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RESEARCH ARTICLE

Agricultural use of peat bog soils and changes in water duty to floodplains of rivers of the Left-Bank Forest-Steppe

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Goal–To establish regularity of transformation of drained peat bog soils, also changes in the water duty to floodplains in the process of agricultural use. Determine the ways of their rational use in the conditions of the Left-Bank Forest-Steppe.
Research methods. General scientific and special, empirical and theoretical, historical – for a retrospective synthesis of scientific achievements of domestic and foreign scientists on the study of the formation of indicators of fertility and productivity of drained soils; analytical – for analysis of conditions and processes of changing fertility indicators; laboratory – for determination of agrochemical and water-physical properties of soil; field – to establish the botanical composition of the grass stand, accumulation of the amount of root and crop residues in the soil, to establish the intensity of mineralization of organic matter and crop productivity; mathematical statistics – to assess the reliability of the research results.
Many years of experience summarized and scientific estimates of the transformation of drained peat bog soils with long-term agricultural use are presented. It has been established that over 80 years of use of these soils in agricultural production, peat deposits wear amounted to 100 cm (in the early years, an annual decrease in peat depth was 1, 63, subsequent – 1, 45, and the last – 0, 88 cm). Decrease the depth of the peat bed also occurs due to their compaction.
Qualitative and quantitative changes in peat soils under the influence of drainage and long-term agricultural use we researched. We have established the patterns and directions of soil processes depending on the influence of the duration of development of peat soils. We also identified scientific and methodological approaches to assessing the conditions and factors affecting the formation of fertility and productivity of drained soils. We have analyzed existing approaches to rationalizing nature management, taking into account the characteristics of the economic development of drained lands.
Regularities and directions of transformation of drained peat bog soils under the influence of long-term agricultural use are justified. We have identified trends in the indicators of fertility and productivity of drained peat bog soils. We have implemented a systematic approach to the spatiotemporal study of the soil potential of drained soils in order to rationalize nature management in the risky farming zone. We also found that the high-productivity use of organogenic soils provides for the functioning of agrophytocenoses from perennial crops with the aim of creating conservation agrolandscapes and improving the ecological balance in the floodplains of small rivers.

Key words: Peat soils; Draining; Mineralization; Perennial herbs; Productivity; Agricultural use

Introduction

The inevitability of human intervention in the environment requires a rational direction of economic activity, which would support the basic requirements for environmental safety. This is especially true for drained organogenic soils of floodplains . The rational use of soil resources provides an organic combination of their maximum production capacity for the conservation and increase of peat soil fertility, inculcation of measures ecological safety of water resources and Improvement and environmental functioning of reclaimed and surrounding area (Romashchenko M.I. et al., 2018; Tarariko Y.O., 2018; Yatsyk A.V., et al., 2018).

The analysis of domestic and world experience regarding the areas of rational use of natural resources in the risky farming zone indicates the need to review the strategic priorities of economic development including territories of drained agricultural land (Buchmann N. et al., 2019; Hofer D. et al., 2017; Pornaro C. et al., 2019).

The scientific community has repeatedly raised the issue of protecting and preserving the environment, since the 70s of the last century, when the scale of land reclamation of drained soils was grandiose. So, Maslov B.S., StarikovKh.N. (Maslov B.S.,

StarikovKh.N. 1976) indicate that when conducting land reclamation, it is necessary to take into account not only production, economic, but also aesthetic and environmental problems.
Thus, awareness of the integrated approach to the use of reclaimed lands of the humid zone of the Left-Bank Forest-Steppe necessary for processing the main directions of environmentally safe and highly productive use of drained peat soils for agricultural production.
Purpose of the study – establish methods for the impact of agricultural use on the transformation of drained peat bog soils and changes in the water regime of floodplains of small and medium rivers. To determine ways of rational environmentally safe use of organnic soils in the drainage reclamation zone of the Left-Bank Forest-Steppe.

