

## ЕКОЛОГІЧНИЙ МОНІТОРИНГ, ПРОГНОЗУВАННЯ ТА ОЦІНКА СТАНУ ДОВКІЛЛЯ

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### APPLICATION OF THE RAPID ASSESSMENT OF THE ECOSYSTEM SERVICES TOOL FOR THE WETLAND “PRUT RIVER HEADWATERS” IN THE CARPATHIAN NATIONAL NATURE PARK (UKRAINE)

Wetlands are among the most important ecosystems on Earth. They improve water quality, control floods, regulate global carbon levels, have significant cultural and recreational values, and provide habitat for plants and animals uniquely adapted to living in wet conditions.

The EU Water Framework Directive defines wetlands as diverse, hydrologically complex ecosystems, which tend to develop within a hydrological gradient going from terrestrial to mainly aquatic habitats. In 2019, two wetlands of the Carpathian National Nature Park (CNNP), Ukraine, were identified by the Secretariat of the Ramsar Convention as wetlands of international importance. The Prut River Headwaters Wetland is in the focus of this study. It belongs to Prut River basin that is very important transboundary tributaries of the Danube River. The Site acts as a flood regulator, and a freshwater reservoir, providing drinking water to people within the Prut River basin.

The wetland is biodiversity hotspot with valuable species, many of them are listed as threatened in the national and global Red Lists, and a great number are endemic to the Eastern Carpathian biogeographic region. Due to the favourable climate and availability of almost undisturbed landscapes, the wetlands are very popular for visitors.

In this study key research task is to apply Rapid Assessment of Wetland Ecosystem Services (RAWES) approach to the Prut River Headwaters Wetland of International importance in order to provide a qualitative and semi-quantitative assessment of a comprehensive range of wetland ecosystem services (ESS). The objective of the RAWES approach is to facilitate an assessment of the plurality of benefits provided by a wetland, which can be considered genuinely rapid, involving limited resources.

The main ESS of the Wetland “Prut River Headwaters” have been assessed within four categories: provisional, regulatory, cultural and supporting. The importance of the service has been assessed using the following relative scale which the benefit is realized: local, regional or global. The Ecosystem Services Index (ESI) within each service category has been calculated.

**Keywords:** Wetlands of International Importance, Carpathian National Nature Park, Ecosystem Services, Rapid Assessment of Wetland Ecosystem Services, Ecosystem Services Index.

**Problem statement.** Wetlands perform regularly, and to a high capacity, a range of processes that in combination result in the delivery of significant benefits for human welfare, wildlife and for the maintenance of environmental quality. Some wetlands have been recognised for their international conservation values [CIS Water Framework Directive, 2003].

The development of the RAWES approach, as an example of approaches that can be developed, has considered the requirements of the Ramsar Convention, and particularly the need for qualitative assessments that are not resource intensive and that can be applied within the context of Ramsar Convention-related reporting [Ramsar Regional Center - East Asia, 2020].

The RAWES approach addresses the four ecosystem service categories:

- Provisioning services: Physical and other resources extracted from ecosystems to support a diversity of human needs, such as food, water and natural medicines;
- Regulating services: Regulatory processes within ecosystems maintaining balance, such as pollination, water purification and climate moderation;

- Cultural services: Non-material benefits enriching society, such as those supporting tourism, recreation and spiritual interests; and
- Supporting services: Processes within ecosystems that maintain overall functioning and resilience, such as soil formation, photosynthetic production of oxygen and habitat for wildlife [Ramsar Regional Center - East Asia, 2020].

Increasing interest in measuring, modelling and valuing ecosystem services, the benefits that ecosystems provide to people, has resulted in the development of an array of ESS assessment tools in recent years [Ramsar Regional Center - East Asia, 2020]. On the other hand, it is important for the updating the Ramsar Site Information Sheet (RIS); Ramsar Site management planning; development and implementation of Ramsar National Policies understanding the importance of ecosystem services. On the other hand, it is also important for the local population for capacity-building, education, participation, and awareness raisin to protect nature, to understand its benefits and values including spiritual and cultural ones. Depending on the question and context for the ESS assessment, qualitative or quantitative methods may be preferred [Neugarten, R.A. et al, 2018].

