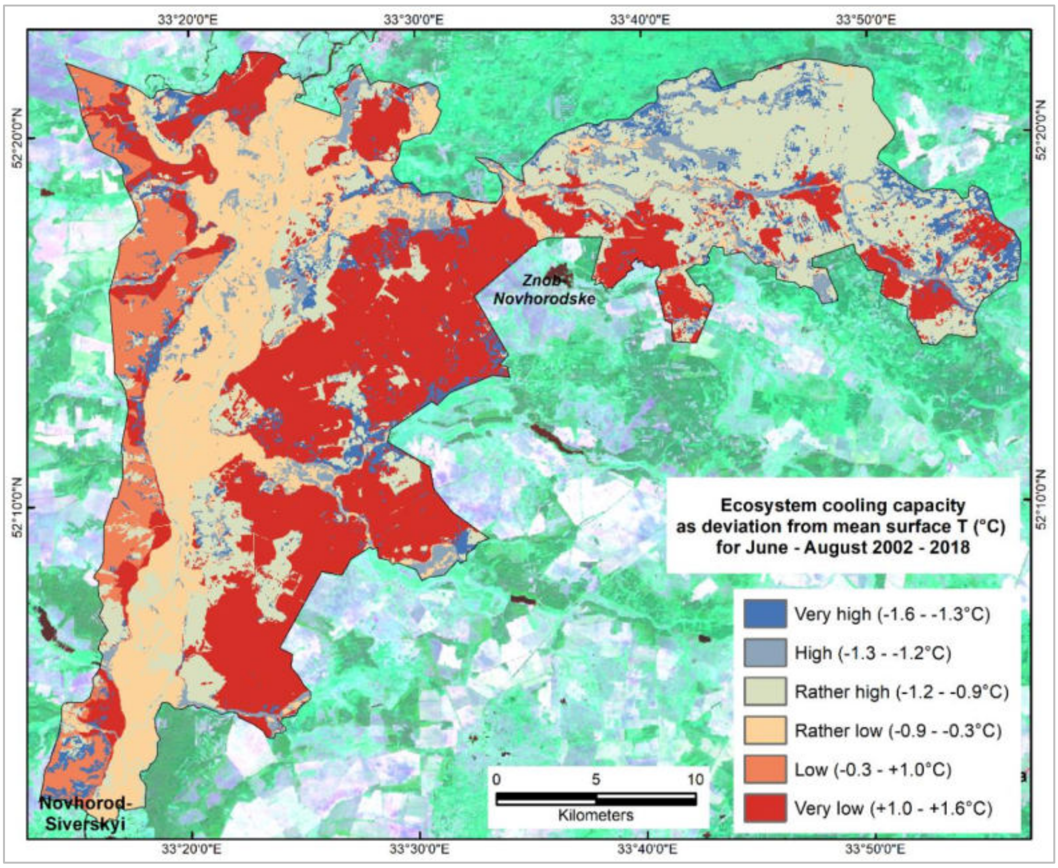


Map 9 Deviation from mean surface T (°C) for June-August (2002-2018) - max air T 25-30°C

