

A black and yellow salamander is the central focus, resting on a thick carpet of vibrant green moss. The background is a lush forest with moss-covered tree trunks and fallen logs, creating a sense of a healthy, undisturbed ecosystem.

ECOSYSTEM SERVICES

IN SLOVAKIA, POLAND
AND UKRAINE

ABOUT THIS BROCHURE

The Eastern Carpathians are one of Europe's last wild mountain regions – a mosaic of forests, rivers, and mountain meadows shared by Slovakia, Poland, and Ukraine.

This cross-border area forms the **East Carpathians Biosphere Reserve (ECBR)**, recognized by UNESCO as a symbol of cooperation in nature conservation.



This brochure presents the results of four scientific analyses on **eco-system services, water retention, tourism and carbon storage** in selected protected areas of the region. Full text of each of the report can be found on OTOP, Aegis and FZS websites.

They were prepared within the project “*Data-Based Advocacy for Sustainable Management of the East Carpathians Biosphere Reserve*”, supported by the **International Visegrad Fund**, to make expert knowledge accessible to decision-makers, local communities, and all who care about the future of the Carpathians.



Currencies are converted to EURO with January 2026 conversion rate.

The aim was to show how forests and wetlands support our lives – by storing carbon, regulating floods, purifying water, and providing space for recreation – and to explore **new, nature-based financing opportunities** that could strengthen protection while reducing logging pressure.

A key challenge for cross-border research is the **uneven availability of environmental data**. While Poland and Slovakia maintain open geospatial and ecological databases, the Ukrainian territory still lacks comparable standardized data due to historical and institutional limitations. Therefore, the analyses focus mainly on areas with accessible and reliable information, with the intention to expand this work as more data become available.

The findings serve as a **tool for communication, education, and advocacy**, supporting sustainable forest and water management, new conservation projects, and public awareness about the hidden value of nature.

The full technical reports are available in English, and this brochure is translated into Slovak, Polish, and Ukrainian.

This publication was created through cooperation between Aevis n.o. - Slovakia, OTOP - Polish Society for the Protection of Birds, FZS - Frankfurt Zoological Society and scientific experts from the region.

Together, we can ensure that the **Eastern Carpathians** remain a living landscape where nature, science, and people thrive side by side.

NATURE
is not a cost
– it is our
most valuable
asset.



CHANGING PERCEPTIONS OF FORESTS

Our expectations of forests are constantly evolving. In the past, their main value was often seen almost exclusively through **timber production**. Today, we increasingly recognize their broader role in providing **ecosystem services** – such as water retention, climate regulation, flood protection, or benefits to human health and well-being.

Yet most of these services remain **poorly reflected in the real economy**. They are difficult to measure and still lack functioning markets. As a result, forests are too often managed primarily as sources of wood, while their wider public benefits are overlooked.

The outcome is a paradox: society bears the long-

term cost of degraded forests and damaged ecosystems, while only a few gain short-term profit from logging. Unfortunately, this pattern continues even in some **state-managed forests**, including those located **within protected areas** – where the public interest and nature conservation should come first. Even in **Poloniny National Park**, the heart of the Slovak Carpathians, these contradictions can still be seen today.

WHAT ARE ECOSYSTEM SERVICES?

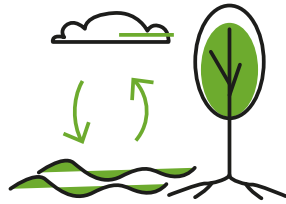
Ecosystem services are the benefits we receive from nature – clean water, fertile soil, fresh air, carbon storage and beautiful landscapes.

Their value is immense, yet often invisible in economic and political decisions. They are grouped into four main types (according to Millennium Ecosystem Assessment):



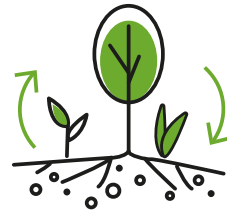
PROVISIONING

– food, timber,
fresh water



REGULATING

– climate regulation,
flood protection,
carbon storage



SUPPORTING

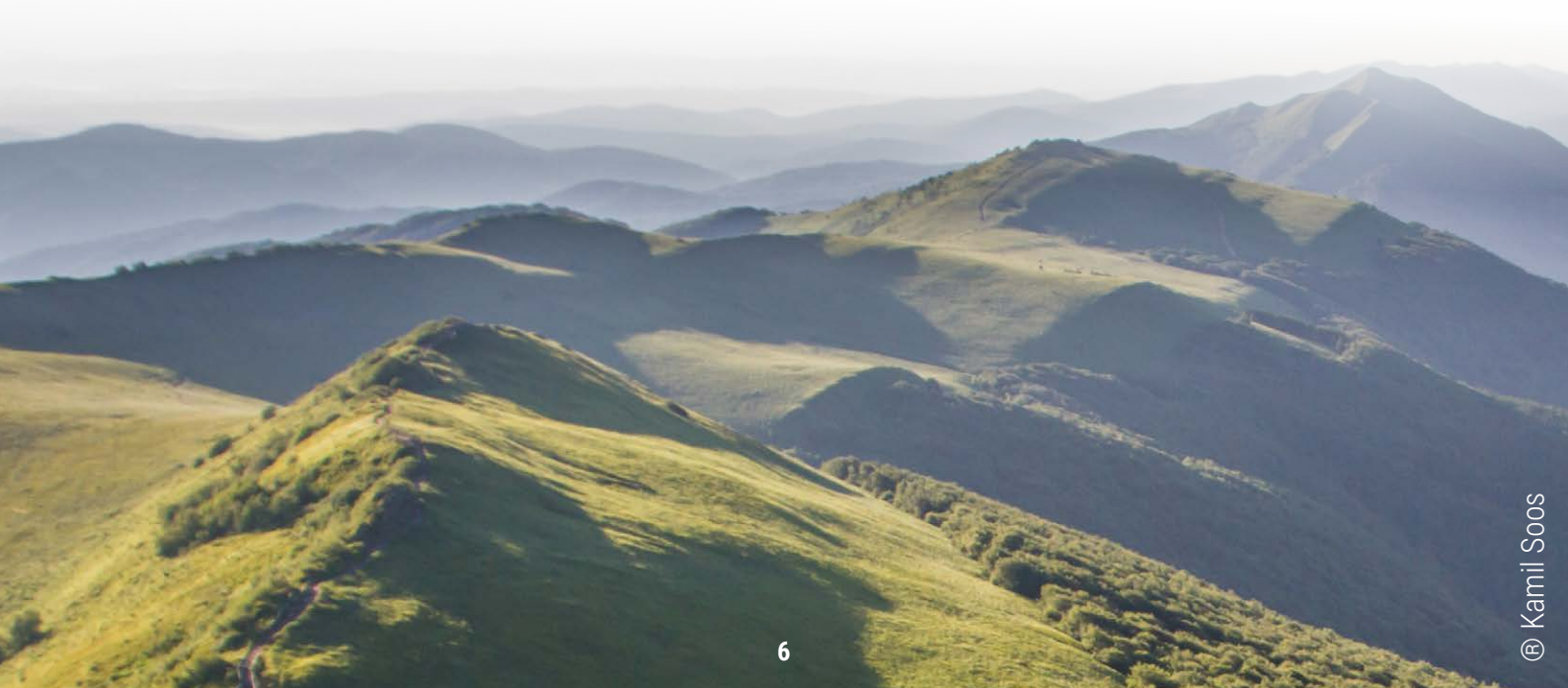
– soil formation,
nutrient cycling,
biodiversity