**Literature review.** The Ramsar Convention promotes the wise use of wetlands as a fundamental tenet behind the desire to stop and reverse the loss and degradation of wetlands. The concept of wise use has been formally defined as the maintenance of ecological character, of which ecosystem services form an integrated element [McInnes, R. J. et al, 2017].

Rapid Assessment of Wetland Ecosystem Services (RAWES) was described in Resolution XIII.17 on ‘Rapidly assessing wetland ecosystem services’ adopted at the 13th Meeting of the Conference of the Contracting Parties to the Ramsar Convention on Wetlands in October 2018 as an example of a cost-effective and pragmatic approach for assessing the multiple benefits that wetlands provide. To achieve wise use, and for wetlands to contribute fully to sustainable development, policy makers and practitioners (such as site managers) need to recognize the important functions and the multiple values of wetlands, and reflect them in their decisions, policies and actions [McInnes, R. J. et al, 2017]. Many wetland managers have limited time and resources. Therefore, the development of approaches to assessing wetland ecosystem services needs to satisfy the definition of “rapid” insofar that no more than two people should spend more than half a day in the field and another half day on preparation and analysis [McInnes, R. J. et al., 2017]. Increasing interest in measuring, modelling and valuing ecosystem services (ESS), the benefits that ecosystems provide to people, has resulted in the development of an array of ES assessment tools in recent years.

Ramsar Information Sheet has opened access to data of the Wetlands of International importance and provides a standardized format for recording *information* about the *Ramsar* site.

The «Prut River Headwaters» data includes its brief description, size, location, and date of designation, reasons for designation, information on flora and fauna and a site-relevant bibliography. Wetland (total area – 4935.44 ha) is represented by an alpine post-glacial community of wet meadows, peat bogs, lakes, streams, watercourses, riparian zones, and century-old forests of the Chornohora mountain range in the Ukrainian part of the Carpathians (Figure1). The Site holds a high concentration of Carpathian endemic and a number of post-glacial relict species. It is one of the most important biodiversity hotspots in the Ukrainian Carpathian region, crucial for the conservation of its species and ecological communities.

The territory is also characterized by a unique landscape with a high diversity of relief mountain forms, developed under the prolonged effect of geological epochs. Apart from this, the Site acts as a large storage tank of water resources, slowly accumulating them during heavy rains or snow-melting, and thus preventing drastic floods in the downstream areas. It is an important source of fresh water for at least 5,000 people and crucial for the support of the hydrological balance of the Prut River. The favourable climate conditions and weakly disturbed landscapes have turned the wetland into a very popular and the most frequently visited place of interest in the Ukrainian Carpathians. The Site is a part of the Carpathian National Nature Park, which is responsible for the restricted use and management of natural resources of the area [Ivan Danylyk et al, 2019].

