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RESEARCH ARTICLE

Meadow communities of the Middle Ob floodplain over two years under different flooding conditions

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Abstract

The paper presents a comparative analysis of changes in species, ecological and biological composition, dominant species composition, and net primary productivity (NPP) of floodplain meadows in low (2023) and high (2024) flooding years. Meadows in the study area exhibited higher productivity in 2024 compared to 2023. In 2024, NPP increased by 45.6% in the forb-grass meadow, by 37.8% in the sedge-reedgrass meadow, and by 34.5% in the elecampane meadow. Changes were observed in species richness, the proportions of ecological groups, and dominant species composition. The most significant changes were recorded in upland meadows that are not regularly flooded. The productivity of the forb-tussock sedge meadow remained virtually unchanged (an increase of only 1.4%), indicating stability and potentially maximum productivity under these conditions. An increase in NPP was attributed to the increase in both above-ground and below-ground phytomass and correlated with structural shifts in the grass stand toward a higher proportion of moisture-demanding species.

Keywords
Ob floodplain, meadow communities, above-ground and below-ground phytomass, net primary productivity

Introduction

The structure and functioning of the Ob floodplain meadow communities have been addressed in numerous studies. The properties of the vegetation cover were studied in the Altai Territory (Penkovskaya 1963, 1972; Logutenko 1963; Aleksandrova et al. 1985; Shibanova 2010; Shibanova and Terekhova 2012), and in the Novosibirsk (Penkovskaya 1963, 1972; Logutenko 1963), Tomsk (Elizarieva 1951; Lvov 1963; Vytslan 1968; Lvov et al. 1987; Shepeleva 1986, 1987, 1998, 2019; Dymina et al. 1989; Taran and Dymina 1990; Taran 1995; Igosheva 2001; Kosykh et al. 2023), and Tyumen (Baryshnikov 1933) regions, as well as in Khanty-Mansi Autonomous (Dydina 1961, 1968; Tyurin 2004; Samoylenko et al. 2009; Kushanova and Korkin 2015) and Yamalo-Nenets Autonomous (Rozhdestvensky 1992; Morozova and Golovatin 2023) Okrugs. The results of a long-term study (from 1978 to 1994) of meadow communities in the Middle Ob floodplain were reported by L.F. Shepeleva (2019). The study was conducted at the key sampling sites located along a floodplain segment approximately 300 km in length.

Despite being well studied, these ecosystems continue to attract research interest due to their exceptional capacity for carbon sequestration and accumulation (Bardgett et al. 2021; Sommer et al. 2023). Current climatic and anthropogenic changes are causing a significant restructuring of the composition and functioning of one of the most productive ecosystems in Western Siberia (Shepeleva 2019; Kosykh et al. 2023), which could substantially impact the carbon balance (Vicente-Serrano et al. 2013; Hossain et al. 2021). Therefore, in recent years, we have conducted biodiversity monitoring and assessed above-ground and below-ground phytomass at the Kaibasovo site of the Tomsk carbon polygon (Shepeleva et al. 2022, 2023, 2024; Pudova and Shepeleva 2022).

Floodplain meadows feature high interannual variability, with both the composition of above-ground phytomass and the dominance of species responding to environmental changes (Rabotnov 1984; Shepeleva 1998). The most significant factor influencing these changes is the hydrological regime, which determines the scale and duration of flood events (Shepeleva 1998, Silvertown et al. 1999; Mathar et al. 2015; Shi et al. 2017). The role of flooding in altering the vegetation structure is somewhat ambiguous. On one hand, plants immersed in flood waters are exposed to specific conditions of illumination and gas exchange, and a constant shift from terrestrial to aquatic environments can be highly stressful (Junk 1989; Prokopyev 2012). During prolonged flood events, soil oxygen is depleted under anaerobic conditions and toxic compound are formed (Rabotnov 1985). On the other hand, changes in soil moisture regimes and the influx of organic matter via floodwaters can positively affect the development of floodplain plants adapted to regular disturbance from flooding. Changes in moisture conditions affect plants via altering their nutritional and thermal regimes (Rabotnov 1984).

The aim of this study was to assess the impact of flooding on the proportions of plant species, ecological groups, and total NPP in the Middle Ob floodplain meadows. Investigating these relationships is critical for improving floodplain meadow management and maintaining ecosystem stability.

Materials and methods

Study area

The study was conducted at the Kaibasovo site of the Tomsk carbon polygon (57°14'44"N, 84°11'00"E). The structure, dynamics and stock of phytomass in the Middle Ob floodplain meadows with different moisture patterns were assessed at permanent sampling sites (Fig. 1), specifically:

T1 – a non-flooded forb-grass meadow located on a high ridge,

T2 – a regularly flooded sedge-reedgrass meadow located in the lower part of a gentle slope,

T3 – a rarely flooded elecampane meadow located on a high ridge,

T4 – a regularly flooded forb-tussock sedge meadow located on a ridge slope.

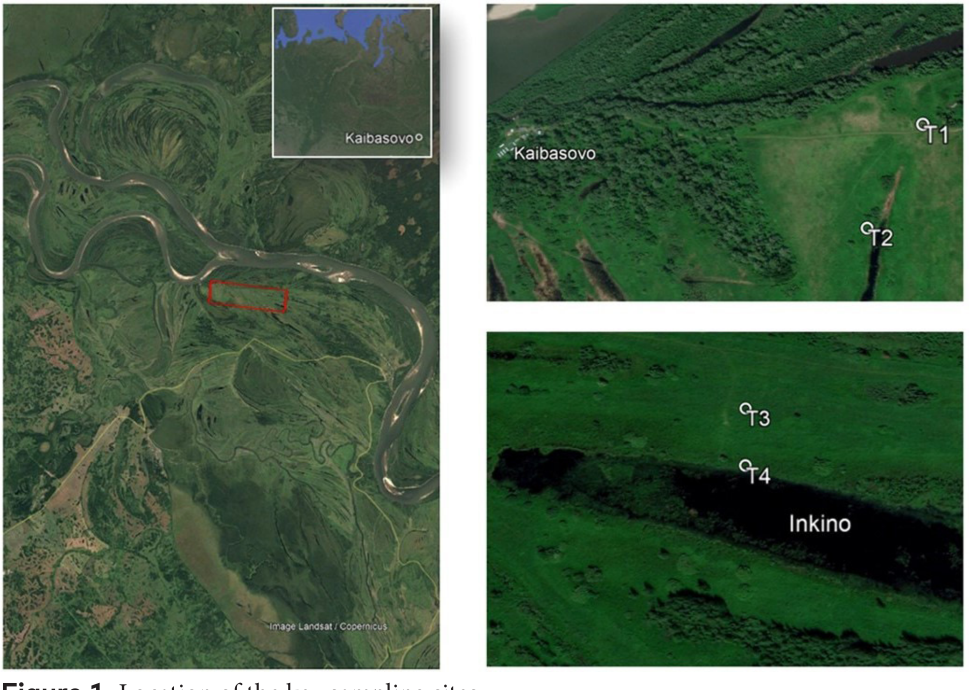

Figure 1. Location of the key sampling sites.

We presented detailed characteristics of the key sampling sites earlier in (Shepeleva et al. 2022, Shepeleva et al. 2023, 2024).

To study meadow communities, above-ground phytomass and soil monoliths were sampled to incorporate the mass and structure of below-ground phytomass into the calculations. Above-ground phytomass was collected by mowing. A geobotanical description was made and the total projective cover of the grass stand was determined on a 100 m^2 sampling area. Plants were cut to ground level from four 0.25 m^2 sites in three replicates. The harvested material was separated by species, air-dried, and then weighed. The masses of individual species were summed to determine the total mass of the grass stand. The dominant species composition, the species richness, and the contribution of various biological and ecological groups of species were identified. Subsequently, the average indicators of phytocoenosis were determined per 1 m^2: productivity (g/m^2), biodiversity for the sampling site (species composition, dominant species composition, species richness, composition and proportion of various fractions in the phytomass) for biological (grasses, sedges, forbs, legumes) and ecological groups. Plant species were assigned to ecological groups using the bioindication ecological scales developed by L.G. Ramensky (Ramensky et al. 1956; Shepeleva 2019). Moisture groups were identified and named in accordance with the classification by Yu. A. Lvov et al. (1987). The Latin nomenclature of plant species were adopted in compliance with the WFO Plant List (https://wfoplantlist.org/plant-list).