Research Methods

From 1938 to 2018, an experiment was been conducted on the drained peat soils of the Supiy River floodplain of Panfilska research station of the NSC «Institute of Agriculture of NAAS». Soils in the test area- peat-gley and peat bogs shallow, medium and deep. The research had been conducted according to conventional field and laboratory methods using measurement-weight, calculation, comparative, chemical and mathematical-statistical methods. The depth of the peat layer was determined by sounding, excluding 1983, when it was determined on peat-gley soils by the calculation method, since the peat layer was been mixed with the parent rock during processing. The density, total moisture capacity and porosity were determined according to Kachinsky. Groundwater level - twice a decade. Gross nitrogen content in peat according to GOST 7911: 2015, phosphorus – on a photocolorimeter, potassium - on a flame photometer - according to Machigin (GOST 4114-2002). The degree of decomposition of peat was determined by centrifugation, ash content - dry exposure. The content on high-molecular organic acids is according to Tyurin (DSTU 4289: 2004).

Results and Discussion

Agricultural use of drained organogenic soils leads to a decrease in the depth of the peat layer, mainly due to the type of lands and technological features of growing crops. However, depending on the depth of the peat layer of the soil, this decrease in different periods of use was different. On deep peatlands in the first 19 years (1938–1957) for the use of test areas, mainly in fodder crop rotation with a saturation of 50% with perennial grasses peat layer depth reduction amounted to deep peatlands, for the period from 1938-1957 – 1, 63, for the period 1957–1983 – 1, 45 cm, and for the period from 1983 to 2018, the decrease in peatland thickness was only 0, 88 cm. That is, in the first years of development of ameliorative organogenic soils, the process of decomposition of organic mass of peatlands is most intensive. In course of time, the processes of the peat horizon are decayed (in the studies by 11 and 23% respectively) and is largely dependent on anthropogenic factors. On the organic mid-deep soils of the Supiy River floodplain, the annual activation of the peat horizon was the most intense and amounted to 1.7 cm between 1957 and 1983 annually, which was mostly dependent on activation of microbiological processes in the soil.

Table 1. Influence of agricultural use on reducing the depth of peat soil on organogenic soils of the Supiy floodplain.

Soils	Depth of peat layer, cm				Decrease in peat depth over the years, cm		Annual decrease in peat depth over the years, cm		
					27	80	19	27	34
	years								
	1938	1957	1983	2018	1957-1983	1938-2018	1938-1957	1957-1983	1983-2018
The peatlands are deep	300	269	230	200	39	100	1, 63	1, 45	0, 88
Peat bogs are medium and shallow		153	107		46			1, 7	
Peat-silt soils		28	6		22			0, 8	

Note: The data for 1938 are from the Panfil Experimental Field Report

On peat-silt soils, the decrease in peat depth during the 27-year observation period was minimal and amounted to 0.8 cm per year (Table 1), which is caused by high ash content (70-75%) and intensive decomposition of organic matter of peat-silt soils of the forest-steppe zone. Long-term studies conducted on organogenic soils in the area of drainage reclamation (Panfil Research Station, NAAS), that the intensive reduction of the roughness of the peat horizon does not lead to a significant loss of soil organic matter, as there are processes of mineralization and compaction of the soil profile of the peat (Shtakal M. I. and others, 1987).
Our studies on changes in water-physical and agrochemical parameters showed, that in the process of agricultural use, first of all, there is a process of compaction (Table 2). Thus, during the period 1957-1983 the density of folding of arable (0-30 cm) soil layer increased on average in sections 2-7 from 0.25 to 0.34 g / cm^3, or by 33%. It caused to a decrease in the total moisture content of peatlands from 342 to 247% and a roughness from 86 to 83%.
Peaty gley soils differ from multi-deep peat soils with higher folding density (0, 75-0.80 g/cm^3), low total moisture capacity (98-90%) and roughness (72%), that is, in their water-physical indicators occupy an intermediate position between peat and mineral soils (Truskavetsky R.S., 2010). Therefore, the change in these indicators over the 27 years of observation in our conditions was minimal. $CaCO_3$ content and ash content increased by 2-5%, the pH of water remained virtually unchanged.
During the observation period, significant changes occurred in the arable layer of soil by the content of gross forms of nitrogen and phosphorus. Thus, for 27 years of their use, in the deep and medium peatlands the gross nitrogen content decreased from 2, 8–3, 5% to 1, 6–1, 9%, and on peat-silt soils – from 3, 0% to 1, 1%, or almost 2-3 times, indicating the intensive processes of mineralization of the arable layer of peat soil. Gross phosphorus content also decreased, on average, by 2 times (from 0, 5–0, 8 to 0, 28–0, 43%) and only on peatlands of various depths. On peat-silt soils rich in vivianite layers, the reduction of the peat horizon's power was negligible. There was no significant change in the content of gross potassium in the soil.