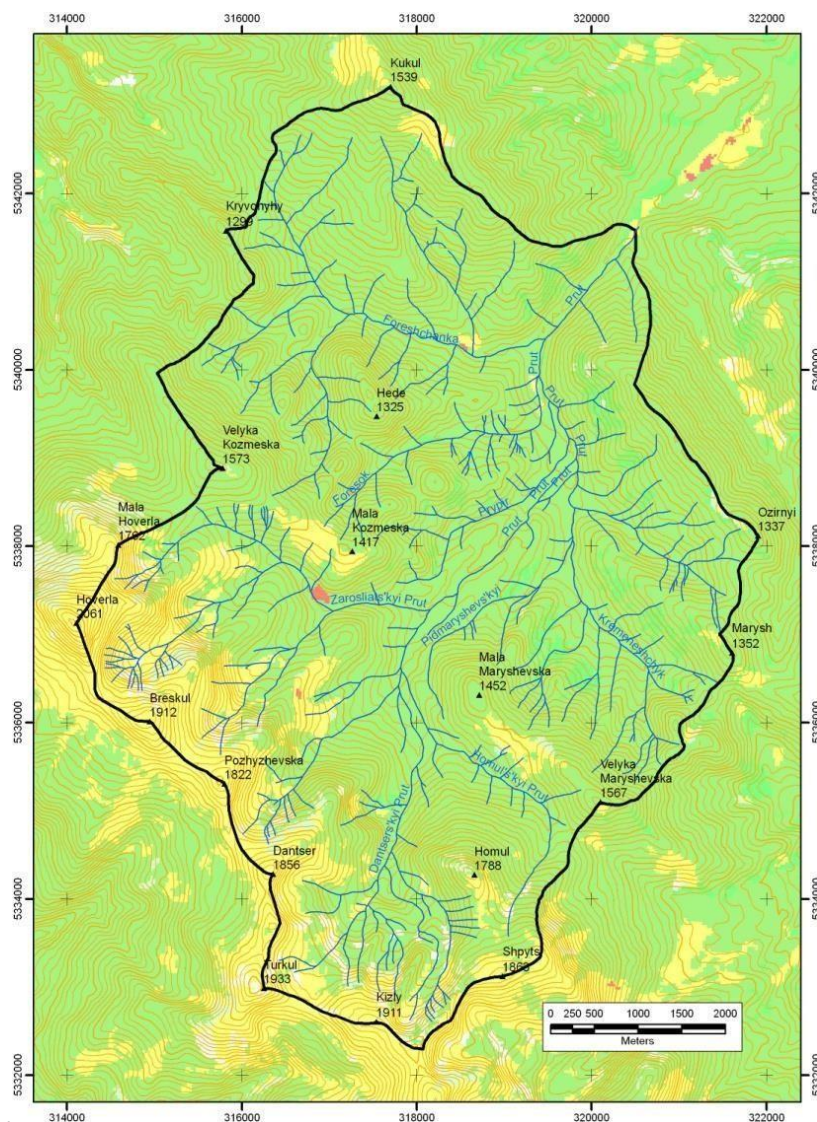
The Site is crucial for the natural functioning of the Prut river basin and supporting its hydrological balance. It plays a leading role in the natural control and mitigation of floods and is an important storage tank seasonally accumulating water for the areas protected within the Carpathian National Nature Park (Ukraine) and located downstream [Ivan Danylyk et al, 2019].

The Prut basin on the territory of Ukraine is characterized by a fairly dense hydrographic network. The density of the river network is 0.94 km/km<sup>2</sup>, which is almost three times higher than the

average indicator for Ukraine (0.34 km/km<sup>2</sup>). The density of the network is caused, first of all, by two factors: the large dismemberment of the terrain and, at the same time, a significant amount of precipitation.

Both surface water and groundwater sources are a major factor in meeting the drinking and economic needs of private households not provided with centralized water supply and sewerage in this area [Arkhypova L et al, 2019]. At present, the population is experiencing a shortage of water resources in the western region of Ukraine due to climate change [Chelmicki W et al., 2011], [Arkhypova L M. et al, 2015]. Nowadays, the management of the sheep breeding in the Carpathians is not possible without constant water supplies, which are often natural springs [Kinash, I et al, 2019].

The main task of the research is RAWES application to Prut River Headwaters Wetland in order to recognize its ecosystem services, to obtain results through field study and workshops with internal experts, to compare results with information about Wetland ESS in the RIS, and to discuss within working group the most significant benefits of Wetland ESS and to identify potential threats for wetland functioning. All these practical steps are crucial for wetland managers. Human activities and climate change can lead to degradation and loss of wetlands and therefore, loss of their ability to provide the entire range of ecosystem services.



**Fig. 1. Wetland "The Prut River Headwaters" boundaries**

**Materials and Method.** In this study a main method for RAWES application is expert estimation based on observation and analysis, statistical data processing and modeling. The CNRP working group consisted of 5 specialists: a hydrochemist - group leader, a geographer, a botanist, a zoologist, a forester. Field studies and working meetings were conducted. Key considerations have been discussed with the head of the scientific department.

The RAWES approach includes:

- Qualitative methods, mainly used to display and report the results of assessments; and
- Quantitative methods, which allow greater analysis and even semi-statistical investigations [Neugarten, R.A. et al, 2018].

One of the ways to display qualitative results of a RAWES assessment is simple reporting on presence or absence of ecosystem services. The assessment sheet provides an initial list of ecosystem services under the four main categories of provisioning, regulating, cultural and supporting services.

Quantitative, or even semi-quantitative, approaches can be used to provide a slightly more robust analysis of the results of RAWES assessments. Basic approaches can include simple counts of all the ecosystem services that scored ‘++’, ‘+’, ‘0’ or a negative score.