Soil monoliths were extracted from depths of 0–10 cm and 10–20 cm, where most plant roots are concentrated (Titlyanova and Shibareva 2020). The below-ground phytomass was washed using 0.25 mm mesh sieves, dried, and then weighed. The fractions of live (B) and dead (V) roots were identified based on visual characteristics using the method described in (Bazilevich et al. 1978). Key criteria for identification included the root tensile strength and stress, the integrity or loss of internal structure, changes in natural color, etc.

NPP dynamics can be analyzed using various methods, ranging from satellite imagery to modeling. However, direct harvest (mowing) methods, although labor-intensive, provide greater accuracy and detail when studying floodplain meadow communities. This is attributed to the floodplain heterogeneity, varying moisture levels, and soil diversity, which forms a mosaic landscape that poses challenges for indirect methods (Shepeleva 2019). One of the earliest methods for studying NPP is G_{max}, an estimate based on the phytomass stock at peak vegetation, specifically at the time of maximum growth rate. However, this estimate tends to underestimate true productivity (Titlyanova et al. 1996; Titlyanova and Shibareva 2020). In this study, we used the balance method used by numerous researchers (Bazilevich et al. 1978; Titlyanova et al. 1996; Titlyanova and Shibareva 2020). The following designations were used: phytomass (G); maximum stock ($G - G_{max}$); dead plant material (D); litter (L); live below-ground plant organs (B); dead below-ground plant organs (V). The calculation was performed using the balance equations (Bazilevich et al. 1978; Titlyanova et al. 1996).

Since the mineralization rates for litter and dead below-ground organs were not determined, the minimum estimate method was employed (Titlyanova and Shibareva 2020).

The analyzed processes included: growth, measured as NPP, which represents the amount of biomass produced per unit area per unit time; AP, above-ground production; BP, below-ground production; NPP = AP + BP.

Weather conditions and flood duration were assessed using data from the Molchanovo weather station (https://meteoinfo.ru) and the Nikolskoye hydrological station (https://allrivers.info/gauge/ob-nikolskoe). Soil temperature was assessed using data from the Kaibasovo meteorological station.

Results

Weather conditions have a significant impact on floodplain meadows (Rabotnov 1984; Shepeleva 2019; Shepeleva et al. 2022; 2024). Therefore, we analyzed precipitation and temperature for 2023 and 2024 in comparison to the long-term average (Table 1). April and May 2023 were relatively dry and cold compared to the long-term average. Warm and humid conditions prevailed from June to September, unlike the previous autumn. In 2024, spring months were warmer than the long-term average but experienced significant precipitation. This trend reversed during the hotter summer months, with precipitation remaining below normal levels until September.

Table 1. Average monthly air temperatures and total precipitation in April–September 2023–2024, data from the Molchanovo weather station

Years	April	May	June	July	August	September
			Temperature, oC			
Average for 10 years	4.3	9.3	17.5	18.8	16.1	9.2
2023	-0.8	10.8	17.2	20.3	16.2	11.2
2024	5.2	12.3	21.7	22.8	17.8	10.9
			Precipitation, mm			
Average for 10 years	35	53	49	70	69.9	47
2023	28.1	10.9	77.1	108	133.7	75.4
2024	58.2	61.5	45.5	52.7	72	48.7

Regarding the flood events, the 2023 flood was not high and did not result in flooding of the meadows (Fig. 2). However, water reached to the floodplain via intra-floodplain streams and channels, leading to a sharp increase in groundwater levels and wetting of lowland meadows (T2 and T4). In contrast, the 2024 flood was more intense; water levels rose significantly higher, exceeding the four-year average, which resulted in flooding of the meadows and increased soil moisture. In 2024, the elecampane meadow (T3) was also flooded.

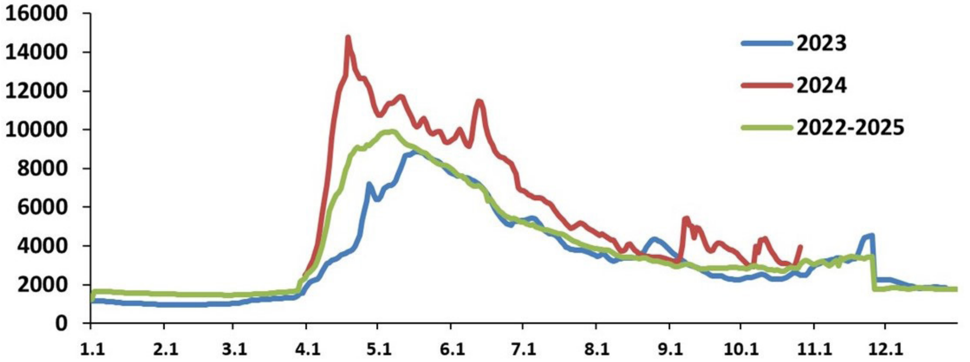

Figure 2. Water discharge [m^3 per second] in the Nikolskoe hydrological station. The discharge is indicated in red line for 2024 and in blue for 2023. The average water discharge over 4 years is shown in green.

Table 2 summarizes the geobotanical characteristics of the sampling sites obtained based on the analysis of the grass stand. Table 3 presents the species composition of the meadow grass stand.

In July 2023, the forb-grass meadow (T1) was characterized by sparse, low-growing grass stand dominated by *Poa angustifolia* and *Bromus inermis*, accounting for approximately 70% of the total projective cover. *Dactylis glomerata* and *Alopecurus pratensis*, as well as *Phlomoides tuberosa* and *Tanacetum vulgare*, nested in clusters (5–7%). *Equisetum arvense*, *Vicia megalotropis*, and *Cirsium arvense* were moderately abundant (3–5%). *Elymus repens*, *Geranium pratense*, *Achillea millefolium* and *Potentilla anserina* showed low abundance (approximately 1%). A total of 34 species were recorded. In July 2024, quantitative changes were recorded in the grass stand composition of the forb-grass meadow (T1). Productivity increased sharply (by 2.3 fold), along with an increase in the projective cover and height of the grass stand. The dominant species composition changed insignificantly, with an increase in abundance of *Poa angustifolia* (up to 36.5%) and *Equisetum arvense* (up to 16.8%), and *Dactylis glomerata* (over 10%). Among the biological groups, the proportion of forbs and legumes, particularly *Lathyrus pratensis*, increased. The species richness of the grass stand remained unchanged.

In 2023, the sedge-reedgrass meadow (T2) was dominated by *Calamagrostis purpurea* and *Phalaroides arundinacea*. *Cirsium arvense* and *Elymus repens*, indicators of community disturbance, were also abundant. Among forbs, *Veronica longifolia* and *Calystegia sepium* were comparatively abundant (1–3%), while legumes were represented by *Vicia cracca* and sedges were represented by *Carex atherodes*. Most of the 24 species (*Lysimachia vulgaris*, *Carex vesicaria*, *Ranunculus polyanthemos*, *Filipendula ulmaria*, *Galium boreale*, *Geranium pratense*) occurred sporadically. In 2024, an increase was observed in the projective cover, height and mass (approximately twofold) of the grass stand. The main dominant species remained, but they also included *Veronica longifolia*, a more moisture-tolerant species, likely responding to increased habitat moisture. The species richness was observed to decrease. In 2023, the grass stand of the elecampane meadow (T3) was significantly dominated by forbs. *Pentanema salicinum* accounted for approximately 40% of the phytomass. *Thalictrum simplex* and *Tanacetum vulgare* each made up 10–15%. Grasses *Elymus repens* and *Phleum pretense*, as well as legumes *Lupinaster pentaphyllus*, were also abundant (5–7%). Less abundant (1–3%) were *Poa angustifolia*, *Hieracium umbellatum*, and *Linaria vulgaris*. A total of 35 species were recorded. In 2024, *Bromus inermis* and *Elymus repens*, species that can withstand prolonged flood events (Rabotnov 1984), became dominant, although *Thalictrum simplex* retained its dominant position. Drought resistant *Pentanema salicinum* and *Tanacetum vulgare* that dominated in 2023 became less abundant. The species richness increased due to the presence of mesophilic forbs.