CULTURAL

– recreation,
heritage, inspiration,
and education

In European classification systems, regulating and supporting services are often grouped together as ‘regulation and maintenance services’.

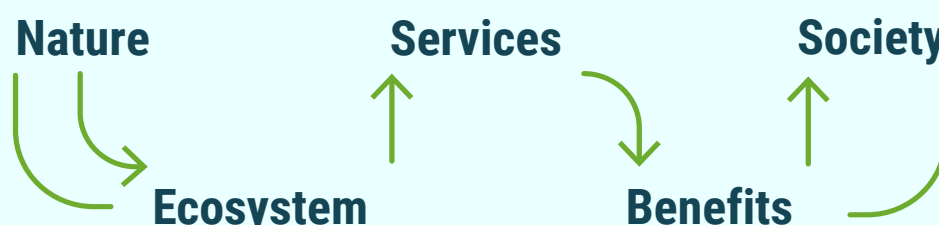


WHY ECOSYSTEM SERVICES MATTER FOR THE EASTERN CARPATHIANS

Shared by Poland, Slovakia and Ukraine, the Eastern Carpathians form a living network of forests, rivers, wetlands and mountain meadows that support both nature and society in countless ways. They supply drinking water, regulate floods, store carbon, protect soils, provide space for recreation, and carry immense scenic and scientific value.

Across the region, these services are often visible in very concrete ways:

- The **Starina water reservoir** in the Slovak Poloniny National Park provides clean drinking water for over 645,000 people.
- In **Bieszczady National Park**, wetlands and valley peatlands naturally store carbon, help slow down flood waves after intense rainfall, and release water back into the landscape during dry periods.
- The **primeval beech forests** of the Carpathians, shared across all three countries, hold exceptional biodiversity and were recognized as a UNESCO World Heritage Site for their scientific importance.
- In Ukraine, the Carpathians have also become a place of **healing and recovery** for soldiers and civilians affected by the war — reminding us that cultural and psychological benefits are just as important as economic ones.



Recognizing these diverse values helps communities and leaders see that **nature is not a cost, but our most valuable asset.**

Cross-border cooperation can further strengthen data collection, ecosystem mapping and monitoring, support sustainable tourism and land use, create **payment schemes for ecosystem services (PES)**, and guide **green recovery** in war-affected areas.

Payments for Ecosystem Services (PES) are mechanisms in which those who benefit from nature —

such as clean water or flood protection — financially support the people or institutions who protect or restore the ecosystems that provide these services.

In practice, this means that **the beneficiaries pay**, and **the stewards of nature receive support** for keeping forests, wetlands or meadows healthy.

Beneficiaries → pay → Providers → who protect Ecosystems → that deliver Services → that are given back to society



While ecosystem services are a shared concept across Europe, each country approaches their assessment and use in its own way. The following section offers a brief look at how these ideas are implemented in **Slovakia, Poland, and Ukraine.**



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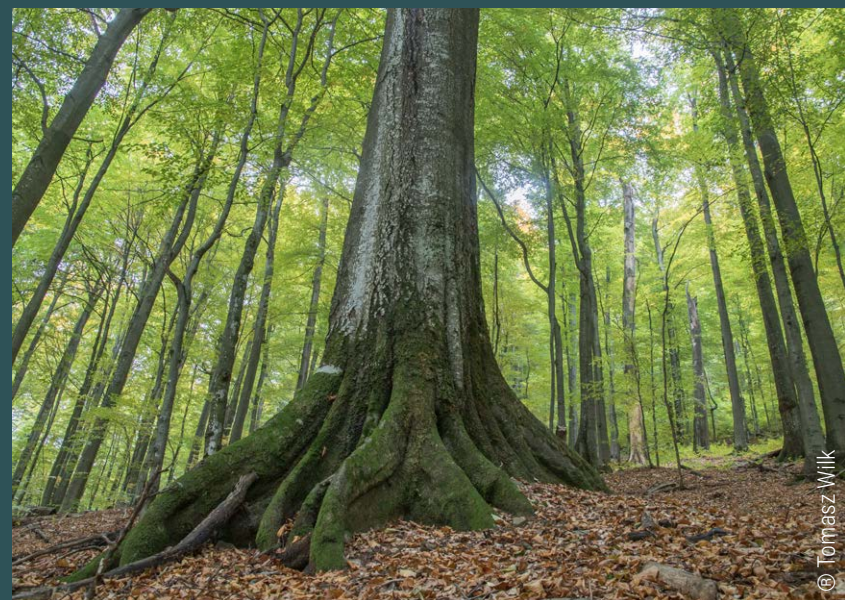
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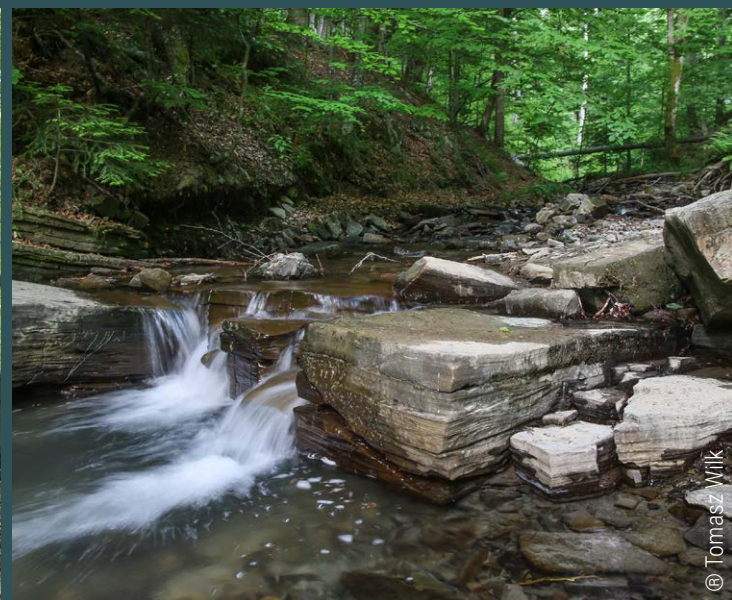
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SLOVAKIA: MOUNTAINS THAT SUSTAIN LIFE

