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THE IMPACT OF THE DRAINAGE NETWORK ON SURFACE RUNOFF FORMATION IN THE SOMYNE MIRE IN THE CONTEXT OF HYDROLOGICAL REGIME RESTORATION

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Abstract

In Western Polissia, the peatland complexes of the Rivne Nature Reserve provide vital ecosystem services. However, their hydrological regime has undergone significant alterations due to land reclamation and military-agricultural development. Using the Somyne Mire as a case study, the consequences of drainage have been analysed, including peat degradation, the disappearance of autochthonous communities, increased wildfire risk, and the intensification of drought and flood extremes.

Using Sentinel-1 radar imagery (VH polarisation) from 2019, the impact of the channel network and dam on the distribution of surface runoff in the area surrounding the Somyne Mire has been demonstrated.

With support from the Frankfurt Zoological Society, a hydrological rehabilitation project has been launched, involving the blocking of drainage canals with earthen dams, ongoing monitoring, and adaptive management. The expected outcomes include the restoration of natural moisture and organic matter accumulation processes, increased biodiversity, stabilisation of baseflows in small rivers, and a reduction in flood peaks.

Keywords: *mire, land reclamation, Sentinel-1, hydrological rehabilitation, Somyne, Western Polissia, flood, fire risk.*

In Ukraine, and particularly in Rivne Oblast, the conservation and restoration of wetlands is among the most pressing environmental challenges. One of the key areas in this context is the peatland complexes of the Rivne Nature Reserve. According to the Ramsar Convention, Somyne (along with Syra Pohonya and Perebrody) is designated as a wetland of international importance [1]. These

natural systems (mire complexes) play a crucial role in the environmental network of Western Polissia, preserving unique species of flora and fauna, including rare and endangered plants and animals protected at both national and international levels.

The transformation of the natural Somyne Mire into a system of weirs, canals, and drained areas was originally carried out to support agricultural and military land use.

Despite the initial economic benefits associated with land reclamation infrastructure, recent decades have revealed the vulnerability of both natural ecosystems and nearby settlements to the alteration of the hydrographic network and peatland landscapes.

The consequences of this transformation for natural complexes and the ongoing processes include:

- Degradation of peatlands due to organic matter decomposition and the development of wind erosion.
- Decline in both the quantity and quality of surface water during low-flow periods.
- Increase in the frequency and severity of droughts and floods.
- Conversion of valuable mire areas into dryland habitats, leading to the disappearance of autochthonous flora and fauna and a reduction in the ranges of rare species.
- Peatlands cease to perform their natural functions of regulating water flow and carbon cycles.
- Peat and forest fires.
- Settlements located in areas where water is discharged from peatland systems are increasingly affected by high water levels during flood events, as peak flows tend to exhibit shorter durations and higher amplitudes compared to undisturbed natural conditions.

Following the cessation of agricultural use of the mirelands, a network of drainage channels remained in place. Some of these channels continue to actively divert water, while others are partially or fully obstructed by beaver dams. Based on satellite imagery, a vector dataset of the channel network was created (Figure 1).

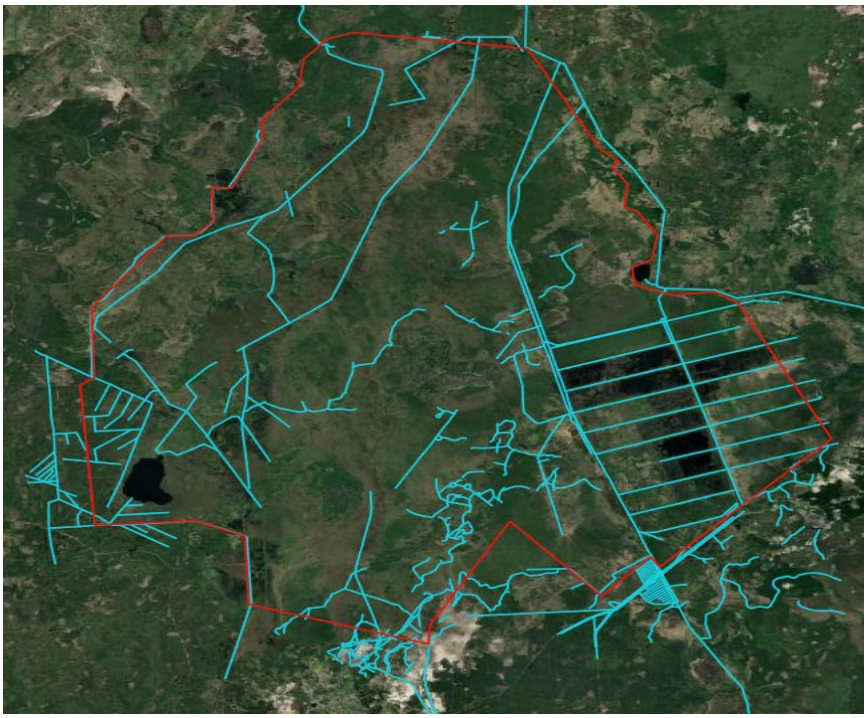

Fig. 1. *Identified drainage channel network within the Somyne Mire (ESRI Imagine, imagery date: 5 October 2021)*