Table 2. Geobotanical characteristics of the meadow grass stand at the Kaibasovo site of the Tomsk carbon polygon in July 2023–2024

Sampling sites	**T1**		**T2**		**T3**		**T4**	
	2023	**2024**	**2023**	**2024**	**2023**	**2024**	**2023**	**2024**
Total projective cover of grass stand, %	70–80	80	80–90	100	80	100	90	100
Height, cm	35–40	50–60	80–90	120	35	100	60	110
Number of species	34	34	28	20	35	41	32	36
Grass stand mass (G max), g/m^2	330.93	456.27	409.17	709.67	367.43	604.92	489.6	776.83
2023. Dominant species (>10% of mass or projective cover)	*Poa angustifolia*, *Bromus inermis*		*Elymus repens*, *Calamagrostis purpurea*, *Cirsium arvense*		*Pentanema salicinum*, *Tanacetum vulgare*		*Cirsium arvense*, *Phalaroides arundinacea*, *Calamagrostis purpurea*	
2024. Dominant species (>10% of mass or projective cover)	*Poa angustifolia*, *Equisetum arvense*, *Dactylis glomerata*		*Elymus repens, Calamagrostis purpurea, Cirsium arvense, Veronica longifolia*		*Bromus inermis*, *Elymus repens*, *Thalictrum simplex*		*Cirsium arvense*, *Carex cespitosa*	

Note: SS – sampling site; TPP – total projective cover of grass stand; T1 – forb-grass meadow; T2 – sedge-reedgrass meadow meadow; T3 – elecampane meadow; T4 – forb-tussock sedge meadow.

Table 3. Species composition of the meadow grass stand at the Kaibasovo site of the Tomsk carbon polygon in 2023–2024

No	Species composition of grass stand, % of mass	T1		T2		T3		T4	
		2023	2024	2023	2024	2023	2024	2023	2024
1	*Achillea millefolium* L.	0.44	4.21	-	-	1.49	0.88	-	-
2	*Achillea salicifolia* Besser ex DC.	-	-	+	-	-	+	-	-
3	*Agrostis gigantea* Roth	0.14	0.01	-	-	-	-	-	-
4	*Alopecurus pratensis* L.	6.05	4.44	-	-	-	-	5.02	6.41
5	*Anemonidium dichotomum* (L.) Holub	-	-	-	-	-	-	0.38	0.06
6	*Archangelica decurrens* Ledeb.	+	0.12	-	-	-	+	-	-
7	*Arctium tomentosum* Mill.	+	+	-	-	-	-	-	-
8	*Artemisia vulgaris* L.	+	+	-	-	0.14	3.82	-	-
9	*Bromus inermis* Leyss.	28.32	6.29	0.53	-	-	40.06	1.69	1.34
10	*Calamagrostis purpurea* Trin.	-	-	21.18	21.08	-	-	11.54	7.82
11	*Calystegia sepium* (L.) R. Br.	-	-	1.49	+	0.26	2.19	3.99	7.24
12	*Carex atherodes* Spreng.	-	-	1.18	-	-	-	-	-
13	*Carex cespitosa* L.	-	-	-	-	-	-	8.14	17.32
14	*Carex disticha* Huds.	-	-	-	-	-	-	1.68	+
15	*Carex praecox* Schreb.	+	+	-	-	0.19	1.00	0.14	1.24
16	*Carex vesicaria* L.	-	-	+	+	-	-	-	-
17	*Cirsium arvense* (L.) Scop.	0.45	1.80	33.83	25.08	2.31	1.11	20.88	16.76
18	*Conium maculatum* L.	2.24	+	-	-	-	-	-	-
19	*Dactylis glomerata* L.	7.28	12.16	-	-	-	-	-	-
20	*Elymus repens* (L.) Could	0.53	7.08	19.2	25.57	7.13	14.96	2.22	8.77
21	*Equisetum arvense* L.	2.88	16.80	-	0.63	0.62	1.26	-	0.1
22	*Equisetum pratense* Ehrh.	1.46	+	-	-	0.51	0.31	-	-
23	*Festuca pratensis* Huds.	0.3	+	-	-	0.07	+	-	-
24	*Filipendula ulmaria* (L.) Maxim.	-	-	+	-	-	+	2.92	1.87
25	*Galium boreale* L.	-	-	+	1.03	0.34	1.0	4.66	1.44
26	*Geranium pratense* L.	1	0.01	+	+	0.46	0.31	0.46	3.19
27	*Glechoma hederacea* L.	-	-	-	+	0.11	0.03	-	0.38
28	*Hieracium umbellatum* L.	-	-	-	-	1.31	+	-	-
29	*Hylotelephium telephium* (L.) H.Ohba	-	-	-	-	0.05	+	+	+
30	*Kadenia dubia* (Schkuhr) Lavrova & V.N. Tikhom.	-	-	-	-	+	0.22	0.15	1.03
31	*Lathyrus pratensis* L.	+	6.41	0.05	0.57	0.66	0.02	1.67	0.08
32	*Leucanthemum vulgare* Lam.	-	-	-	-	+	+	-	-
33	*Linaria vulgaris* Mill.	-	-	-	-	2.17	0.61	-	-
34	*Lysimachia vulgaris* L.	-	-	+	+	-	1.47	0.56	0.53
35	*Melandrium album* Garcke	+	+	-	-	-	-	-	-

No	Species composition of grass stand, % of mass	T1		T2		T3		T4	
		2023	2024	2023	2024	2023	2024	2023	2024
36	*Moehringia lateriflora* Fenzl	-	-	-	-	0.01	+	-	-
37	*Pentanema salicinum* (L) D. Cut. Larr. Santos-Vicente	-	-	-	-	40.91	8.37	1.93	0.25
38	*Phalaroides arundinacea* (L.) Rauschert	-	-	5.86	6.44	-	-	20.65	9.19
39	*Phleum pratense* L.	+	+	-	-	4.1	0.18	-	0.37
40	*Phlomoides tuberosa* (L.) Moench	19.12	0.11	-	-	-	-	-	-
41	*Poa angustifolia* L.	28.49	36.43	-	-	2.28	8.64	0.2	0.60
42	*Poa palustris* L.	-	-	0.63	2.61	0.53	-	0.12	0.69
43	*Poa pratensis* L.	-	-	+	-	-	+	+	+
44	*Polygonum aviculare* L.	+	+	-	-	-	-	-	-
45	*Potentilla anserina* L.	0.01	1.88	-	-	-	-	-	-
46	*Ranunculus acris* L.	-	0.02	-	-	-	-	-	-
47	*Ranunculus polyanthemos* L.	+	+	0.75	+	0.02	+	-	-
48	*Rhinanthus major* Fr.	+	+	-	-	-	-	-	-
49	*Rumex aquaticus* L.	-	-	-	-	-	-	+	+
50	*Rumex confertus* Willd.	+	+	+	+	-	-	+	+
51	*Sanguisorba officinalis* L.	0.05	0.03	+	+	1.62	2.26	0.18	2.73
52	*Serratula coronata* DC.	+	+	-	-	0.18	+	1.76	+
53	*Stachys palustris* L.	-	-	-	-	0.08	+	0.03	+
54	*Stellaria graminea* L.	+	+	-	-	+	+	-	-
55	*Tanacetum vulgare* L.	+	+	-	-	14.79	0.14	-	-
56	*Taraxacum officinale* F.H. Wigg.	-	-	-	-	0.02	+	-	-
57	*Thalictrum flavum* L.	-	-	0.38	0.45	-	-	-	5.71
58	*Thalictrum simplex* L.	-	-	-	-	9.52	10.42	0.25	+
59	*Trifolium lupinaster* L.	-	-	-	-	4.93	+	-	-
60	*Urtica dioica* L.	+	+	3.23	0.02	-	-	-	-
61	*Veronica longifolia* L.	-	-	2.86	16.5	1.21	0.64	6.79	4.43
62	*Vicia cracca* L.	0.07	0.08	8.83	0.04	-	0.07	+	0.44
63	*Vicia megalotropis* Ledeb.	1.17	2.13	-	-	0.59	+	1.8	+
64	*Vicia sepium* L.	+	-	-	-	-	-	0.19	+
65	*Viola canina* L.	-	-	-	-	-	+	-	-
66	*Víola elatior* Fr.	-	-	-	-	1.39	0.04	-	-
	Total number of species	34	34	24	20	35	42	31	36

Note: + less than 0.01%; T1 – forb-grass meadow; T2 – sedge-reedgrass meadow; T3 – elecampane meadow; T4 – forb-tussock sedge meadow.