Forests, wetlands and grasslands are Slovakia's main providers of ecosystem services.

Research by the Slovak Academy of Sciences and the State Nature Conservancy shows that **natural and semi-natural ecosystems cover over 38% of the country**, with the **highest service capacity in beech – fir and mixed mountain forests and wetlands**.

Protected areas such as **Veľká Fatra, Muránska Planina and Tatra National Parks** bring major benefits:

- **VEĽKÁ FATRA NATIONAL PARK – €179 million/year (≈ €4,400/ha)**, total economic value (multiple services aggregated via benefit-transfer).
Source: **Považan et al., 2014a**. Value of ecosystem services in mountain national park. Case study of Veľká Fatra National Park (Slovakia).
- **MURÁNSKA PLANINA NATIONAL PARK – ~€10 million/year**, total economic value (use + non-use values).
Source: **Považan et al., 2015**. Valuation of ecosystem services in the NP Muránska planina (Slovakia) – case study.)
- **TATRA NATIONAL PARK – €17.5 million/year**, recreation only (visitor willingness-to-pay, contingent valuation).
Source: **Kubak et al., 2020**. Economic Value Estimation of the Natural Heritage of the Tatra National Park.)

Although calculated with different methods, these figures together show that **nature contributes far more to our well-being than we usually realise.**

Forests and meadows support tourism, clean water and air, and carbon storage – all vital to both people and the economy.

Integrating the ecosystem-services concept into planning can help **balance development with nature's limits.**



POLAND: MAPPING NATURE'S BENEFITS

In Poland, the concept of **ecosystem services (ES)** is increasingly used to connect scientists, local communities and policy makers.

The **MAES Poland Project (2020–2023)** mapped forests, farmland, rivers and urban areas using EU standards, showing that **forests and river catchments with low human pressure** offer the richest mix of services — from clean air to recreation.

Studies (Zydroń et al. 2021, Boćkowski et al. 2024) show that people who value nature's **cultural and recreational benefits** are generally more supportive of creating or maintaining protected areas — as illustrated by research in the projected **Turnicki NP** and **Wielkopolski regions**.

Local research also reveals a strong **willingness to pay for nature-based tourism**, confirming that the economic value of **ecosystem services often exceeds the costs of protection**.

Although some conflicts arise between local resource use and conservation goals, **participatory mapping and dialogue** help find fair, win-win solutions for people and nature.

DID YOU KNOW?

In Poland, studies show that people who see nature as more than just a source of raw materials are also the ones who **support it the most.**

UKRAINE: NATURE'S RECOVERY AND RESILIENCE

Ukraine's diverse landscapes – from **Carpathian forests to steppes and wetlands** – hold vast but uneven ecosystem value. The **Carpathians, forest-steppe and floodplains** rank highest, together covering about 27% of the country. National studies estimate the **total value of ecosystem services** at roughly **UAH 77.8 billion per year** (1,5 billion EUR).



Case studies from **Carpathian protected areas** highlight specific ecosystem functions and benefits:

- **PRUT RIVER HEADWATERS (CARPATHIAN NNP)**
 - flood regulation, water storage, recreation
(Source: **Korchemlyuk 2022**)
- **SYNEVYR NATIONAL PARK**
 - mountain peatlands storing carbon and regulating water flow
(Source: The Information Sheet on Ramsar Wetlands (RIS), WWF-BCG country recovery report)
- **SKOLE BESKIDS & CARPATHIAN BIOSPHERE RESERVE**
 - satellite mapping for forest and carbon monitoring
(Source: **Chaskovsky et al. 2025**, MARISCO / CBR participatory management documents)

A **Draft Law on Ecosystem Services** is under preparation, with adoption expected by 2025.

War-related environmental damage **exceeding 50 billion USD (42 billion EUR)** makes **ecosystem restoration and valuation** essential for rebuilding Ukraine's **natural capital** and for **alignment with EU environmental standards**.

On average,
one hectare of forest
stores about 5 t CO₂ and
provides **oxygen production**
and air-filtration services
worth around 75 000 UAH
(1 463 EUR) per ha
(Stoiko et al. 2024).