Table 2. Change of basic water-physical and agrochemical parameters of peatlands for their long agricultural use.

No plots	Folding density, g / cm^3	Total moisture capacity, %	Porines s, %	Ash conten t , %	Content $CaCO_3$, %	pH water	Gross form content, % on a dry lot		
							N	P_2O_5	K_2O
Deep and medium peatlands for the period 1957-1984 (soil layer 0-30 cm)									
2				35/40	7/9	7, 6/7, 8			
3	0, 22/0, 3	410/283	88/84	34/41	11/13	7, 6/7, 6	3, 5/1, 8	0, 8/0, 4	0, 15/0, 17
4	0, 21/0, 29	412/291	88/85	35/44	12/19	7, 6/7, 4	2, 8/1, 6	0, 5/0, 3	0, 1/0, 08
5	0, 26/0, 33	324/249	86/83	39/46	27/30	7, 2/7, 8			
6	0, 28/0, 37	303/224	85/84	54/56	28/32	7, 6/7, 6	3, 5/1, 9	0, 8/0, 4	0, 15/ 0, 14
7	0, 27/0, 38	323/220	86/84	54/55	32/32	7, 5/7, 5			
2-7	0, 25/0, 34	342/247	86/83	42/47	20/22	7, 5/7, 5	3, 3/1, 8	0, 7/0, 4	0, 13/0, 13
Peat-silt soils for the period 1957-1984 (soil layer 0-30 cm)									
15	0, 75/0, 80	98/90	73/72	63/70	28/28	7, 6/7, 5	3, 0/1, 1	0, 6/0, 5	0, 3/0, 33
Deep peatlands for the period 1957-2018 (soil layer 40-50 cm)									
3	0, 22/0, 26	410/330	88/86	34/36	11/12	7, 6/7, 6	3, 5/2, 8	0, 8/0, 7	0, 15/0, 16

Note: The numerator shows the figures for 1957, and the denominator – for 1983 and 2018.

Now in the scientific literature there are reports of the harmful effects of intensive agricultural use of drained and developed peat soils on the ecological situation of floodplains (Yatsik A.V., Pashenyuk I.A. et al., 2019; Bogovin A.V. et al., 2014; Kurgak V. et al., 2012). Therefore, studies have been conducted on the change in the water-physical and agrochemical properties of the subsoil (40-50 cm) soil layer for the period of their use from 1957 to 2018, i.e. for 61 years. As a result, it was found that the addition density of the uncultivated peat bog horizon increases by 18%, which is almost two times less than the value of this indicator in the arable layer of the soil. The corresponding regularity was also noted in studies of the total moisture capacity of the soil. The value of the total moisture content varies from 28% to 19%, respectively. Inconsequential changes also occur in the content of gross forms of nitrogen (the decrease is only 20% or an order of magnitude lower in the arable layer), and changes in the gross forms of phosphorus and potassium practically did not occur. It is not difficult to predict that in the peat layers below the undersoil water level during the growing season (75-100 cm) these processes will practically not pass, and the peat will be preserved. That is, nutrients due to the mineralization of peat are released mainly from the arable soil. Therefore, agricultural use of peat soils mainly changes only the topsoil, which does not have catastrophic consequences for the entire peat layer and the floodplain ecosystem as a whole.

Along with these changes, there is also a change in the degree of decomposition of peat (Table 3). So, when growing mainly perennial herbs on deep peatlands in the arable layer, the degree of decomposition of peat over the period from 1957 to 1983 increased from 35 to 58-59%, and for use in rotation according to 66%. However, the highest rates of peat decomposition (87%) are noted for its use mainly in cultivated crops. Peat-silt soils also had a high degree of peat decomposition (79%), which indicates a high microbiological activity in them. Thus, during long-term agricultural use (45 years), peat in the arable layer reached a high degree of decomposition and transformed into humus, and peat and peat-silt soils received the status of humus-peat and humus-peat-silt soils. This was observed even in areas of experience that were used mainly under grasses.