The forb-tussock sedge meadow (T4) is primarily formed by *Carex cespitosa* L. growing in hummocks and occupying 20–25% of the area, with height and diameter ranging from 5 to 10 cm. In 2023, the leaf surface of *Carex cespitosa* was poorly developed, constituting only 8% of the total mass of the grass stand. *Calamagrostis purpurea*, *Phalaroides arundinacea* and *Cirsium arvense* were common in the inter-hummock areas (10–20%). *Alopecurus pratensis*, *Veronica longifolia*, and *Galium boreale* were abundant (5–7%). *Filipendula ulmaria*, *Calystegia sepium*, *Elymus repens*, *Carex disticha* and *Serratula coronata* were less abundant (1–3%). Legumes were represented by *Vicia cracca*, *Lathyrus pratensis* and *Vicia megalotropis* (1–3%). A total of 32 species were recorded. In 2024, unlike the previous year, *Carex cespitosa* began to dominate the grass stand (17.3%), while *Calamagrostis purpurea* and *Phalaroides arundinacea* were abundant (7–9%) but did not dominate. A high prevalence of the weed *Cirsium arvense* remained stable.

The phytomass stock accumulated over the two years varied significantly according to the water regime phases. The above-ground phytomass at vegetation peak in July varied from 238.1 to 351.0 g/m^2 in 2023 and from 388.4 to 767.5 g/m^2 in 2024. This clearly illustrates seasonal variations between dry and wet periods. In 2023, the lowest phytomass was recorded in the regularly flooded meadows (T2 and T4). In contrast, the upland meadows exhibited the greatest interannual variation, with nearly a twofold increase in phytomass (Table 2).

Assessing productivity based on peak values may provide an incomplete picture. Therefore, seasonal variations were analyzed throughout the growing seasons (Figs 3–5). A similar pattern of growth and development of the above-ground phytomass was observed in both seasons. Fig. 3 illustrates the development peaks in July–August and declines to near-zero values in October in the flooded and non-flooded meadows, which is consistent with data reported in other studies (Productivity…1978; Shepeleva et al. 2024). However, the phytomass stock in 2024 significantly exceeded that in 2023.

The mortmass showed distinct differences between the two years. In the drier year of 2023, the mortmass displayed a gradual transition of dead plant material into litter during mid-season, mirroring the phytomass dynamics, which was not observed in the wet year of 2024.

A gradual accumulation of dead plant material was observed in 2024, peaking in October. The maximum amount of litter was associated with two distinct periods of the growing season: May (mortmass accumulated over previous seasons) and August–September (dead plant material and litter accumulated after the vegetative period).

In 2023, live root mass in the upland meadows was predominant and remained at a relatively stable level from July to October (Fig. 5). In contrast, the lowland meadows exhibited a consistent increase in live root mass until October.

The dynamic pattern for below-ground mortmass (Fig. 6) was similar across three meadows: forb-grass meadow (T1), sedge-reedgrass meadow (T2), and forb-tussock sedge meadow (T4). This pattern was characterized by peak accumulation of mortmass in September, followed by decreased accumulation in October. In contrast, the elecampane meadow (T3) exhibited a consistent accumulation of dead root mass towards October, whereas the forb-tussock sedge meadow (T4) showed its maximum accumulation in September, followed by a decrease in the subsequent month.

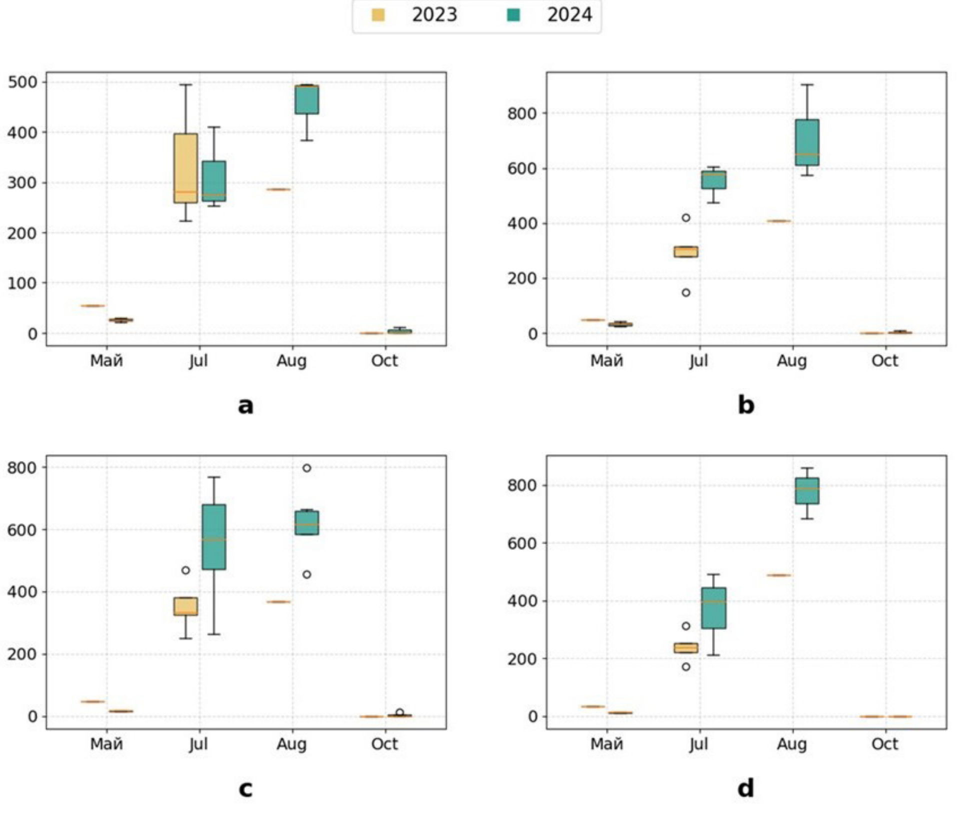

Figure 3. Phytomass dynamics (G) over two growing seasons (g/m^2). a) T1, forb-grass meadow; b) T2, sedge-reedgrass meadow; c) T3, elecampane meadow; d) T4, forb-tussock sedge meadow.

In 2024, changes in plant root mass differed from those in the previous year. On the ridges, an increase in live root mass was observed until September, followed by a sharp decline after the growing season in October. In contrast, the flooded meadows exhibited a consistent decrease in live root mass from May to October. The dynamic pattern for mortmass was similar in the upland and lowland meadows: accumulated dead roots decomposed gradually until September, followed by a sharp increase in mass in October due to the contribution of freshly dead root mass.