The RAWES field assessment sheet is a simple table with cells into which assessors record the importance of each ecosystem service produced at the wetland site, with space for free text descriptions of key features supporting that assessment [Ramsar COP13 Resolution XIII.17, 2018]. Score for assessment of ecosystem service (Defra, 2007) is next (Table 1). It is also possible to convert the scoring system to numeric values. It is also possible to convert the scoring system to numeric values [Ramsar Regional Center - East Asia, 2020]. Scores are thus allocated semi-quantitatively, using assessor knowledge and other local and technical input.

Table 1

**Defra (2007) scale of likely significance of ecosystem services**

Score	Assessment of ecosystem service	Numeric values
++	Significant positive contribution	1.0
+	Positive contribution	0.5
0	Negligible contribution	0.0
-	Negative contribution	-0.5
--	Significant negative contribution	-1.0
?	Gaps in evidence	Remove from calculation

The method to collate the importance of ecosystem service provision is semi-statistical transformation in the form of an ESI.

Groups of ecosystem services should be summed and divided by the number of services in that category, omitting from this total those services assessed as not relevant. The ESI is calculated using the equation 1:

$$ESI = \frac{\sum(n_{+1.0} + n_{+0.5}) + \sum(n_{-1.0} + n_{-0.5})}{\sum n_{TOTAL}}, \text{ [Neugarten, R.A. et al, 2018]} \quad (1)$$

where  $n$  – number of ESS within the same category.

Wetlands can be essential for multiple livelihoods, both locally and across broader geographical scales. Therefore, the next step of assessment is linking services to beneficiaries at different scales: local, regional or global benefits.

The process for applying the RAWES approach comprises three principle activities: preparation, field assessment and information management [Ramsar COP13 Resolution XIII.17, 2018]. Working group representatives should be knowledgeable about the site and the type of wetland being assessed.

**Results and discussions.** During spring-autumn period, 2022 the CNNP expert group on ESS estimation of Wetland “Prut River Headwaters” conducted four field studies of different types of wetland ecosystem such as peat bog, highland meadow, river riparian zone, lake coastal zone.

After that two office workshops were conducted regarding discussion of initial scoping assessment in order to identify the range and importance of ecosystem services a wetland may be providing.

Each of experts had received an evaluation table that has been filled based on their personal skills and experience. General discussion made it possible to find common points of view, although it also revealed many problems in the assessment, as well as the lack of certain information and differences of opinion regarding the interpretation of the evaluations.

The main ESS of the Wetland “Prut River Headwaters” were assessed within four categories: provisional, regulatory, cultural and supporting. Numeric values of ESS with positive and significant and positive benefits, and scale of impact of each ESS category is presented on the Figure 2–Figure 5.

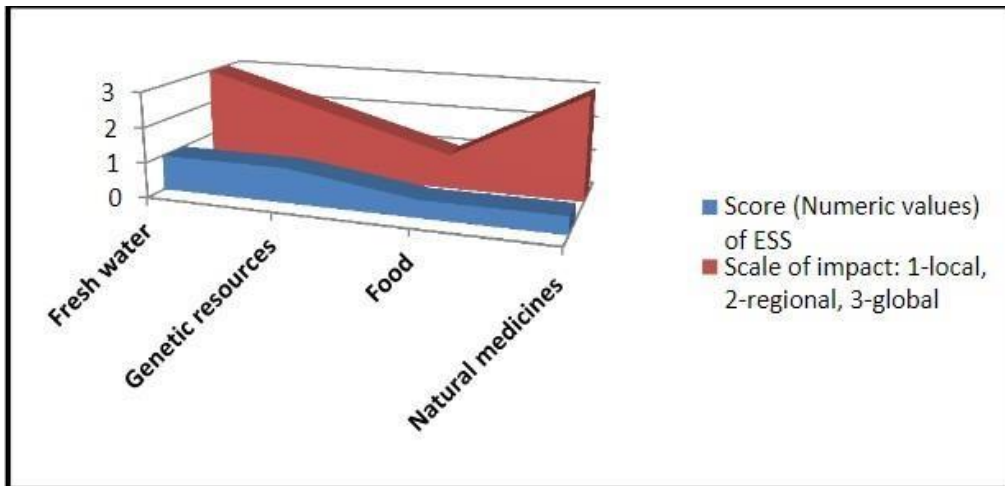


Fig. 2. Main Provisioning Ecosystem Services of the Prut River Headwaters Wetland