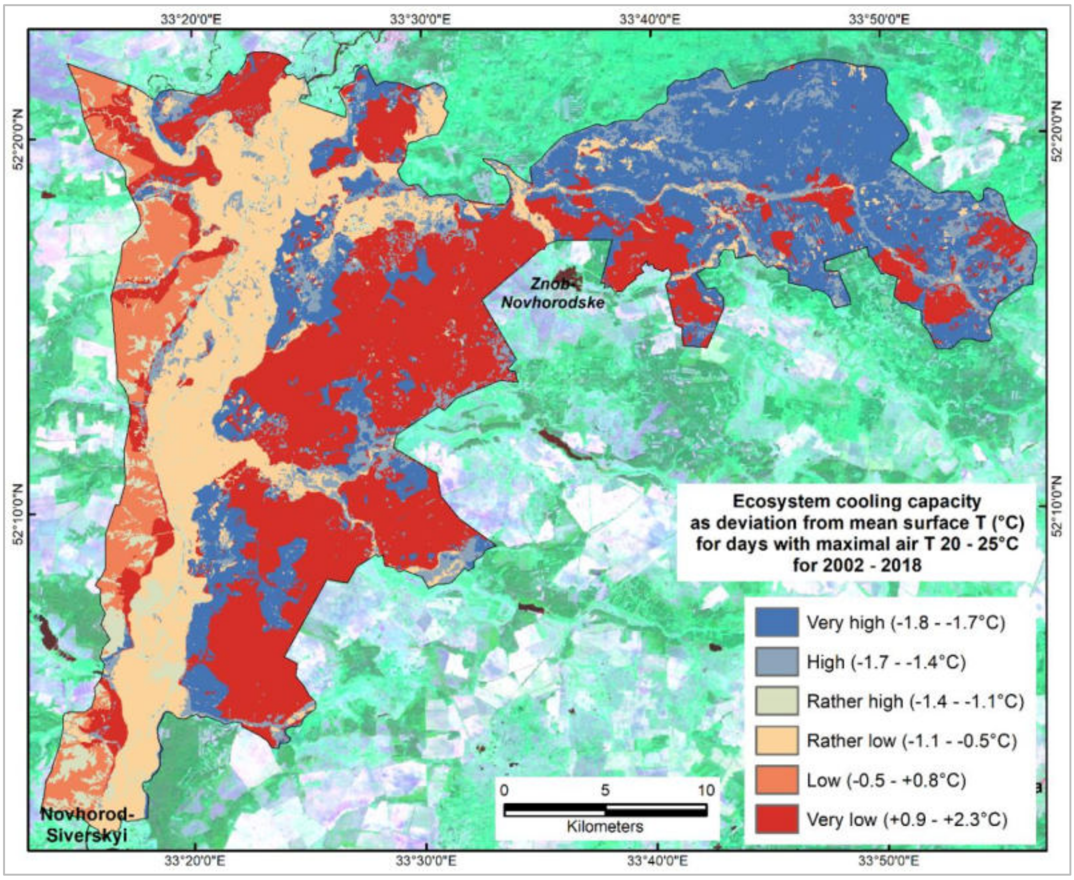


Map 10 Deviation from mean surface T (°C) for June-August (2002-2018) - max air T >30°C

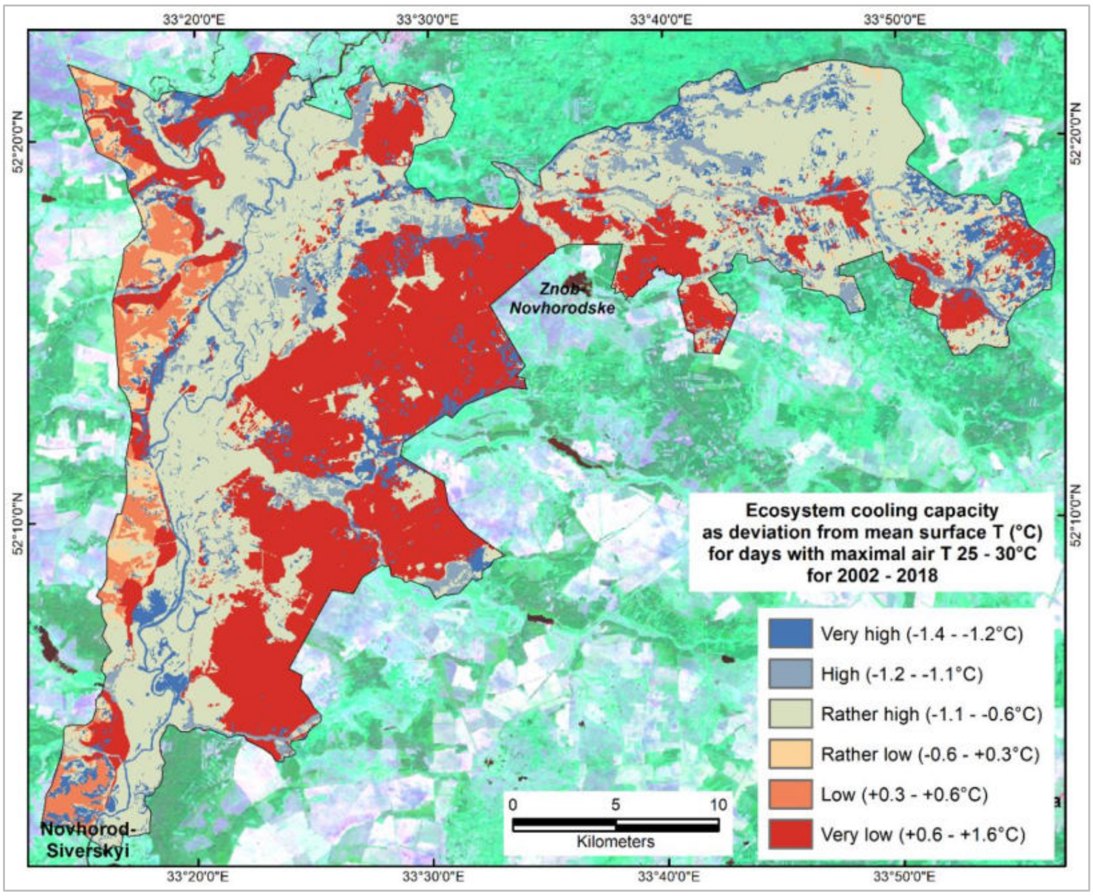
4.3 Maps: Ecosystem Cooling Capacity – Summer Months 2002-2018