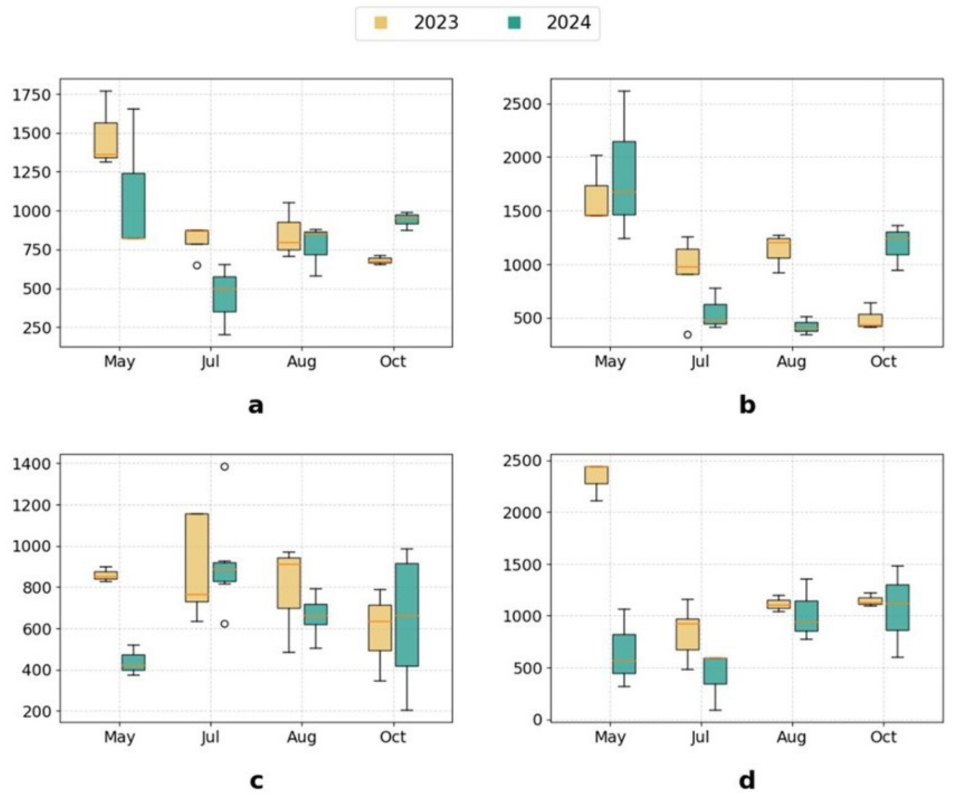

Figure 4. Mortmass dynamics (D+L) over two growing seasons (g/m²). a) T1, forb-grass meadow; b) T2, sedge-reedgrass meadow; c) T3, elecampane meadow; d) T4, forb-tussock sedge meadow.

Discussion

In July 2023, grasses accounted for approximately 70% of the total phytomass in the forb-grass meadow (T1), while forbs constituted about 30%. Other biological groups occurred sporadically. In terms of ecological composition, mesophytes, xeromesophytes, and subxerophytes were predominant. In July 2024, the ecological composition of the grass stand remained unchanged, with xeromesophytes and mesophytes being dominant. However, changes were observed in the secondary groups: the proportion of drought-tolerant subxerophytes decreased, while that of moisture-demanding eumesophytes increased (Table 4).

Agrostis gigantea, a species previously recorded by E.P. Prokopyev (2012) on ridges of the Irtysh floodplain, was recorded only in this non-flooded meadow. Several other species, including *Archangelica decurrens*, *Arctium tomentosum*, *Conium maculatum*, *Dactylis glomerata*, *Melandrium album*, *Phlomoides tuberosa*, *Polygo-*

num aviculare, *Potentilla anserina*, *Ranunculus acris*, and *Rhinanthus major*, were also encountered. *Dactylis glomerata*, a species that prefers moderately moist soils but has low flood tolerance and poor resistance to water stress (Rabotnov 1984; Küsters et al. 2021), became dominant in the forb-grass meadow (T1) in 2024. Furthermore, the proportion of *Achillea millefolium* L. increased in 2024. This species was also reported to thrive in the Irtysh floodplain during wet years (Prokopyev 2012).

Another species dominant in 2024 was *Equisetum arvense*, a vegetatively mobile perennial growing in areas with moderate to high moisture levels. It is known to be sensitive to soil moisture and competition from other species (Andersson and Lundegardh 1999; Cloutier and Watson 1985; James and Rahman, 2010; Prokopyev 2012; Filipov and Robu 2013). The plant spores are known to germinate most effectively under high moisture conditions (Hoekstra 2002). The proportion of *Elymus repens* increased under high moisture conditions in this and other meadows. This species is adapted to flood events and increased soil alluviation (Prokopyev 2012), requires substantial soil moisture, and often dominates the grass stand of floodplain meadows (Gubanov et al. 1976).

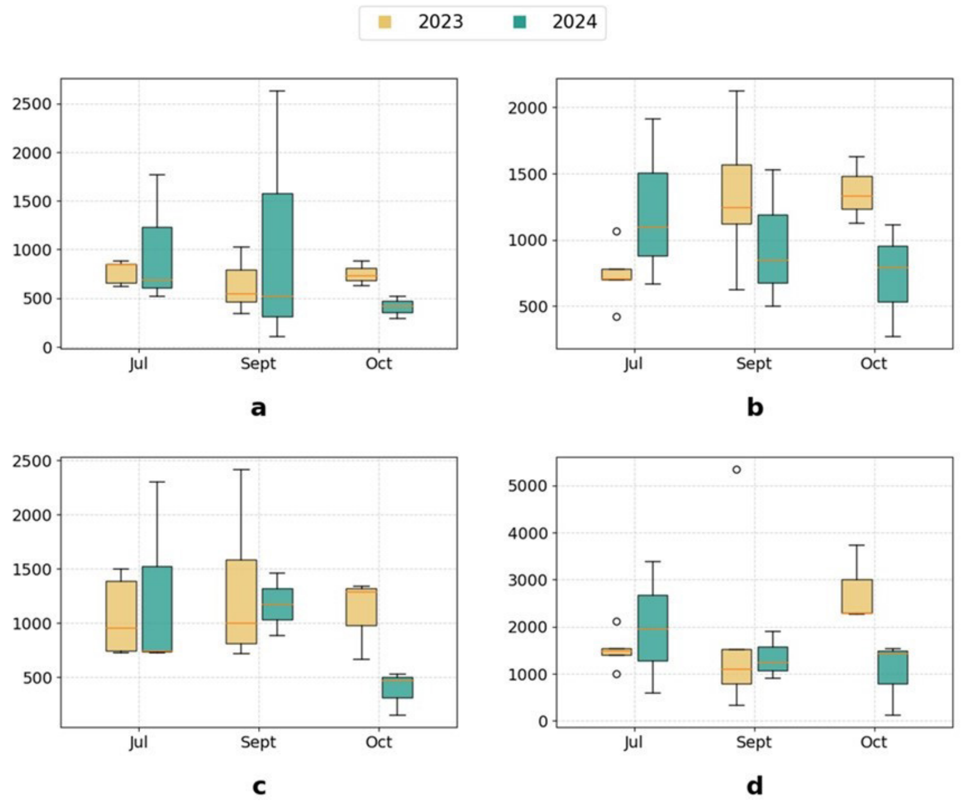

Figure 5. Live root mass dynamics (D+L) over two growing seasons (g/m²): a) T1, forb-grass meadow; b) T2, sedge-reedgrass meadow; c) T3, elecampane meadow; d) T4, forb-tussock sedge meadow.

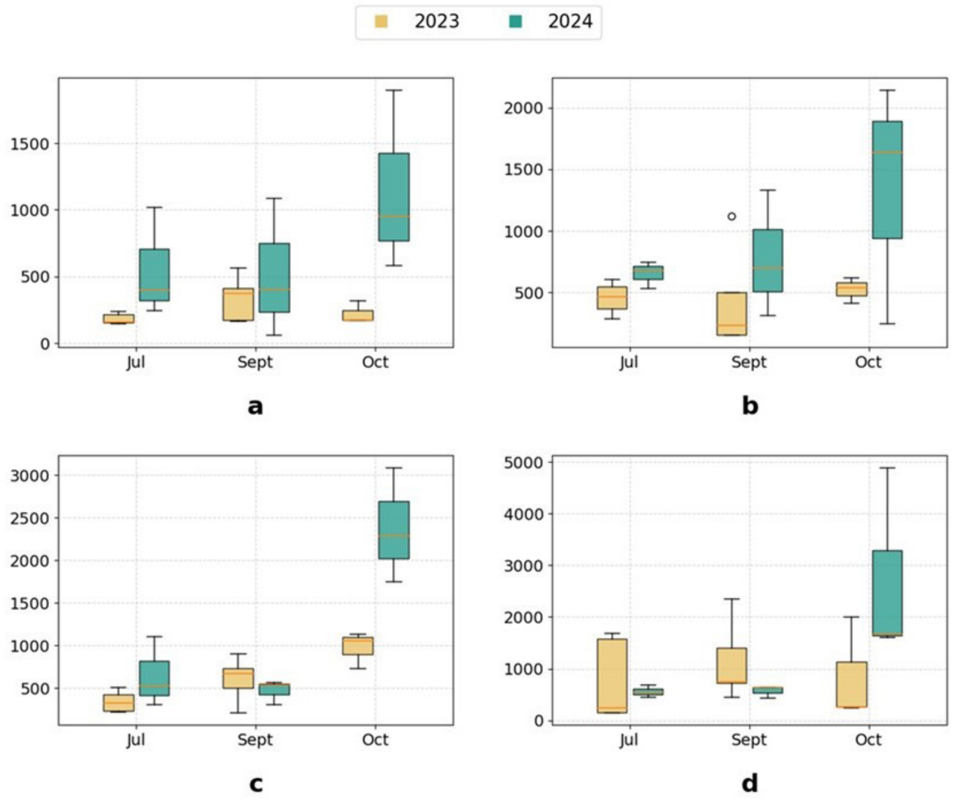

Figure 6. Dead root mass dynamics (D+L) over two growing seasons (g/m^2): a) T1, forb-grass meadow; b) T2, sedge-reedgrass meadow; c) T3, elecampane meadow; d) T4, forb-tussock sedge meadow.