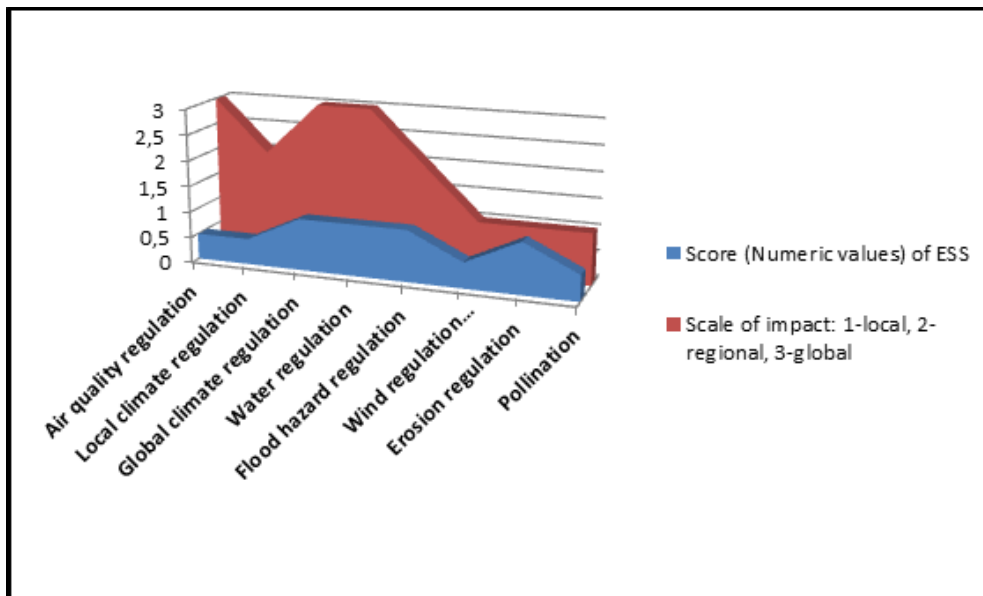


Fig. 3. Main Regulatory Ecosystem Services of Prut River Headwaters Wetland

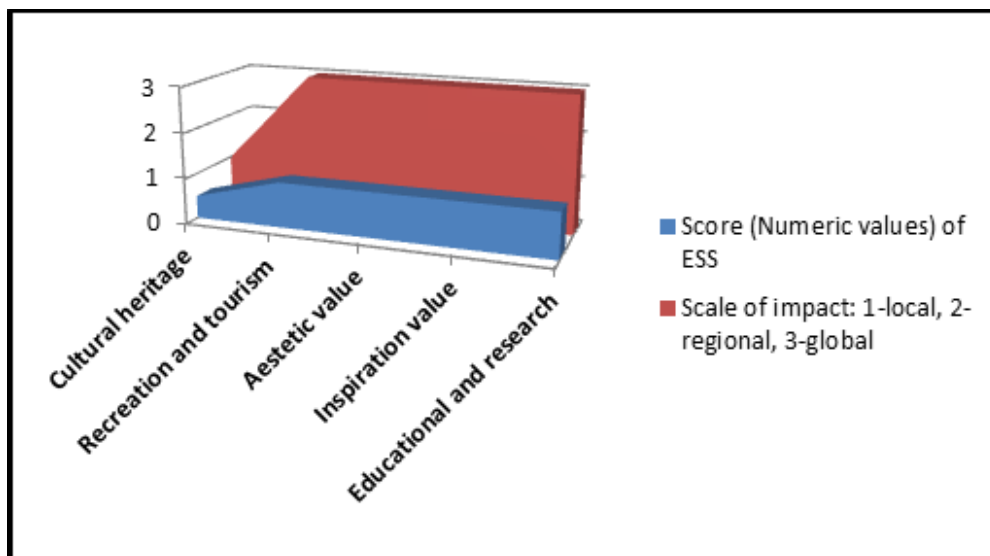
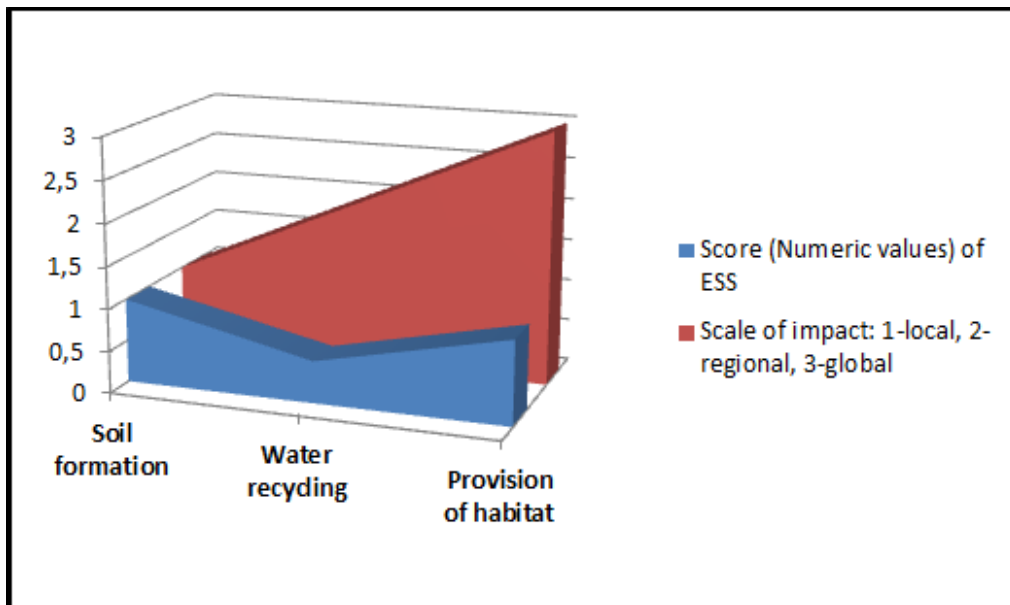