The dataset also includes channels that were illegally constructed for amber extraction. Each of these structures influences the mire differently depending on the season. During the summer, these channels may remain dry, whereas in spring they often actively drain water beyond the wetland boundary.

Therefore, we conducted an assessment of the impact of the existing channels on water retention conditions across the mire area.

We begin by examining a radar-based model of the area (VH polarisation, Sentinel-1) prior to the flood event, using imagery acquired on 7 May 2019 (Figure 2a).

a) b)

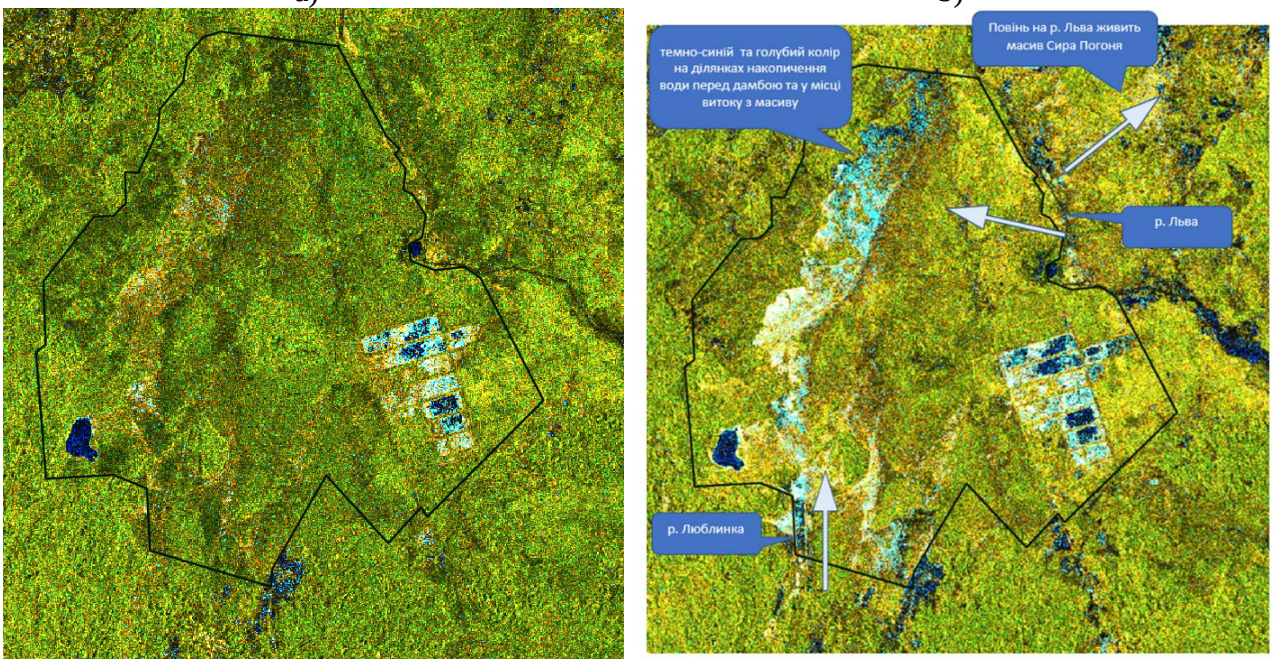

Fig. 2. *The Somyne mire: (a) during the low-flow period; (b) under the influence of flood conditions in the Lva River basin*

We now turn to the rainfall-induced flood event of 16–19 May 2019, which affected a large part of the Sarny district (within the Sluch and Stvyha river basins). Further details on the progression of the flood can be found via online resources [2, 3]:

This event can be classified as a hydrological occurrence with a 5% exceedance probability.

The radar model (Figure 2b), based on VH polarisation (vertical transmission, horizontal reception) and acquired on 17 May 2019, illustrates the flooded areas and zones of elevated soil moisture. Dark blue and light blue tones correspond to open water surfaces.

It is important to note that models derived from optical imagery are generally unsuitable for monitoring rainfall-induced flooding, as such events are typically accompanied by persistent cloud cover.