Table 4. Biological and ecological composition of the grass stand in meadow communities (proportion of biological and ecological groups in phytomass), 2023–2024

	Biological groups, %							
Year/SS	**Grasses**		**Forbs**		**Legumes**		**Sedges**	
	2023	**2024**	**2023**	**2024**	**2023**	**2024**	**2023**	**2024**
T1	71.1	60.1	27.7	31.2	1.2	8.6	+	+
T2	47.4	55.7	42.5	43.7	8.9	0.6	1.2	+
T3	14.1	63.8	79.5	35.1	6.2	0.1	0.2	1.0
T4	41.4	35.2	44.9	45.7	3.7	0.5	10	18.6

Year/ SS	Ecological groups,%													
	SX		XM		M		EM		HM		SH		AH	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
T1	19.1	0.1	28.9	42.8	44.9	41.9	7.1	15.2	-	-	-	-	-	-
T2	-	-	0.8	-	10.9	2.3	53.0	50.6	25.4	24.2	8.7	22.9	1.2	-
T3	-	-	64.6	22.9	22.5	26.5	11.1	18.3	9.5	0.2	1.3	2.1	-	-
T4	-	-	2.1	2	16.6	14.6	28.3	34.7	16.8	17.2	36.2	31.5	-	-

Note: SS – sampling site; SX – subxerophytes, XM – xeromesophytes, M – mesophytes, EM – eumesophytes, HM – hydromesophytes, SH – subhydrophytes, AH – aerohydrophytes.

In 2023, forbs were the dominant biological group in the elecampane meadow (T3). In terms of moisture, xeromesophytes and mesophytes were the dominant ecological groups, followed by eumesophytes. The contribution of other ecological groups (total of five) was insignificant. The abundance of large-sized species in the grass stand resulted in high above-ground phytomass, with *Pentanema salicinum* being dominant (41%). In 2024, the projective cover, height, and productivity of the grass stand were observed to increase. Dominance shifted to mesophytic grasses (*Bromus inermis* at 40%) and eumesophytic grasses (*Elymus repens* at 15%), which are tolerant to increased soil alluviation (Prokopyev 2012). The developed root system of *Bromus inermis*, with its numerous lateral branches, facilitates adaptation to excess moisture, waterlogging, and other adverse environmental factors (Pang et al. 2022; Mackiewicz-Walec et al. 2024). This species can withstand short-term spring flooding for up to 45–50 days (Ulrich and Perkins 2014). Mesophytic forbs retained a significant presence, for instance, *Thalictrum simplex* maintained its dominant status. In contrast, *Pentanema salicinum* and *Tanacetum vulgare*, drought-tolerant species that were dominant in 2023, were less abundant. The proportion of species adapted to flooding increased. These included *Artemisia vulgaris*, *Calystegia sepium*, *Carex praecox*, *Cirsium arvense*, *Equisetum arvense*, *Poa angustifolia*, as well as *Elymus repens* and *Galium boreale*.

In 2023, the biological groups of grasses and forbs in the sedge-reedgrass meadow (T2) were represented in equal proportions, with legumes accounting for a significant portion. It is known that legumes thrive in the meadows of the Middle Ob region in years when edificators are not dominant (Shepeleva 1998). Among the ecological groups, eumesophytes were dominant in terms of moisture. However, the ecological composition of the sedge-reedgrass meadow was heterogeneous, likely due to weather conditions and mowing activities in the area adjacent to the sedge-reedgrass meadow (T2), which facilitated the invasion of *Elymus repens*. In 2024, the composition and proportions of biological groups remained unchanged, whereas the proportion of mesophytes decreased and the proportion of moisture-demanding subhydrophytes increased among the ecological groups. An increase was observed in the proportion of hydromesophytes *Poa palustris* and *Veronica longifolia*, whereas the abundance of *Vicia cracca*, a species with poor flood tolerance (Prokopyev 2012), decreased. Overall, the observed changes were quantitative, with the grass stand retaining the structural composition observed in previous years.

The dry spring of 2023 contributed to low phytomass in the forb-tussock sedge meadow (T4). The proportion of grasses and forbs was equal, with sedges accounting for approximately 10%. The ecological composition of the grass stand was heterogeneous, comprising five moisture groups, four of which reached dominant abundance levels. In 2024, the forb-tussock sedge meadow (T4) exhibited an increase in the projective cover, height, and mass (by 1.6 fold) of the grass stand. The biological groups exhibited a decreased proportion of grasses and an increased proportion of sedges. An increase was observed in the proportion of *Alopecurus pratensis* and *Elymus repens*, grasses with high flood tolerance (Rabotnov 1984), and *Carex cespitosa*, a species tolerant to lowland waterlogging (Prokopyev 2012). The proportion of *Calystegia sepium*, *Sanguisorba officinalis*, and *Thalictrum flavum* also increased. The ecological composition changed insignificantly, indicating sufficient habitat moisture and community stability.

After the short-term flood event in 2024, which occurred after a series of dry years (Shepeleva et al. 2023), the composition of the grass stand in the meadow communities exhibited increased phytomass and greater contribution of relatively more moisture-demanding species, primarily grasses and sedges, and sometimes forbs. Correspondingly, a shift in dominant species was observed across all the sampling sites, which is consistent with previous studies conducted in the Ob River floodplain (Shepeleva 2019).

The data on monthly dynamics were employed to calculate the quantitative indicator, NPP, using the balance equation method (Titlyanova et al. 2020). This allows for a quantitative assessment of functioning of the meadow ecosystems and enables a direct comparison of their productivity across years characterized by different hydrological regimes (Table 5).

Table 5. Above-ground production (AP), below-ground production (BP), and net primary productivity (NPP), g/m^2

SS	2023			2024			Difference, %
	AP	BP	NPP				
T1	746.30	971.67	1717.97	943.81	1557.00	2500.81	+45.57%
T2	529.81	1891.33	2421.15	1186.77	2070.33	3257.11	+37.78%
T3	609.28	2078.33	2687.61	934.85	2768.00	3702.85	+ 34.52%
T4	1149.47	3615.33	4764.80	1067.91	3767.00	4834.91	+1.4%

In 2023 and 2024, NPP of the sampling sites ranged from 1717.97 to 4834.91 g/m² (17.2 to 48.4 t/ha), which is considered high for grassland ecosystems (Titlyanova 1988; Titlyanova and Shibareva 2020; Kosykh et al. 2023). By averaging data from the grassland ecosystems across Western Siberia, A.A. Titlyanova and E.K. Vishnyakova (2022) determined an average NPP of 24 t/ha per year, with the highest phytomass stock being characteristic of floodplain meadows. Our data on AP, ranging from 934.85 to 1186.77 g/m², are consistent with findings by N.I. Igosheva (2001), V.N. Tyurin (2017), and N.P. Kosykh et al. (2023). A comparison of our data on G_{max} with data from other studies indicates substantial interannual and intralandscape variability.

In both years, below-ground production constituted the dominant part of NPP, which is characteristic of the floodplain meadows (Titlyanova 1988; Titlyanova & Shibareva 2020; Kosykh et al. 2023) and grassland ecosystems (Titlyanova & Vishnyakova 2022), accounting for 56.6% to 78.1% of NPP.