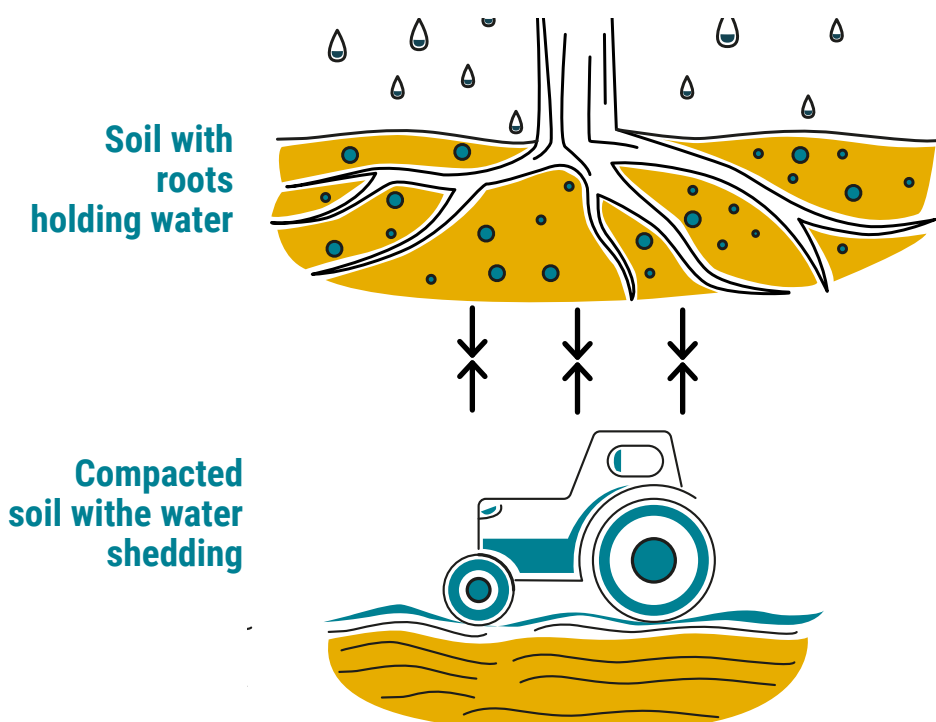
NATURAL WATER RETENTION IN THE EASTERN CARPATHIANS

How forests, soils, and mountain landscapes help hold water in the region

© Katarzyna Gubrynowicz

Why Water Retention Matters

In the Eastern Carpathians, rain and snow do not simply run off into rivers. Forests, soils, wetlands and valleys **hold water like a sponge**, slowing runoff, reducing floods, and maintaining rivers and springs during dry periods.



This “natural water storage” is a vital ecosystem service – especially in a time of increasing climate extremes such as droughts and flash floods.

A Shared Mountain Region

The **East Carpathian Biosphere Reserve (ECBR)** spans parts of **Slovakia, Poland** and **Ukraine**. It is a mosaic of **mountain forests, deep valleys, meadows** and **wetlands**.

Because the landscape is steep and the bedrock is mostly **flysch sandstone** and **shale**, water tends to run off quickly unless slowed by **vegetation and soil**.

What Determines Water Retention?

Factor	Why it matters	What it means here
Topography (shape of the land)	Steeper slopes → faster runoff	Many slopes in ECBR are steep → runoff risk is high
Soils	Deep, humus-rich soils hold water	Forest soils retain moisture; compacted or eroded soils lose it
Vegetation	Forest canopies slow rainfall & roots help infiltration	Forests are key water regulators
Geology	Some bedrock absorbs water, some repels	Flysch has limited storage → landscape relies on forests & soil
Land use	Human activities can accelerate runoff	Clearcuts, forest roads & intensive grazing increase erosion + runoff

What the Study Found

Using landscape hydrological indicators (TWI and LHP), the study (prepared by Tomáš Lepeška) mapped where the landscape is most able to **retain water**:

- **Valley bottoms, wetlands and floodplains** → excellent natural water retention
- **Forested slopes** → good retention, especially in older or mixed forests
- **Open grasslands and pastures** → moderate retention
- **Steep, sparsely vegetated slopes** → low retention, high runoff
- **Forest roads, compacted areas, construction zones** → very low retention



KEY MESSAGE

Water retention is **very uneven** across the Carpathians – protecting the **right areas** and managing land carefully is crucial.

What Helps Keep Water in the Landscape?

Forests (mountain slopes & uplands)

- Keep continuous forest cover on steep slopes
- Support diverse **mixed and old-growth** mountain forests, not monocultures
- Leave **deadwood** in forests – it enhances water storage and slows runoff
- Avoid dense networks of forest roads; **analyse the existing road network and consider rewilding or decommissioning unused roads**
- Restore degraded slopes gradually, using native deep-rooted species

Wetlands, peatlands & floodplains (lowlands and valleys)

- **Protect and actively restore natural processes** in wetlands, peatlands and floodplains – they are natural water reservoirs
- **Protect buffer zones** around water reservoirs and wetlands
- Restore drained or degraded wetland areas to slow runoff and increase long-term water storage

Farmland & cultural landscapes

- Use grazing and mowing in ways that prevent soil compaction
- Maintain landscape heterogeneity (meadows, hedgerows, small patches) to improve infiltration

System-level actions

- Adopt a **holistic, integrated approach** to landscape management
- Involve **local communities** in participatory ecosystem-service valuation and planning

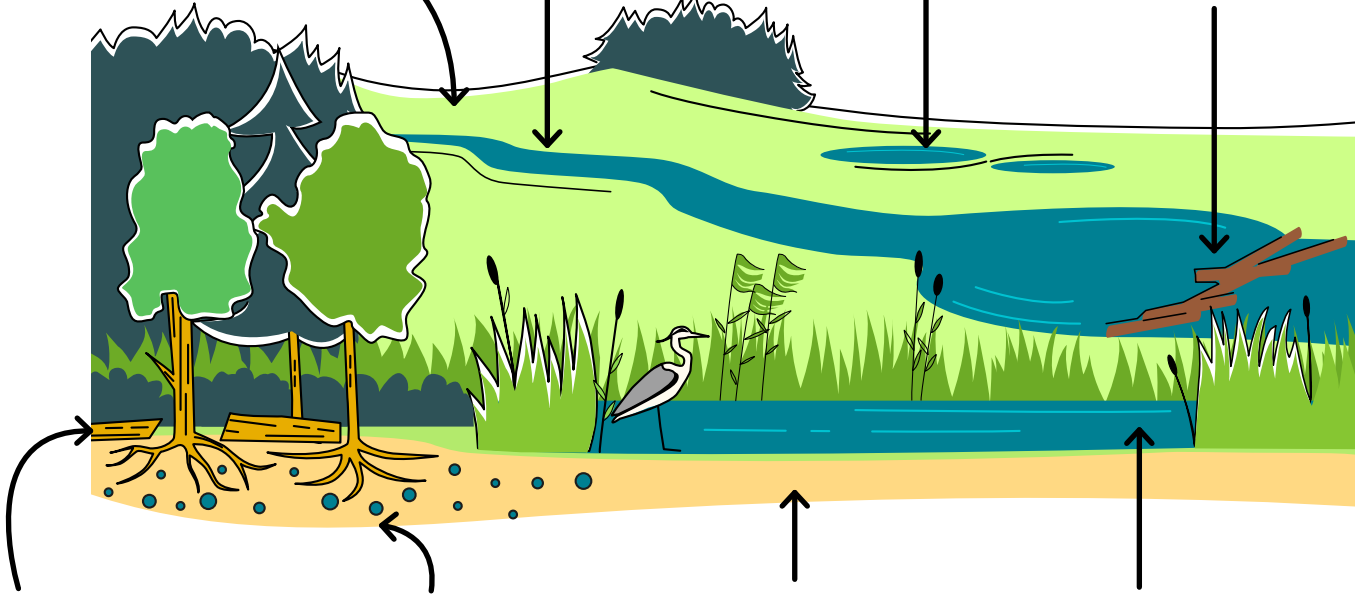
What IMPROVES retention?