The analysis of the image indicates that the Lva River (a tributary of the Stvyha) plays a significant role in replenishing the water reserves of the mire from the east. The southern inflow is provided by the Lyubonka River (a tributary of the Sluch), which has now been transformed into a main channel of the drainage system. During peak flow conditions, water overflows onto the floodplain, facilitating its movement into the mire area located between the Lva and Sluch rivers.

This process contributes to the establishment of a favourable water and air regime for the development of mire ecosystems.

During peak water levels within the Somyne mire, the most significant artificial structure is the dam stretching from the south-western to the northern part of the mire. Its position is clearly delineated by the western boundary between the blue and light-yellow zones (Figure 3).

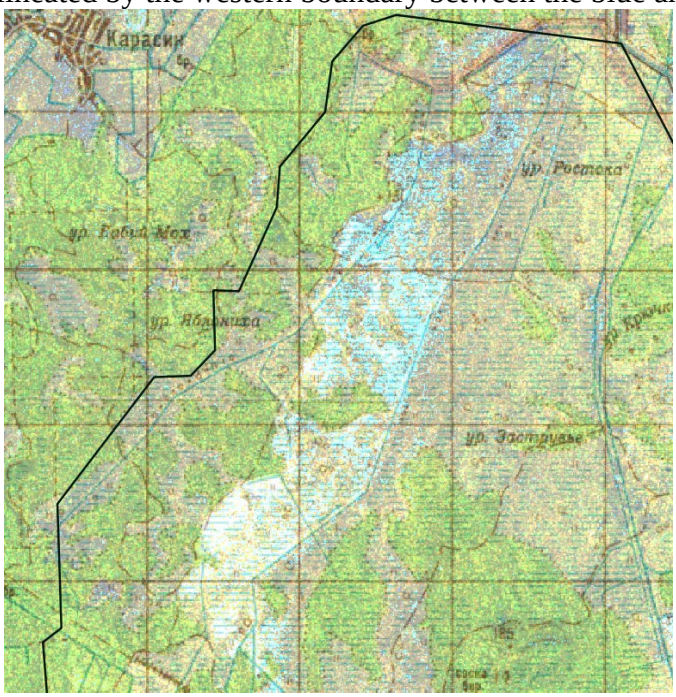

Fig. 3. *Influence of the dam on surface runoff distribution – overlay of a topographic map and a VH-polarised radar model based on Sentinel-1 imagery from 17 May 2019*

As observed, the area beyond the dam also becomes inundated during periods of high water. However, the pronounced contrast in backscatter intensity indicates that over the years the dam has created a distinct landscape gradient by impeding surface water flow: the eastern side is clearly more saturated. To facilitate spatial interpretation, a fragment of a topographic map is overlaid on the surface moisture model.

As the flood recedes and the low-flow period begins, water returns to the river channels, and the drainage function of the canal network becomes evident. Water is no longer retained within the mire. Consequently, open water bodies vanish by mid-spring, adversely affecting conditions for the development of autochthonous flora and fauna. The peat soils of the mire do not become saturated; instead, they release moisture into the drainage system. This contributes to low-flow conditions during dry periods and increases the risk of wildfires on desiccated peatland areas.

It should be noted that in recent years, intensive drainage of water from the western (post-dam) part of the Somyne Mire has been carried out via a canal constructed along the boundary between the Rivne Nature Reserve and the state forestry enterprise "Forests of Ukraine".

A satellite image fragment (Figure 4) illustrates the impact of this construction. Surface runoff accumulation lines are shown in pink. As can be seen, the canal intercepts and diverts groundwater that would otherwise recharge surrounding areas extending towards the village of Karasyn. Field surveys have confirmed that the canal is 7 metres wide and approximately 2 metres deep. A continuous stream has formed within the channel, with a water depth of up to 1.5 m and a measured discharge of 145 L/s.

For comparison, the Lva River at the Somyne Mire section had a discharge of 385 L/s during the same period. However, its catchment area is 965.28 km², whereas the canal's drainage area is approximately 10 km².

Discharges ranging from 100 to 120 L/s were also recorded at other outlets from the mire. Therefore, when comparing the specific runoff at the time of observation (mid-August 2024) — 14.5 L/s/km² from the Somyne Mire versus 0.4 L/s/km² from the Lva River — it can be concluded that the drainage network within the Somyne Mire is actively diverting significant volumes of water from the peatland, thereby desiccating the peat soil layers.