Compared to 2023, a significant increase in NPP was recorded in 2024 at three out of four sampling sites, reaching a maximum of 45.57%. It should be noted that studies on further north floodplain meadows reported an inverse correlation between the productivity and the level and duration of flooding (Dyidina 1961; Tyurin 2017; Shepeleva et al. 2021).

The analysis revealed that the upland meadows exhibited a more pronounced difference, as waterlogging and a rise in the groundwater level were stimulating factors for the predominantly non-flooded ecosystems. Specifically, NPP increased by 45.6% in the forb-grass meadow (T1) and by 37.8% in the elecampane meadow (T3). The change in NPP was less marked in the regularly flooded meadows, that is, NPP increased by 34.5% in the sedge-reedgrass meadow (T2), which was primarily driven by AP. Insignificant changes were recorded in the forb-tussock sedge meadow (T4), with a minimal year-on-year increase of 1.4%. This indicates community stability and potentially maximum productivity under these specific conditions.

Conclusion

In conclusion, water regime phases exerts a significant effect on the productivity and composition of floodplain meadows. A comparative analysis of two years characterized by different moisture conditions: the drier year of 2023 and wetter 2024 (characterized by intensive flooding) – revealed a clear trend towards increasing NPP depending on the flood events.

The most significant increase in NPP was observed in the non-flooded or rarely flooded meadows. The most significant growth was recorded in the meadows located on ridges, which experienced partial flooding or elevated soil moisture in 2024. In contrast, the regularly flooded meadows exhibited less pronounced dynamics. The lowland meadows adapted to consistent waterlogging demonstrated insignificant response to changes in the flood regime.

An increase in productivity was driven by both AP and BP components. In all cases, increased NPP resulted from increased AP and BP, although their contribution to the total NPP varied across the sampling sites.

The observed changes in NPP correlate with shifts in the grass stand composition. It was wetter period in the year 2024, the sampling sites exhibited changes in dominant species composition and in biological and ecological composition, showing a trend towards a greater proportion of more moisture-demanding species (mesophytes and eumesophytes). This confirms a direct correlation between the water regime phases, flooding duration and ecosystem functioning.

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References

Andersson TN, Lundegardh B (1999) Growth of field horsetail (*Equisetum arvense*) under low light and low nitrogen conditions. Weed Science 47: 41–46. http://www.jstor.org/stable/4046234

Bardgett RD, Bullock JM, Lavorel S, Manning P, Schaffner U, Ostle N, Chomel M, Durigan G, fry EL, Johnson D, Lavallee JM, Provost GL, Luo S, Png K, Sankaran M, Hou X, Zhou H, Ma L, Ren W, Li X, Ding Y, Li Y, Shi H (2021) Combatting global grassland degradation. Nature Reviews Earth & Environment 2: 720–735. https://doi.org/10.1038/s43017-021-00207-2

Baryshnikov MK (1933) Grassland of the Ob and Irtysh Rivers in the Tobolsk North. Goszemobedinenie, Moscow, 95P p. [In Russian]

Bazilevich NI, Titlyanova AA, Smirnov VV, Rodin LE, Nechayeva NT, Levin FI (1978) Methods of studying the biological cycle in various natural zones. Mysl', Moscow, 184 pp. [In Russian]

Cloutier D, Watson AK (1985) Growth and regeneration of field horsetail (*Equisetum arvense*). Weed Science 33: 358–365. http://www.jstor.org/stable/4044272

Dydina ZA (1961) Ob-Irtysh meadows within the Khanty-Mansiysk Okrug. Gr. Research Institute of Agriculture of the Far North. 10: 159–250. [In Russian]

Dymina GD (1989) Classification, dynamics and ontogenesis of herbaceous phytocenoses (for example, regions of Siberia and the Far East). Abstract of a dissertation for the degree of Doctor of Biological Sciences. Novosibirsk. [In Russian]

Elizarieva MF (1951) Meadow vegetation of Tomsk region as a forage base for animal husbandry. Proceedings of Tomsk University 114: 135–149. [In Russian]

Filipov F, Robu T (2013) The Degradation of the Asphalt Alleys by Rhizomes of Herbaceous Plant Species of Couch Grass. In: Recent advances in Energy, modelling Enviroment and Geology. Proceedings of the 2nd International Conference on Natural Resources management (October 8–10, 2013). WSEAS Press Antalya, Turkey, 136–141.

Hoekstra FA (2002) Pollen and spores: desiccation tolerance in pollen and the spores of lower plants and fungi. In: Black M, Pritchard HW (Eds) Desiccation and survival in plants: drying without dying. CABI Publishing, Wallingford, 185–205. https://doi.org/10.1079/9780851995342.0185

Hossain ML, Kabir MH, Nila MUS, Rubaiyat A (2021) Response of grassland net primary productivity to dry and wet climatic events in four grassland types in Inner Mongolia. Plant-Environment Interactions 2(5): 250–262. https://doi.org/10.1002/pei3.10064

Igosheva NI (2001) Composition, structure and productivity of meadow vegetation in the middle stream of the Ob River. Botanical Journal 86: 111–122. [In Russian]

James TK, Rahman A (2010) Chemical control of field horsetail (*Equisetum arvense*). New Zealand Plant Protection 63: 102–107. https://doi.org/10.30843/nzpp.2010.63.6543

Junk WJ (1989) Flood tolerance and tree distribution in central Amazonian floodplains. In: Holm-Nielsen LB, Nielsen IC, Balslev H (Eds) Tropical Forests: Botanical Dynamics, Speciation & Diversity. Academic Press, 47–64. https://doi.org/10.1016/B978-0-12-353550-4.50012-5

Kosykh NP, Mironycheva-Tokareva NP, Peregon AM (2023) Productivity of Water Meadows under Haymaking in the Mid-Stream of the Ob River. Water 15(6): 1083. https://doi.org/10.3390/w15061083

Kushanova AU, Korkin SE (2015) Evaluating the productivity of farmlands in the floodplain segment-insular landscape area of the Ob river region. Bulletin of Udmurt University. Series Biology. Earth Sciences 25(4): 14–21. [In Russian]

Küsters J, Pötsch EM, Resch R, Gierus M (2021) The effect of summer water stress on the nutritive value of orchard grass (*Dactylis glomerata* L.) in permanent grassland under increased temperature and elevated atmospheric CO_2. Ecological Indicators 125: 107566. https://doi.org/10.1017/s0021859621000460

Logutenko NV (1963) Lowland meadows and grassy bogs of the forest-steppe and steppe zones of the Altai Territory and Novosibirsk Region. Vegetation of the forest-steppe and steppe zones of Western Siberia. Siberian Branch of the USSR Academy of Sciences, Novosibirsk, 306–333. [In Russian]

Lvov YuA (1963) On the characteristics of the vegetation of the Ob River floodplain. Proceedings of Tomsk State University 152: 258–267. [In Russian]

Lvov YuA, Shepeleva LF, Lapshina ED (1987) Assessment of floodplain meadows by the fluctuation capacity of their vegetation cover. Botanical Journal 72 (5): 599–609. [In Russian]

Mackiewicz-Walec E, Żarczyński PJ, Krzebietke SJ, Żarczyńska K (2024) Smooth Brome (*Bromus inermis* L.) – A Versatile Grass: A Review. Agriculture 14(6): 854. https://doi.org/10.3390/agriculture14060854

Mathar W, Kleinebecker T, Hölzel N (2015) Environmental variation as a key process of co-existence in flood-meadows. Journal of Vegetation Science 26: 480–491. https://doi.org/10.1111/jvs.12254

Morozova LM, Golovatin MG (2023) Floristic diversity of the Lower Ob River floodplain in the Yamalo-Nenets Autonomous Okrug. Proceedings of the Komi Science Center of the Ural Branch of the Russian Academy of Sciences. Experimental Biology and Ecology Series (64): 47–61. https://doi.org/10.19110/1994-5655-2023-6-47-61 [In Russian]

Pang Z, Xu H, Chen C, Zhang G, Fan X, Wu J, Kan H (2022) Comparing Water Use Characteristics of *Bromus inermis* and *Medicago sativa* Revegetating Degraded Land in Agro-Pasture Ecotone in North China. Water 15(1): 55. https://doi.org/10.3390/w15010055