Healthy mountain meadows
(good infiltration)

Restored river channels
(re-meandering)

Small water bodies
(ponds, pools)

Beaver dams
(mini reservoirs)



Deadwood in forests
(absorb and store water)

Natural forests
(deep roots, humus, shade → slow runoff)

Undrained organic soils

Healthy wetlands & peatlands
(absorb and store water)

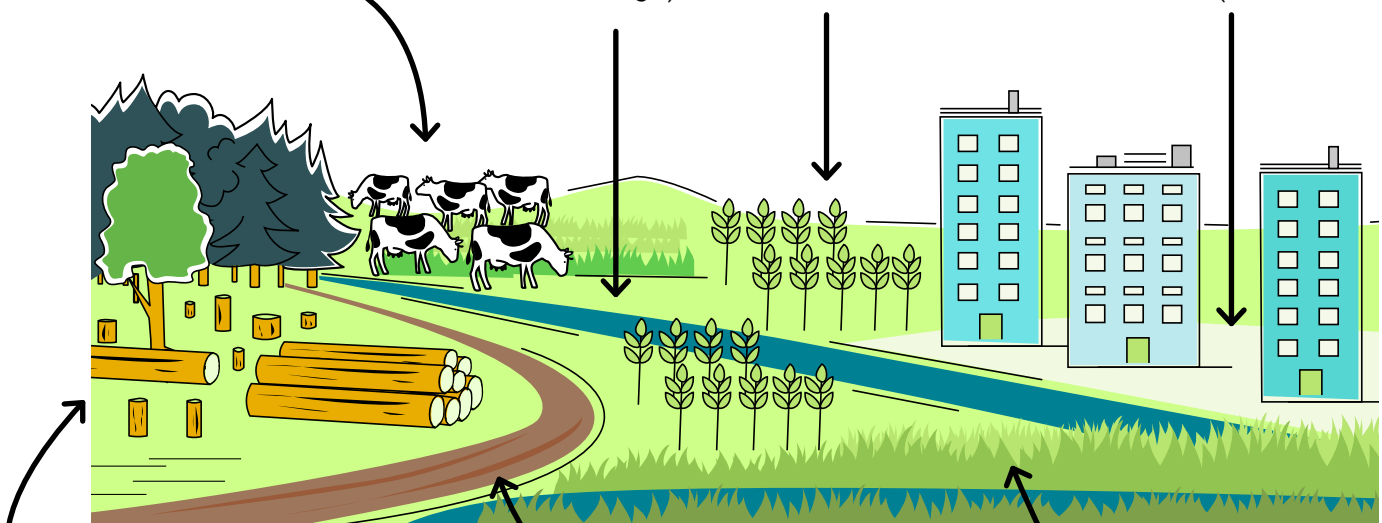
What WORSENS retention?

Overgrazing
(compacted soil → no infiltration)

Straightened rivers
(too fast flow, no natural storage)

Monoculture plantations
(poor soil structure)

Urbanization & sealed surfaces
(no infiltration)



Deforestation & logging roads
(soil compaction → fast runoff)

Eroded or degraded soils

Drained wetlands/ melioration channels
(water flushed out)

Why This Matters for Local Communities

- **Less flood damage** after heavy rain
- **More stable springs and streams** during summer droughts
- **Cleaner water**, requiring lower water treatment costs
- **Healthier forests and soils**, supporting tourism and biodiversity

Studies from the U.S. and Costa Rica show that **forests reduce the cost of drinking water treatment. Every 10% increase in forest cover in a watershed can reduce water treatment costs by about 20%.** This means **protecting mountain forests is also an economic investment** – not only an ecological one.