Fig. 4. Main Cultural Ecosystem Services of Prut River Headwaters Wetland



**Fig. 5. Main Supporting Ecosystem Services of Prut River Headwaters Wetland**

The most important ESS that have been defined by expert group are next:

Provisioning: fresh water and genetic resources;

Regulatory: global climate change, water regulation, flood hazard regulation, erosion regulation;

Cultural: recreation and tourism, aesthetic value, inspirational value, and education and research;

Supporting: soil formation and provision of habitat.

Understanding how a wetland supports different livelihoods can be a vital component to inform management planning. Using the RAWES approach, it is possible to capture essential information on the variety of livelihoods, and nature of the beneficiaries, in and around a wetland. Management actions can then be designed and implemented to ensure that these livelihood interdependencies are not compromised and that threats to livelihoods are addressed [Ramsar Regional Center - East Asia, 2020].

The wetland provides regulatory services for such ecosystem processes as the climate formation, protection from floods, landslides and other natural disasters, air and water purification, as well as local and global climate impact mitigation through carbon absorption by sphagnum wetland oligotrophic meadows.

There is a wide network of thematic ecological trails: botanical, zoological, geographic and landscape ones. Their aim is to show visitors the natural ecosystems, geological and geomorphologic monuments. Also the Prut is mentioned in many ancient historical texts. The territory is deeply connected with a cultural ethnographic nationality of Ukraine and the Carpathians, called the Hutsuls. The site is valuable in terms of ecological education, recreation and scientific research. It encloses part of the highest peak of Ukraine, Mount Hoverla, being is an important social and cultural heritage of the national level [Ivan Danylyk et al, 2019].

The territory of the site is one of the most important scientific research areas for the investigation of the Carpathian alpine zone. The ecological, biological and geographic surveys are carried out by employees of the Carpathian National Nature Park, scientists of the Ivan Franko National University of Lviv and the Institute of Ecology of the Carpathians (Lviv). The botanical monitoring within the given area is carried out by scientists of the Carpathian National Nature Park, the Institute of Ecology of the Carpathians (Lviv) and the State Museum of Natural History, NAS of Ukraine (Lviv). A network of transects have been developed to study the alpine biota. A research station, belonging to the Institute of Ecology of the Carpathians (Lviv), and a weather station are located on Pozhyzhevska Mountain. The permanent monitoring of rodents, ground beetles, amphibians, bats and large carnivores (brown bear, wild cat) is implemented at the Site [Ivan Danylyk et al, 2019].