Penkovskaya EF (1963) Vegetation of the Ob floodplain. Vegetation of the forest-steppe and steppe zones of Western Siberia 6. Publishing house of the Siberian Branch of the USSR Academy of Sciences, 211–261. [In Russian]

Penkovskaya EF (1972) On the characteristics of meadow vegetation of the Ob floodplain. Biological resources of the Ob floodplain. Nauka, Novosibirsk, 334–350. [In Russian]

Productivity of meadow communities (1978) Nauka, Leningrad, 287 pp. [In Russian]

Prokopiev EP (2012) Vegetation Cover of the Irtysh Floodplain. Tomsk State University, Tomsk, 560 pp. [In Russian]

Pudova MS, Shepeleva LF (2022) Root systems reserve under humid conditions of floodplain meadows of the Ob River in the subzone of the southern taiga. Problems of botany in Southern Siberia and Mongolia 21(2): 151–154. https://doi.org/10.14258/pbssm.2022073 [In Russian]

Rabotnov TA (1984) Meadow Science. Moscow State University named after M.V. Lomonosov, Moscow, 320 pp. [In Russian]

Rabotnov TA (1985) Ecology of meadow grasses. Moscow, 176 pp. [In Russian]

Ramenskiy LG, Tsatsenkin IA, Chizhikov ON, Antipin NA (1956) Ecological assessment of grasslands based on vegetation cover. Selkhozgiz, Moscow, 472 pp. [In Russian]

Rozhdestvensky YuF (1992) Plant groups of floodplain meadows of the lower section of the Ob River and a brief description of the dominant plant species. Nature of the Lower Ob River floodplain. Terrestrial ecosystems. Ural Branch of the Russian Academy of Sciences, Yekaterinburg, 47–63. [In Russian]

Samoilenko ZA, Shepeleva LF, Shepelev AI (2009) Ob-Irtysh interfluve vegetation area units. Bulletin of Tomsk State University 327: 208–213. [In Russian]

Shepeleva LF (1987) Dynamics of meadow communities of the Middle Ob floodplain (within Tomsk Oblast). Abstract of a dissertation for the degree of Candidate of Biological Sciences. Tomsk, 17 pp. [In Russian]

Shepeleva LF (1998) Organization of meadow communities of the Middle Ob floodplain. Abstract of a dissertation for the degree of Doctor of Biological Sciences. Novosibirsk, 33 pp. [In Russian]

Shepeleva LF (2019) Structure and dynamics of meadow communities of the Middle Ob floodplain. Revushkin AS (Ed.) Publishing house of Tomsk State University, Tomsk, 348 pp. [In Russian]

Shepeleva LF, Cherepinskaia AN, Baklanova AA (2021) Influence of abiotic factors on the productivity of grass stand of meadows of the Bolshoy Yugan River floodplain. Innovative technologies in science and education: collection of articles from the XVI International scientific and practical conference (Penza, February 15, 2021). Science and Education, Penza, 20–24. [In Russian]

Shepeleva LF, Kolesnichenko LG, Churakov EE, Pudova MS, RozhkovaTimina IO, Vorobyev SN (2024) Dynamics of phytomass in the floodplain meadows of the middle Ob during the growing season. Vestnik Tomskogo gosudarstvennogo universiteta. Biologiya [Tomsk State University Journal of Biology] 68: 195–218. https://doi.org/10.17223/19988591/68/11 [In Russian]

Shepeleva LF, Pudova MS, Ledeneva EA, Kolesnichenko LG (2022) Dynamics of the aboveground phytomass of the Ob floodplain meadows in the area of the Tomsk carbon polygon (Kaibasovo). Environmental Dynamics and Global Climate Change 13(2): 104–119. https://doi.org/10.18822/edgcc119054

Shepeleva LF, Pudova MS, Ledeneva EA, Kolesnichenko LG (2023) Aboveground and belowground phytomass of meadow communities of the middle Ob floodplain (the Krivosheinsky District of the Tomsk Region). Journal of Siberian Federal University. Biology 16(4): 454–470. [In Russian]

Shepeleva LF (1986) On the influence of floods on the productivity of floodplain meadows. Ecology 2: 3–8. [In Russian]

Shi L, Wang Y, Jia Y, Lu C, Lei G, Wen L (2017) Vegetation Cover Dynamics and Resilience to Climatic and Hydrological Disturbances in Seasonal Floodplain: The Effects of Hydrological Connectivity. Frontiers in Plant Science 8: 2196. https://doi.org/10.3389/fpls.2017.02196

Shibanova AA (2010) Historical review of researches upper Ob flood plain vegetation. Problems of botany in Southern Siberia and Mongolia 9: 272–275. [In Russian]

Shibanova AA, Terehina TA (2012) Meadow and forest vegetation in the upper Ob floodplain. News of Altai State University 3-2(75): 71–74. [In Russian]

Silvertown J, Dodd ME, Gowing DJG, Mountford JO (1999) Hydrologically defined niches reveal a basis for species richness in plant communities. Nature 400: 61–63. https://doi.org/10.1038/21877

Sommer L, Klinger YP, Donath TW, Kleinebecker T, Harvolk-Schöning S (2023) Long-term success of floodplain meadow restoration on species-poor grassland. Frontiers in Ecology and Evolution 10: 1061484. https://doi.org/10.3389/fevo.2022.1061484

Taran GS (1995) Syntaxonomy of meadow-marsh vegetation of the Middle Ob floodplain (within the Aleksandrovsky district of Tomsk region). Sedelnikov VP (Ed.) Preprint. Siberian Branch of the Russian Academy of Sciences, Central Siberian Botanical Garden, Novosibirsk, 79 pp. [In Russian]

Taran GS, Dymina GD (1990) Interannual variability of grass communities in the floodplain of the middle Ob. Izvestiya Rossiyskoy akademii nauk. Seriya biologicheskaya [Biology Bulletin] 2: 85–92. [In Russian]

Titlyanova AA (1988) Productivity of grass ecosystems. Biological productivity of grass ecosystems. Nauka. Siberian Branch, Novosibirsk, 109–128. [In Russian]

Titlyanova AA, Kosykh NP, Mironycheva-Tokareva NP, Romanova IP (1996) Underground organs of plants in grass ecosystems. Nauka, Novosibirsk, 128 pp. [In Russian]

Titlyanova AA, Shibareva SV (2020) Productivity of grass ecosystems: Handbook. MBA, Moscow, 100 pp. [In Russian]

Titlyanova AA, Vishnyakova EK (2022) Productivity changes of wetland and grassland ecosystems along a latitudinal gradient. Soils and the environment 5(2): e176. https://doi.org/10.31251/pos.v5i2.176 [In Russian]

Tyurin VN (2004) Ecological assessment of vegetation of the Surgut segment of the Ob floodplain. Dissertation for the degree of Candidate of Biological Sciences. Surgut, 217 pp. [In Russian]

Tyurin, VN (2017) Results of long-term observations of the dynamics in productivity of grass-dominated plant communities of coastal shallows (Surgut area of the Ob River). Bulletin of the Samara Scientific Center of the Russian Academy of Sciences 19: 2–3. [In Russian]

Ulrich E, Perkins L (2014) *Bromus inermis* and *Elymus canadensis* but not *Poa pratensis* demonstrate strong competitive effects and all benefit from priority. Plant Ecology 215: 1269–1275. https://doi.org/10.1007/s11258-014-0385-0

Vicente-Serrano SM, Gouveia C, Camarero JJ, Beguería S, Trigo R, Lopez-Moreno JI, Azorín-Molina, C, Pasho E, Lorenzo-Lacruz J, Revuelto J, Moran-Tejeda E, Sanchez-Lorenzo A (2013) Response of vegetation to drought time-scales across global land biomes. Proceedings of the National Academy of Sciences of the United States of America 110(1): 52–57. https://doi.org/10.1073/pnas.120706811

Vyltsan NF (1968) Floodplain meadows of the Ob River valley in the northern districts of Tomsk Oblast. Nature and economy of the Aleksandrovsky oil-bearing region (Tomsk Oblast). Tomsk University Press, Tomsk, 212–225. [In Russian]