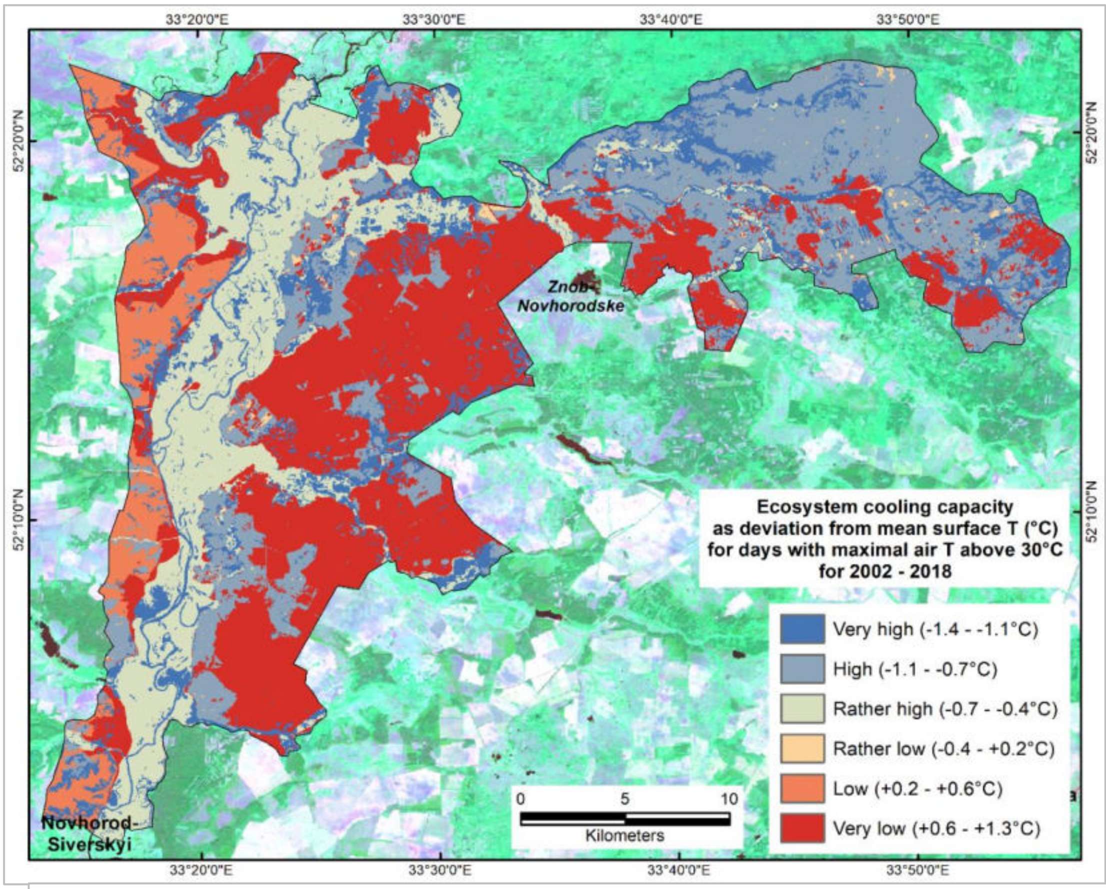
Map 11 Ecosystem Cooling Capacity – based on deviation from mean surface T (°C) June-August (2002-2018)



Map 12 Ecosystem Cooling Capacity – based on deviation from mean surface T (°C) June-August (2002-2018) for max T 20-25°C