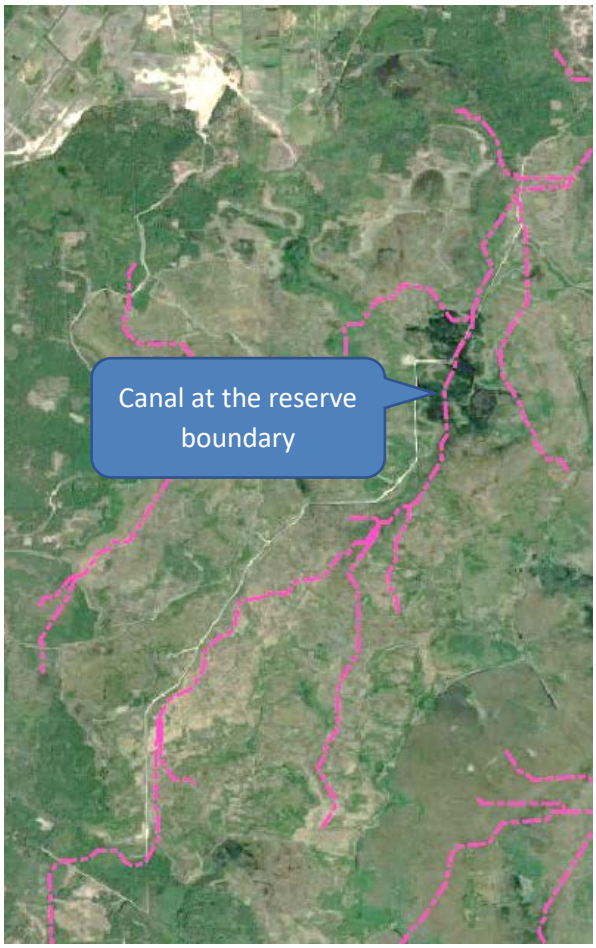

Fig. 4. *Canal constructed along the western boundary of the Somyne Mire*

Deep channels that cut entirely through the peat layer cause a decline in the groundwater table by disrupting the capillary connection between the upper and water-saturated soil horizons. Although such a channel may act as a barrier to the spread of fire under windless conditions (provided it contains sufficient water), it also contributes to an increase in the amount of deadwood. Most critically, it creates a layer of dry peat that is virtually impossible to extinguish across large areas — in the case of the Somyne Mire, this covers approximately 13 km².

A similar pattern is observed with other channels within the mire (see Figure 1). Many of them have lost their flow capacity due to beaver dams. Nevertheless, at the time of field inspection (mid-August 2024), the total volume of water being systematically drained from the mire via the reclamation channel network amounted to approximately 350 L/s.

To support the conservation of the Somyne Mire, and with the technical assistance of experts from the Frankfurt Zoological Society, preparation of project documentation for the restoration of the mire's hydrological regime has been initiated as part of the *Polesia – Wilderness Without Borders* initiative [4]. Key Restoration Measures:

1. Termination of the operation of artificial drainage channels that excessively dry out the mire during the low-flow period, by constructing dams made from local soil material deposited along the channel banks during their initial excavation.
2. Implementation of project-based and post-project monitoring of mire restoration dynamics. Preparation of documentation for impact adjustment and justification of new intervention sites, if required.

Expected Outcomes of the Project Implementation:

- Restoration of runoff formation conditions, hydrochemical parameters, and water level regimes to values typical for mire ecosystems.
- Activation of natural recovery mechanisms within the peatland ecosystem.
- Rehabilitation of mire landscapes capable of performing their natural functions, including water regime regulation, organic matter accumulation, and the reproduction of wetland flora and fauna.
- Increased baseflow in small rivers during dry periods, along with a reduction in peak discharge and water levels during flood events.

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ВПЛИВ МЕРЕЖІ КАНАЛІВ НА ФОРМУВАННЯ ПОВЕРХНЕВОГО СТОКУ БОЛОТНОГО МАСИВУ СОМИНЕ В КОНТЕКСТІ ВІДНОВЛЕННЯ ЙОГО ГІДРОЛОГІЧНОГО РЕЖИМУ

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Анотація

Оцінка впливу гідрографічної мережі на режим поверхневого стоку виконано для обгрунтування комплексу заходів з відновлення та збереження болотного масиву Сомине. Дозволяють сформувати висновки щодо гідрологічних особливостей функціонування масиву та окреслити перелік необхідних організаційних та інженерних заходів. Результати дослідження підкреслюють важливість активних заходів з ревіталізації болотних екосистем у контексті зміни клімату та зростаючого тиску на природні ресурси.

Ключові слова: торфовище, меліорація, Sentinel-1, гідрологічна реабілітація, Сомине, Західне Полісся, паводок, пожежна небезпека.