Different methods of use have also led to changes in the structural composition of the arable soil of organogenic soil. Thus, the content of peat particles of 0, 25–0, 5 mm, easily exposed to wind erosion was quite high (56-59%) in peat-silt and peat soils used for cultivation of cultivated crops.

Table 3. The degree of decomposition of the arable layer of peat, depending on the subtype of peat-bog soils and how they are used.

N	Soil type and method of use	Number of measuring points	The degree of decomposition of peat, %		Aggregate composition of soil particles in 1983, %	
			1957	1983	0, 25-0, 5 мм	>0,5 мм
3	Deep peatlands, cultivated	4	35	87	59	41
6	Deep peatlands, crop rotation	3	35	66	52	48
10	Deep peatlands, perennial grasses	4	35	58	41	59
0	Deep peatlands, perennial grasses	4	35	59	42	58
15	Peat-silt, crop rotation	4	35	79	56	44

A slightly smaller number of structural particles of peat (52%) was observed when using dried lands in crop rotation, and the lowest (41-42%) - for using them under perennial grasses. Of course, as of 2018, the content of peat particles in the plow soil exposed to wind and water erosion has definitely increased, but with environmentally friendly use of peat soils for growing perennial grasses, there is no risk of erosion or deflational processes.

In connection with exacerbation of environmental problems, one of the debating issues is the direction of further use of peat soils in agricultural production (Yatsik M.V., Voropay G.V., etc. 2019; Petrichenko V.F., Kurgak V.G., 2013; Kurgak V.G., etc. 2010; Henkin Z., 2016). Studies that were carried out between 1976 and 2017 showed that drained peat soils, for growing perennial grasses on them, are extremely productive lands (Table 4). Thus, the yield of dry mass of grassy cenoses on peat-gley soils without fertilizer is 5, 63 t/ha or 6, 5 t/ha of hay. When phosphorus-potassium fertilizers are applied, the dry mass productivity rises to 6, 34 t/ha or 4, 6 t/ha of feed units of 1 hectare. Such a high yield of perennial grasses cannot be provided even by chernozem soils. On deep peat soils, the productivity of hayfields with their phosphorus-potash fertilizers is higher and amounts to 10.2 t/ha dry weight or 12 t/ha of hay. With full mineral fertilizer, the productivity of such haystacks reaches 10 t / ha feed units. Such high productivity of these lands is achieved near to optimal wet supply and nutritional regime. Similar results were obtained in the drained lands of Western Polesie (Henkin Z., 2016; Tarariko Y.O., Stetsyuk M.G., 2014).

Table 4. Productivity of perennial grasses on different subtypes of peatlands.

Fertilization	Yield of dry weight, t / ha	Yield, t / ha		
		feed units	GJ / ha	digestible protein
Peat-silt soils, plot 15 (medium for 1976-1978)				
Без добрив	5, 63	4, 1	38, 5	0, 49
P_{67} K_{120}	6, 34	4, 6	44, 6	0, 58
N_{90} P_{67} K_{180}	8, 41	7, 2	69, 8	0, 94
SSD_{05}	0, 33			
Deep peatlands, plot 3 (medium for 2014–2017)				
P_{45} K_{120}	10, 2	7, 5	97, 5	1, 05
N_{90} P_{45} K_{120}	12, 0	9, 4	118, 1	1, 28
SSD_{05}	0, 56			

It should also be noted, that evidence of the high fertility of these soils is a sufficiently significant content of humic acids in the arable layer of peat. Thus, studies conducted in 1980 on peat-silt soils showed that the content of humic acids was 8%, and for the period of 2017, in the deep peatlands, this figure was 15-16%. Such a high humus content is not observed in any of the soil types of agricultural land in the country, according to Medvedev V.V. (Medvedev V.V. et al., 2014). So, in order to slow down the rate of decomposition of the organic matter of peat, these soils should be rationally used for the production, mainly of feed, when growing perennial herbs on them. It should be noted that in the last decade the weather conditions of the growing season have changed in the direction of increasing air temperature and reducing the amount of precipitation (Table 5).

Table 5. Temperature and water regime of the Supiy floodplain for the growing season (april-september).