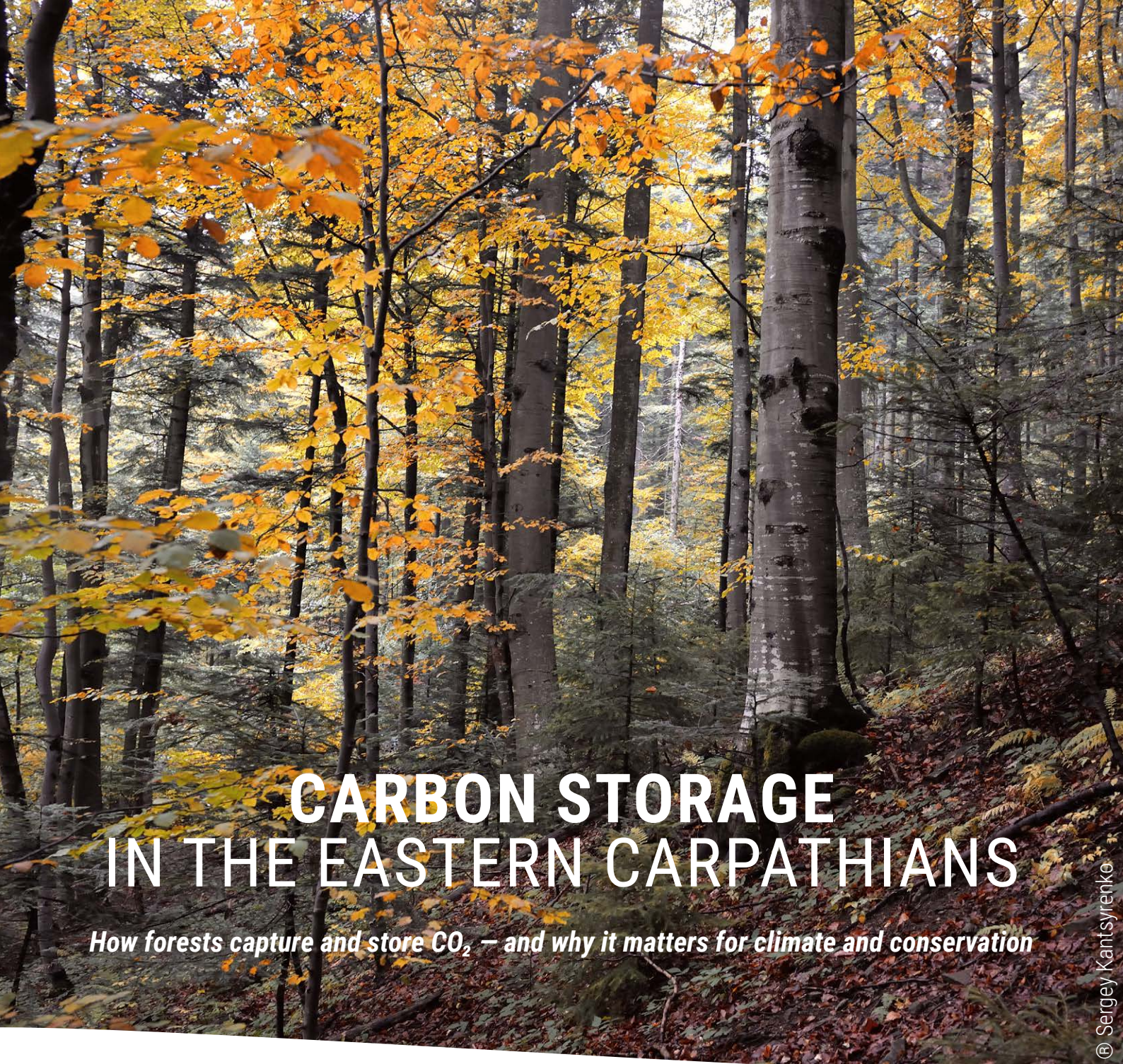


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DID YOU KNOW?

Mountain forests act like natural water filters – their soil can hold up to several hundred liters of water per square meter.

Forest roads can dramatically increase runoff – one badly placed road can drain an entire slope.



CARBON STORAGE

IN THE EASTERN CARPATHIANS

How forests capture and store CO₂ – and why it matters for climate and conservation

© Sergey Kantysrenko

The Role of Forests in Carbon Sequestration

While many ecosystem services are difficult to measure or monetize, carbon sequestration is an exception. It can be quantified with scientific methods and traded on functioning carbon markets.

All green plants — including trees — use **water and carbon dioxide** during photosynthesis to build organic matter, releasing oxygen as a by-product. CO₂ is also the most important greenhouse gas driving climate change when present in excess in the atmosphere.

To address global warming, science identifies two main pathways:

- **reducing emissions**
- **removing excess CO₂ from the atmosphere**, either through technological filters or through plants — which have been doing this naturally for millions of years, for free, at large scale, and with no energy input.

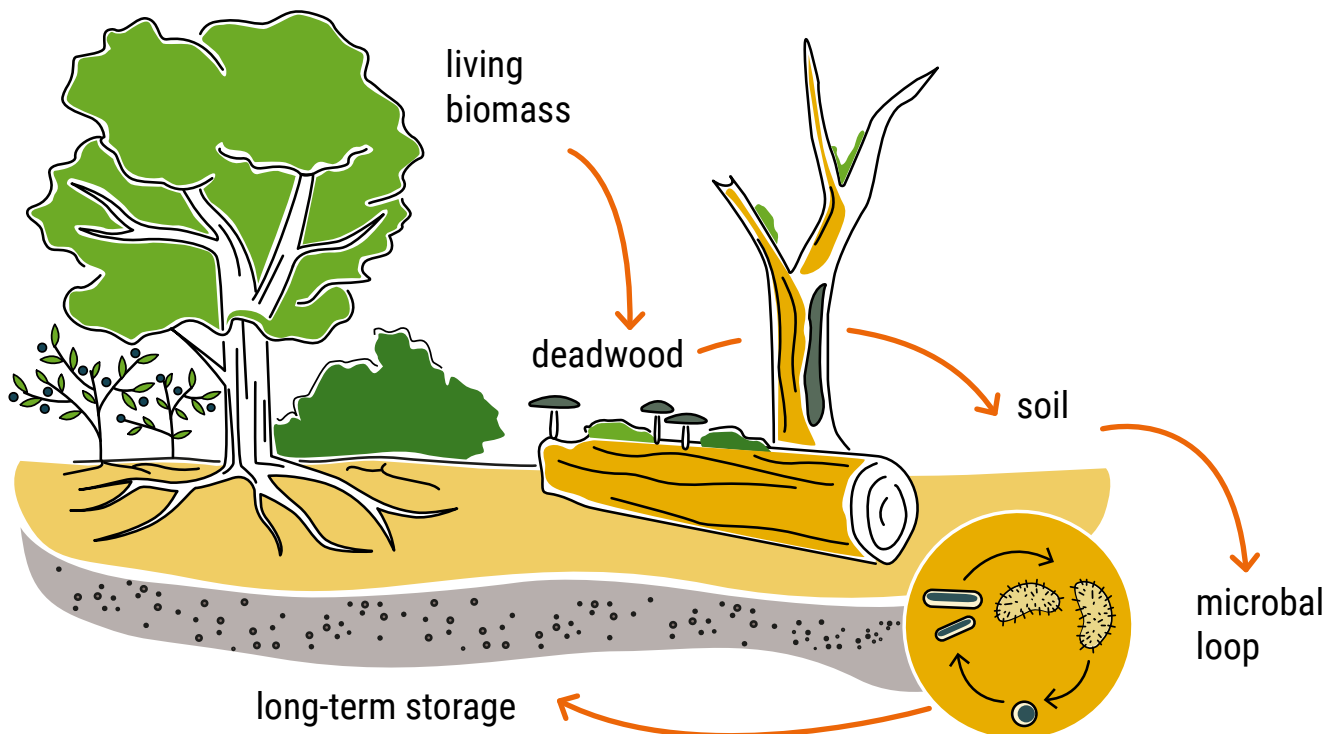
Every tree stores carbon as it grows, increasing its biomass, which is largely made of CO₂. But trees also **send carbon into the soil**: through falling leaves, decomposing roots, and by releasing carbon-rich compounds that feed soil fungi and bacteria. In this sense, **a forest is far more than a collection of trees.**

A planted monoculture harvested every 80–100 years accumulates only a fraction of the carbon found in a natural or old-growth forest. Protecting existing forests from logging is considered far more effective than planting new ones. Young trees may grow quickly in height, but their total biomass — and therefore the amount of carbon they store — increases only slowly in the first decades. In the Eastern Carpathians, a single hectare of primary forest can store **up to 2,500 tonnes of CO₂**, much of it held for decades to centuries.