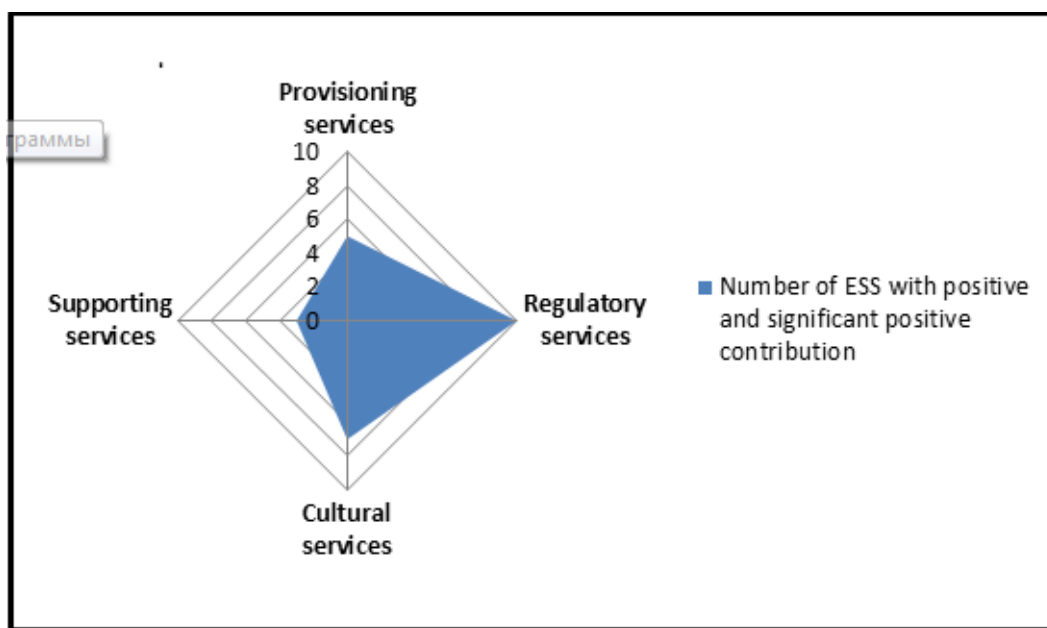
The ecological diversity of the Chornohora mountain range and historical peculiarities of flora genesis have led to a high species variety of plants in this site. 700 species of plants, found there, makes up more than half of the total number of species of the Ukrainian Carpathians.

Invasive plants and animals in ecosystems are represented by small numbers and do not pose a threat to its functions.

The map of the Wetland Ecosystem Services distribution reflects significance of regulatory services (Fig.6).

ESI for all categories of ES of the Wetland “Prut River Headwaters” has been calculated using formula 1. As a result, ESI for regulatory services is 0.85, for cultural – 0.83, for supporting – 0.6, for provisioning – 0.56.

This estimation is preliminary and request additional study with involving all stakeholders. In particular, there are some disagreements regarding genetic resources. In the Ramsar Information Sheet (RIS) (<https://rsis.ramsar.org/ris/2395>) this ESS is assessed as low benefit. According to CNNP expert affirmation, there are natural populations of species that are stably preserved in ecosystems within the Wetland boundaries, therefore, provision of the genetic resources were recognized as significant positive. In this case, additional experts can be involved in the process of ES estimation.



**Fig. 6. Map of Prut River Headwaters Wetland Ecosystem Services distribution**

Therefore, the results of the study can be used by CNNP managers to update the RIS in the context of updating list of Wetland ecosystem services (Chapter 4.5). This section can be supplemented with more extensive information about the ecosystem services of the Prut River Headwaters, especially regarding regulating services, such as air quality regulation, global climate regulation, wind and erosion regulation.

The RAWES approach can help to convey strong visual messages regarding the relative importance of different services without the need for detailed quantitative analysis.

Recognising ecosystem services and the threats to their sustainability is an essential element of wetland site management planning. Individuals and communities both within and beyond a wetland will benefit from the flow of ecosystem services, so it is important to be aware of flows of benefits (and potential disbenefits) across a range of scales. Management activities and interventions need to ensure that these beneficiaries are recognised and protected through the management planning process.

**Conclusion.** The Wetland “Prut River Headwaters” is one of the most important biodiversity hotspots, crucial for the conservation of species and ecological communities of the Ukrainian Carpathians, including regionally rare and threatened ones. This value is increasing under the global threats as biodiversity degradation and climate change impact.