Years	Air temperature at a height of 2 m,°C		The amount of precipitation, mm		Groundwater levels, cm from the surface
	actual	norm	actual	norm	
1938-1957	16, 5	15, 5	279	327	86/79
1957-1983	15, 0		285		76/75
1983-2010	16, 1		371		76/79
2010-2019	17, 6		281		97/96

Note: Groundwater levels are reported in the numerator in the floodplain and in the denominator - in the section 3

This was especially manifested in the increase in average daily air temperature. This is accompanied by an increase in the sum of active temperatures and a decrease in the hydrothermal coefficient, which led to a decrease in groundwater levels by almost 20 cm compared to previous decades, and the depth of their occurrence at the end of summer decreased to 150-170 cm. In such conditions, it became possible to grow such crops as soybeans, corn, cereals, etc. The introduction of intensive cultivation of crops is accompanied by the introduction of fertilizers and a significant amount of pesticides, resulting in contamination of organogenic soils of floodplains and surface waters of rivers. In such conditions environmental authorities need to control compliance with environmental laws, otherwise it will have catastrophic environmental consequences for the forest-steppe ecosystem of the Forest Steppe. Similar consequences are typical for Polissya conditions (Yatsyk A.V., 1997; Field V.M. and others, 2019).

Conclusions and Prospects of Further Research

Long-term experience of long-term agricultural use of the drained land is generalized. It is established that over 80 years of development of organogenic soils in agricultural production of peatlands was 100 cm (in the first years the annual decrease in the depth of peat was 1.63, the following - 1.45 and the last - 0.88 cm). Reducing the roughness of the peat horizon is due to its compaction. Trends of change of fertility indicators of dried peat-bog soils are investigated, the content of gross forms of nitrogen and phosphorus in the treated layer of soil in 27 years of operation decreased by 2-3 times, and the basic macronutrient content of the subsurface layer of soil from 1957 to 2018 varied slightly.

Agricultural functioning of reclaimed land for 42 years has led to an increase of humic acid content in peat-silt soil up to 8%, and in the deep peatlands for the period from 1938 to 2018 up to 16%. At the same time, changes in water-air and nutrient regimes, intensification of biochemical processes in drained peat-bog soils play a leading role in the conversion of organic matter, its humification and mineralization, as a result, the organogenic layer of peat soils over 45 years of agricultural development was transformed into humus with a high content of structural units, which are easily destructive to erosion processes.

It is advisable to use drained organogenic soils of the Left-Bank Forest-Steppe for growing grass mixtures of perennial herbs. The long-term average productivity of agrophytocenoses on peatlands is quite high and by the level of productivity of grass mixtures makes 6, 5 t/ha of hay in the control variant on peat-silt soils and 7, 4 t/ha when applying phosphorus-potassium fertilizer at a dose of P67K120 kg/ha on deep peatlands with the application of complete mineral fertilizer, the yield of dry weight of perennial grasses increases to 12, 0 t/ha.

The development of wetland ecosystems with a view to their efficient agricultural use has not always been accompanied by scientifically sound approaches to rational ecologically safe functioning. Therefore, modern land use on reclaimed lands should be aimed at enhancing their natural renaturalization, including use as a pasture with long meadows, perennial grass.

References

Bohovin A.V., Sliusar I.T. Kaminskyi V.F. (2014) Kontseptsiia efektyvnoho silskohospodarskoho vykorystannia zemel humidnoi zony Ukrainy. Kyiv: NNTs «Instytut zemlerobstva NAAN», p 32. (in Ukrainian)

Buchmann N., Fuchs K., Feigenwinter I. and Gilgen A.K. (2019) Multifunctionality of permanent grasslands: ecosystem services and resilience to climate change. Improving sown grasslands through breeding and management Proceedings of the Joint 20th Symposium of the European Grassland Federation and the 33rd Meeting of the EUCARPIA Section 'Fodder Crops and Amenity Grasses' Zurich, Switzerland 24-27 June P. 19-26 (in English)

Henkin Z. (2016) Rehabilitation of Mediterranean grasslands. Options MéditerranéennesSérie A. V. 114. P. 375–386. (in English)

Hofer D., Suter M., Buchmann N., Lüscher A. (2017) Nitrogen status of functionally different forage species explains resistance to severe drought and post-drought overcompensation. Agriculture Ecosystems & Environment. № 236, P. 312-322 (in English)