Logging reduces carbon stocks immediately — by removing timber and by damaging soils with machinery and skidding. On steep slopes and at high elevations, where soils are thin and slow to regenerate, recovery may take **hundreds or even thousands of years**. In extreme rocky habitats, forest loss may even become **irreversible**.

And importantly:
not all forests store carbon equally!

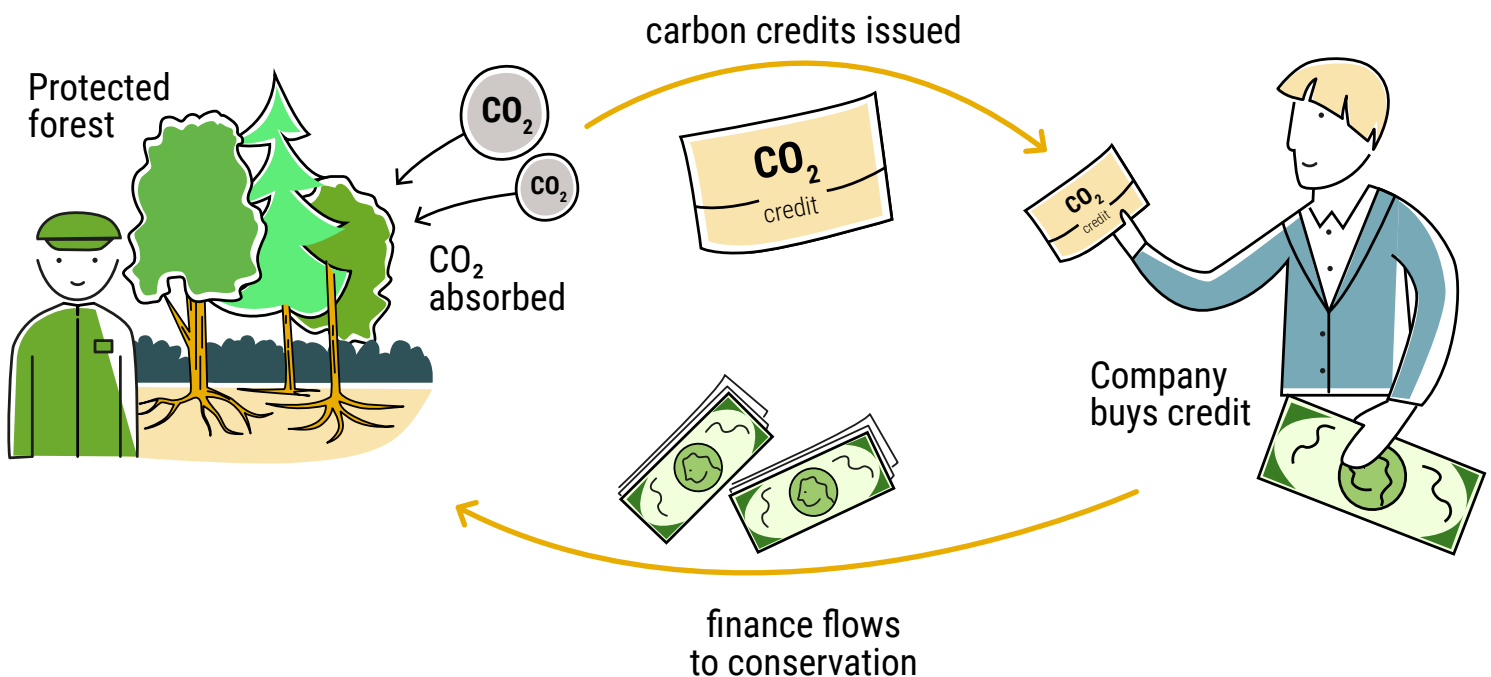
How carbon flows in a forest?



How Carbon Markets Work

Carbon credits are created when a landowner can **prove that their forest absorbs and stores a measurable amount of CO₂**. Companies wishing to offset part of their emissions can then **purchase these credits**, creating a financial incentive for landowners to protect or restore ecosystems instead of logging them.

In Slovakia, this mechanism is still rarely used, but it could become a powerful tool for financing conservation — especially in regions where biodiversity is exceptionally high and logging pressure remains strong.



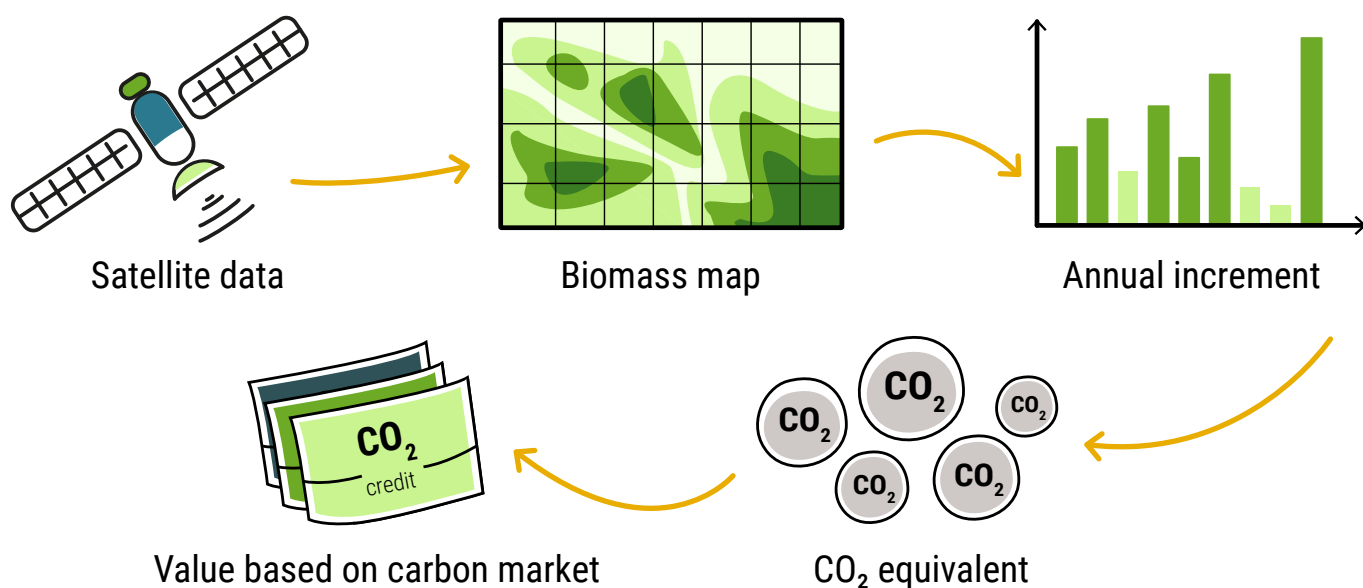
About the Analysis

This analysis examined the **carbon storage potential** of the **East Carpathians Biosphere Reserve (ECBR)** using advanced remote-sensing and forest-inventory methods. The study included Polish and Ukrainian protected areas as well as the Slovak **Poloniny National Park**, which is an important focus area for our organisation.