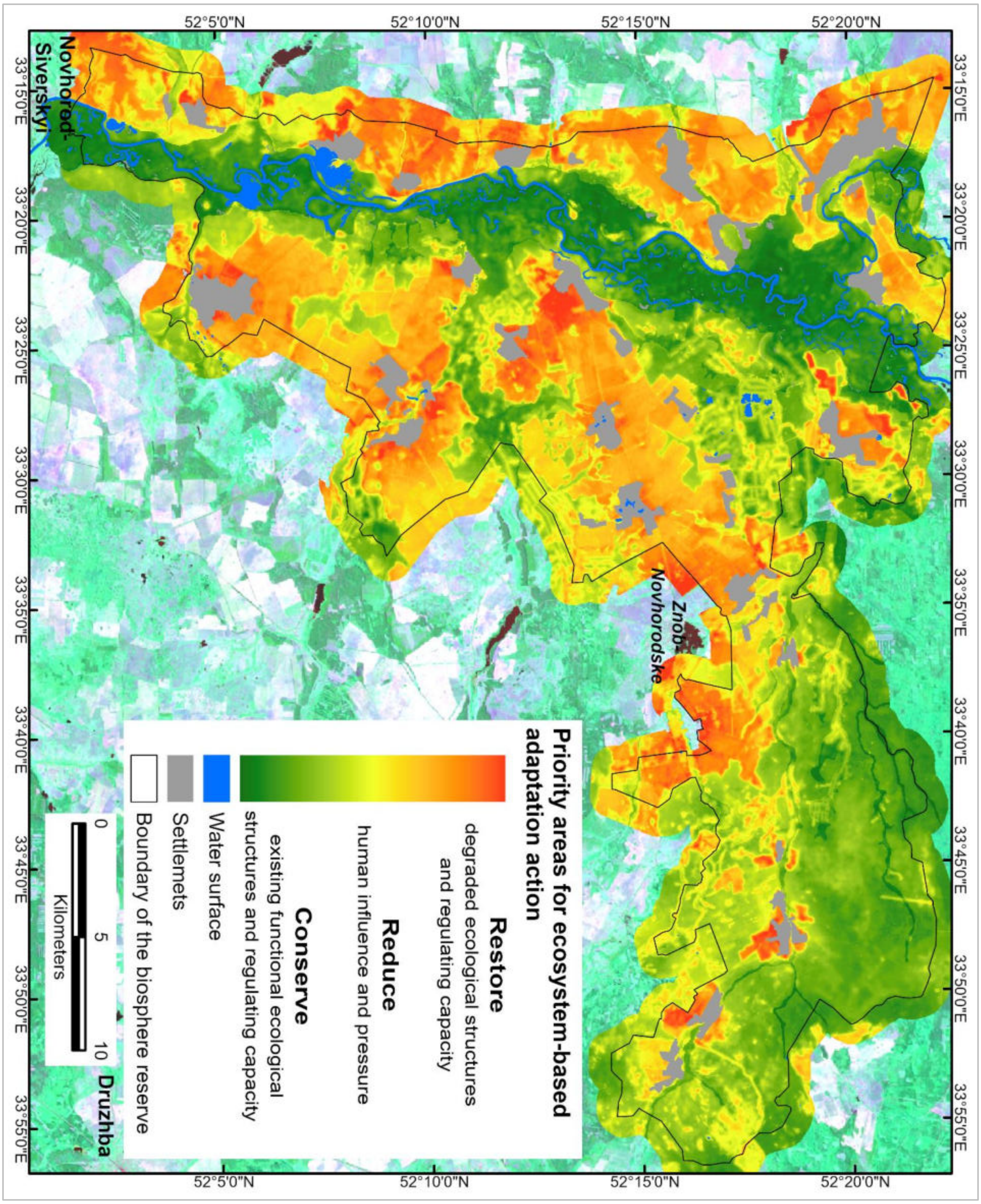


Map 14 Ecosystem Cooling Capacity – based on deviation from mean surface T (°C) June-August (2002-2018) for max T 25-30°C



Map 13 Ecosystem Cooling Capacity – based on deviation from mean surface T (°C) June-August (2002-2018) for max T >30°C

4.4 Map: Priority Areas for Ecosystem-based Adaptation Action



Map 15 Priority Areas for Ecosystem-based Adaptation Action - Restore, Reduce, Conserve

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