Jacyk A.V. (1997) Jekologicheskie osnovy racional'nogo vodoispol'zovanija. Kyiv: Geneza, 610 p. (in Russian)

Kurgak V.G., Sljusar I.T., Birjukovich A.L. (2010) Ispol'zovanie osushennyh zemel' v uslovijah klimaticheskih izmenenij. Zh. Melioracija, RUP «Institut melioracii». Minsk: №1 (63). P. 49-55. (in Russian)

Kurgak V, Petrychenko V., Bohovin A. (2012) More efficient use of grassland under climate warming. Grassland – European Resource?. Pr. of 24th Gen. Meeting of the Europ. Grassland Federation. Lublin - Poland. V. 17. P. 151-153. (in English)

Maslov B.S., Starikov H.N. (1976) Otvoevannaja zemlja. Moskva: Moskovskij rabochij. 280 p. (in Russian)

Medvediev V.V., Plisko I.V., Bihda O.M. (2014) Diahnostyka, parametry i heohrafiia osoblyvo tsinnykh gruntiv v Ukraini. Visn. ahrarnoi nauky. №3. P. 11-17.

Petrychenko V.F., Kurhak V.H. (2013) Kulturni sinozhati ta pasovyshcha Ukrainy. Kyiv: Ahrarna nauka, 412 p. (in Ukrainian)

Polovyi V.M., Lukashchuk L.Ia., Lukianchyk M.M. (2019) Vplyv zmin klimatu na rozvytok roslynnytstva v umovakh zakhidnoho rehionu. Visn. ahrarnoi nauky. №9. P. 29-33. DOI: https://doi.org/10.31073/agrovisnyk201909-04 (in Ukrainian)

Pornaro C., Basso E. Macolino S. (2019) Pasture botanical composition and forage quality at farm scale: A case study. Italian Journal of Agronomy. Vol. 14:1480. P. 214-221. doi.org/10.4081/ija.2019.1480 (in English)

Romashchenko M.I., Yatsiuk M.V., Dekhtiar O.O. (2018) Kontseptualni zasady reformuvannia vodohospodarskoi haluzi Ukrainy. Visn. ahrarnoi nauky. № 12. P. 9-17. doi.org/10.31073/agrovisnyk201812-01 (in Ukrainian)

Shtakal M. I., Shejko N. K., Opanasenko A. G. (1987) Izmenenie torfjano-bolotnyh pochv pri sel'skohozjajstvennom ispol'zovanii. Moskva: Pochvovedenie, № 2. P. 131-135. (in Russian)

Tararyko Yu.O., Stetsiuk M.H. (2014) Potentsial bioproduktyvnosti orhanohennykh gruntiv Polissia. Visn. ahrarnoi nauky. №3. P. 60-63. (in Ukrainian)

Tararyko Yu.O. (2018) Ahroresursnyi potentsial meliorovanykh zemel humidnoi zony Ukrainy. Visn. ahrarnoi nauky. №9. P. 9-13. doi.org/10.31073/agrovisnyk201809-02. (in Ukrainian)

Truskavetskyi R.S. (2010) Torfovi grunty i torfovyshcha Ukrainy. Kharkiv: Miskdruk. 278 p. (in Ukrainian)

Yatsyk A.V., Pasheniuk I.A., Hopchak I.V., Basiuk T.O. (2018) Vodohospodarsko-ekolohichni problemy richok Zakhidnoho Polissia Ukrainy. Visn. ahrarnoi nauky. №10. P. 61-65. doi.org/10.31073/agrovisnyk201810-09 (in Ukrainian)

Yatsyk A.V., Pasheniuk I.A., Hopchak I.V., Basiuk T.O. (2019) Suchasnyi ekolohichnyi stan richok Zakhidnoho Polissia Ukrainy. Visn. ahrarnoi nauky. №2. P. 61-65. doi.org/10.31073/agrovisnyk201902-08 (in Ukrainian)

Yatsyk M.V., Voropai H.V., Kika S.M. (2019) Obhruntuvannia rezhymiv vodo rehuliuvannia pry vyroshchuvanni vysokoproduktyvnykhkormovykhkulturnaosushuvanykhzemliakh. Visn. ahrarnoi nauky. №6. P. 60-67. doi.org/10.31073/agrovisnyk201906-09 (in Ukrainian)

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