Data sources and methods

- **Satellite data from the European Space Agency (ESA)** estimating above-ground biomass (AGB) per hectare, mapped yearly between **2010–2021**.

- Biomass time series were used to calculate **average annual biomass increment** (including below-ground biomass).
- In the case of **Bieszczady National Park (Poland)**, ESA data were verified against ~800 ground plots (Atpole84 network) and forest LiDAR data. The comparison showed **partial agreement**, meaning satellite-based estimates need to be interpreted with care.
- **Carbon credit prices** were taken from voluntary carbon markets, including the **2024 global average price (5,29 EUR)** and the **2024 European regional average (24,39 EUR)**.



Key Findings

Across the ECBR, the estimated financial value of carbon sequestration ranges **from 262,366 EUR to 2.32 million EUR per year** depending on:

- the time period used (2010–2021 vs. 2015–2021)
- and the assumed market price of carbon credits.

Values are significantly lower when calculated over the **longer time series**, due to reduced biomass

growth between 2010 and 2015 — likely influenced by **logging activity** in several areas. This is seen particularly clearly in Poloniny National Park, where:

- **2015–2021:** average + 0.8 t/ha/year (net gain)
- **2010–2021:** average –1.6 t/ha/year (net loss)

This illustrates how even moderate logging can reverse an ecosystem from a carbon sink into a carbon source.

Context from Scientific Literature

Scientific studies show that **Central European mixed and broadleaf forests** can, under optimal conditions, absorb **10–15 tonnes of CO₂ per hectare per year**.

The lower values found in this analysis are partly due to:

- the inclusion of **non-forest areas** (meadows, settlements, bare ground),
- differences in protection levels and disturbance history across the protected areas.

This underscores the importance of maintaining continuous, old-growth-rich forest cover and avoiding practices that undermine long-term carbon storage.

What This Means for Conservation?

Using carbon markets as a complementary financing tool could help **reduce logging pressure**, support the creation of **long-term conservation zones**, and direct new resources toward **forest and peatland restoration** throughout the Eastern Carpathians.

Combined with ecosystem-service assessments and community involvement, **carbon valuation** can become **a strong argument for modern, nature-based forest management the region.**

BENEFITS FROM TOURISM IN BIESZCZADY NATIONAL PARK

Nature protection as a foundation of regional development



Tourism in Bieszczady National Park is inseparably linked to the area's natural values. Visitor surveys clearly show that people come primarily because of the park's protected landscapes, wilderness character and opportunities for quiet, nature-based recreation. Tourism therefore represents one of the most important **cultural ecosystem services** provided by the national park.

This analysis builds on a methodology originally developed for national parks in Germany and later

adapted to Polish conditions. It combines visitor surveys, expenditure data and employment statistics to estimate the **economic benefits generated by tourism associated with Bieszczady National Park**. Importantly, the approach relies on **conservative assumptions**, ensuring that the results do not overestimate the role of tourism.

How were the benefits estimated?

The study focuses on visitor spending related to accommodation, catering and other tourism services in the surrounding region. A key step of the analysis is distinguishing between general tourism income and income that can be attributed specifically to the existence of the national park.

Survey data confirm that the vast majority of visitors would not come to the region if the national park and its protected nature did not exist, making this attribution justified.

Employment effects were estimated using standard economic multipliers, translating tourism revenues into full-time equivalent jobs. While such estimates always involve uncertainty, the applied method is widely used in national park assessments across Europe and provides a robust basis for comparison.

Key economic results

The analysis shows that tourism associated with Bieszczady National Park generates substantial benefits for the regional economy.

Total annual tourism-related income is estimated at approximately **67.2 million PLN (15,9 mln EUR)**.

Around **92% of this income** can be directly attributed to the presence of the national park and its protected ecosystems.

Nature-based tourism supports approximately **1,100 full-time equivalent jobs** in the region, mainly in accommodation, catering and related services.

When expressed spatially, this corresponds to an average benefit of about **2,130 PLN (506 EUR) per year per hectare** of protected land.

These values suggest that the **economic benefits of tourism** are likely to **outweigh the costs of managing and protecting the national park**.

Visitors value protection, not mass tourism

An important qualitative finding of the study is that visitors strongly associate the attractiveness of Bieszczady with its naturalness and tranquillity. Large-scale infrastructure development or mass tourism facilities are generally not seen as desirable. This indicates that maintaining a high level of nature protection is not only compatible with tourism, but essential for sustaining its long-term economic value.

By supporting local businesses while preserving ecological integrity, tourism in Bieszczady National Park illustrates how protected areas can deliver **both environmental and socio-economic benefits.**



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Broader relevance

The results from Bieszczady National Park echo findings from other protected areas in Europe: well-preserved nature is a key asset for regional development. Rather than limiting economic opportunities, national parks often provide a stable and resilient foundation for local livelihoods, especially in remote mountain regions.

Key message:

Protecting wild mountain ecosystems is not a barrier to development – it is one of the strongest long-term investments in regional prosperity.

LOOKING AHEAD

© Kamil Soos

To protect the Eastern Carpathians for future generations, experts call for:

- **Integrating ecosystem services into land-use and development planning** — especially in forest management, wetland conservation and restoration, and in all decisions affecting protected areas.
- **Harmonizing standards and improving data collection** on ecosystem services across all Eastern Carpathian countries, so that cross-border analyses can be more complete and comparable.
- **Launching pilot payment schemes (PES)** for watershed protection, peatland restoration and other nature-based solutions that can support local communities.
- **Raising public awareness** — including among land managers, authorities and local politicians — through education, transparent communication, and truly sustainable tourism.
- **Strengthening cooperation** among national parks, scientists, local communities and NGOs to ensure long-term protection and responsible development.





SOURCES:

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Full reports in English and translations of the report to Slovak, Polish and Ukrainian can be found on our websites.

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