The RAWES application proves that “Prut River Headwaters” as a site of International importance fulfills all categories of ESS with main focus on regulating services that are maintain desired environmental conditions for human society. Cultural ESS as well play crucial role and enrich human society. At the same time supporting services are necessary for the maintenance of ecosystem integrity, functioning and resilience, and for the production of all other ecosystem services. For the “Prut River Headwaters” provision of habitat has significant scale of impact.

Most of ecosystem services have regional and global impact. Some of them are still up of debates. For a more comprehensive study of the wetland ESS, it is necessary to involve additional internal and external experts.

The RAWES application within CNNP has provided initial design of different categories of ESS from wetland. This tool allows the assessors to evaluate the ecosystem services within the local, regional and global context.

This information is essential for describing the ecological character of a wetland and important ecosystem services estimation, both qualitative and quantitative one. RAWES can have multidimensional application for site managers, such as identification of livelihood interests for local communities, define possible threats for wetland ecosystems, and assist to management improvement and wetland “wise use”, understanding of potential site contribution to social benefits.

Depending on RAWES goal, the list of ecosystem services provided under the RAWES approach can be adapted for different uses and in different contexts.

Further steps for this study should be devoted to potential threats for the wetland through development of monitoring program for testing plots. This comprehensive task requires external experts from scientific institutions.

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## **ЗАСТОСУВАННЯ ІНСТРУМЕНТУ ШВИДКОЇ ОЦІНКИ ЕКОСИСТЕМНИХ ПОСЛУГ ДЛЯ ВОДНО-БОЛОТНОГО УГІДЖА «ВЕРХІВ'Я РІЧКИ ПРУТ» КАРПАТСЬКОГО НАЦІОНАЛЬНОГО ПРИРОДНОГО ПАРКУ (УКРАЇНА)**

Водно-болотні угіддя належать до найважливіших екосистем на Землі. Вони покращують якість води, контролюють повені, регулюють глобальні рівні вуглецю, мають значну культурну та рекреаційну цінність і забезпечують середовище існування для рослин і тварин, унікально пристосованих до життя у вологих умовах.

Водна Рамова Директива ЄС визначає водно-болотні угіддя як різноманітні, гідрологічно складні екосистеми, які мають тенденцію розвиватися в межах гідрологічного градієнта, що переходить від наземних до переважно водних середовищ. У 2019 році два водно-болотних угіддя Карпатського національного природного парку (КНПП), Україна, були визначені Секретаріатом Рамсарської конвенції як водно-болотні угіддя міжнародного значення. Водно-болотне угіддя «Верхів'я річки Прут» знаходиться в центрі уваги цього дослідження. Воно належить до басейну річки Прут, яка є дуже важливою притокою річки Дунай. Ділянка діє як регулятор паводку та резервуар прісної води, що забезпечує питною водою людей у басейні річки Прут.

Водно-болотні угіддя є осередками біорізноманіття з цінними видами, багато з них занесені до національних та всесвітніх Червоних списків як такі, що перебувають під загрозою зникнення, а велика кількість є ендеміками Східно-Карпатського біогеографічного регіону. Завдяки сприятливому клімату та наявності майже незайманих ландшафтів водно-болотні угіддя дуже популярні серед відвідувачів.

Ключовим завданням цього дослідження є застосування підходу швидкої оцінки екосистемних послуг водно-болотних угідь (RAWES) до території угіддя міжнародного значення «Верхів'я річки Прут», щоб забезпечити якісну та напівкількісну оцінку повного спектру екосистемних послуг досліджуваної території. Метою підходу RAWES є сприяння оцінці множинних переваг, які надають водно-болотні угіддя. Цей підхід можна вважати справді швидким та залучати для цього обмежені ресурси.

Основні екосистемні послуги водно-болотного угіддя «Верхів'я річки Прут» були оцінені за чотирима категоріями: забезпечувальні, регулюючі, культурні та підтримуючі. Важливість послуги було оцінено за допомогою наступного відносного масштабу, в якому реалізується користь: локальний, регіональний та глобальний.

Також було розраховано індекс екосистемних послуг (ESI) в межах кожної їх категорії.

**Ключові слова:** водно-болотні угіддя міжнародного значення, Карпатський національний природний парк, екосистемні послуги, швидка оцінка екосистемних послуг водно-болотних угідь, індекс екосистемних послуг.

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