Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)

ERAMMP Report-97: Estimates of Atmospheric Nitrogen Deposition in Wales: Made in Wales vs Imported/Exported (2018 data)

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UK Centre for Ecology and Hydrology

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Abbreviations Used in this Report

APIS	Air Pollution Information System
DAERA	Department of Agriculture, Environment & Rural Affairs (Northern Ireland)
EA	Environment Agency
JNCC	Joint Nature Conservation Committee
N	Nitrogen
NAEI	National Atmospheric Inventory
NE	Natural England
NH3	Ammonia
NIEA	Northern Ireland Environment Agency
NO2	Nitrogen Dioxide
NOx	Nitrogen Oxides
NRW	Natural Resources Wales
SEPA	Scottish Environment Protection Agency
SNH	Scottish Natural Heritage
UK	United Kingdom

Contents

1 INTRODUCTION

Atmospheric nitrogen (N) deposition is a significant threat to sensitive habitats and species in the UK, with excessive N supply leading to declines in many important species of high conservation value, at the expense of fast growing species that can exploit the additional N deposited. Atmospheric N deposition originates from emissions of ammonia (NH_3, mainly from agricultural sources) and nitrogen oxides (NO_x, mainly from combustion sources, such as transport, industry, power generation).

This report aims to quantify N deposition to land in Wales from sources within Wales and beyond (rest of the UK, Republic of Ireland, International Shipping and continental Europe) and the amount of N deposition produced by Welsh sources that is deposited to the rest of the UK. Estimating the likely source of N deposition received by Wales will enable policy makers to assess how effective national N mitigation measures are likely to be.

Model estimates are based on FRAME source attribution model output for the emission year 2018, which were developed under the Air Pollution Information System (APIS)[1] project and funded by the UK government agencies (NRW,SEPA, SNH (now Nature Scot), JNCC, EA, NE, NIEA (now DAERA NIEA)).

The source attribution data used here are the latest available version of this periodic modelling exercise, and are based on emission estimates from the year 2018. The UK National Atmospheric Inventory (NAEI[2]) is updated annually, with the historic timeline back to 1990 updated annually ("back-cast") to incorporate any improvements in available data and emission calculation methods. The 2018 data used in the source attribution modelling may differ from the latest publicly available country-level data for Wales which are for the year 2022 (Table 3-1). Since then, substantial change has occurred in terms of emissions and sources, in particular in the steel production sector in Wales, which are important to consider in the context of NO_2 emissions and deposition. One recent development not yet reflected in the NAEI is the closure of blast furnaces at Tata Steelworks in Port Talbot in 2024, which are expected to be replaced by electric arc furnaces by 2027. This shift is expected to significantly reduce NO_2-N emissions.]

In 2022, atmospheric N emissions in Wales amounted to 33.8 kt N (of which 15.1 kt from NO_2 sources and 18.7 kt from NH_3 sources (Table 3-1). Transport (38%) and energy/industry (41%) were the largest NO_2 source sectors, whereas agriculture made up 93% of NH_3 emissions. NO_2 emissions have declined by 61% since 2005, in contrast to NH_3 emissions which have increased by 2% in the same period.

[1] http://www.apis.ac.uk/

[2] Latest available report: https://naei.energysecurity.gov.uk/reports/air-pollutant-inventories-england-scotland-wales-and-northern-ireland-2005-2022

2 RESULTS

2.1 Origin of Atmospheric N Deposited to Land in Wales 2018

The total amount of atmospheric N deposited in Wales in 2018 was estimated at 28.4 kt N yr^{-1} (Table 2-1). Emission sources within Wales are estimated to be the largest contributors of N deposition to Wales (10.9 kt N yr^{-1}) in 2018, making up 38% of the N deposited (Table 2-1,Figure 2-1). Emissions from sources in England are estimated to be the next largest contributor (27%), followed by continental Europe (16%), offshore/international shipping (9%). The Republic of Ireland (6%) and Scotland and Northern Ireland (<2% each). In the UK context, Wales is estimated to be a net importer of N deposition in 2018, with 6.8 kt N exported to vs. 8.7 kt N imported from the rest of the UK.

[N.B. Missing parameters are the export term of N deposition from Wales to the Republic of Ireland, and also to the rest of Europe/outside the domain, which are not available from the model outputs.]

Table 2-1 Modelled estimates of oxidised (NOy), reduced (NHx) and total nitrogen deposition received by Wales and deposition originating from sources within Wales. N.B. The modelling only quantified export of atmospheric N from the four UK countries to each other, but not to the Republic of Ireland or continental Europe.

Country/area of origin	Deposition to land in Wales			Deposition originating from sources in Wales to elsewhere		
	(kt N yr^{-1})			(kt N yr^{-1})		
	NH_x deposition	NO_y deposition	Total N deposition	NH_x deposition	NO_y deposition	Total N deposition
Wales	9.8	1.1	10.9	-	-	-
England	4.5	3.3	7.8	3.4	2.0	5.4
Northern Ireland	0.3	0.1	0.5	0.1	0.1	0.2
Scotland	0.2	0.2	0.4	0.4	0.7	1.2
Republic of Ireland	1.6	0.2	1.8	? (n/a)	? (n/a)	? (n/a)
Continental Europe	1.5	3.1	4.6	? (n/a)	? (n/a)	? (n/a)
International Shipping and Offshore	? (n/a)	2.5	2.5	? (n/a)	? (n/a)	? (n/a)
Total	**17.9**	**10.5**	**28.4**	**Unknown without additional modelling**		

"?" refers to information that is currently unquantified without additional modelling.

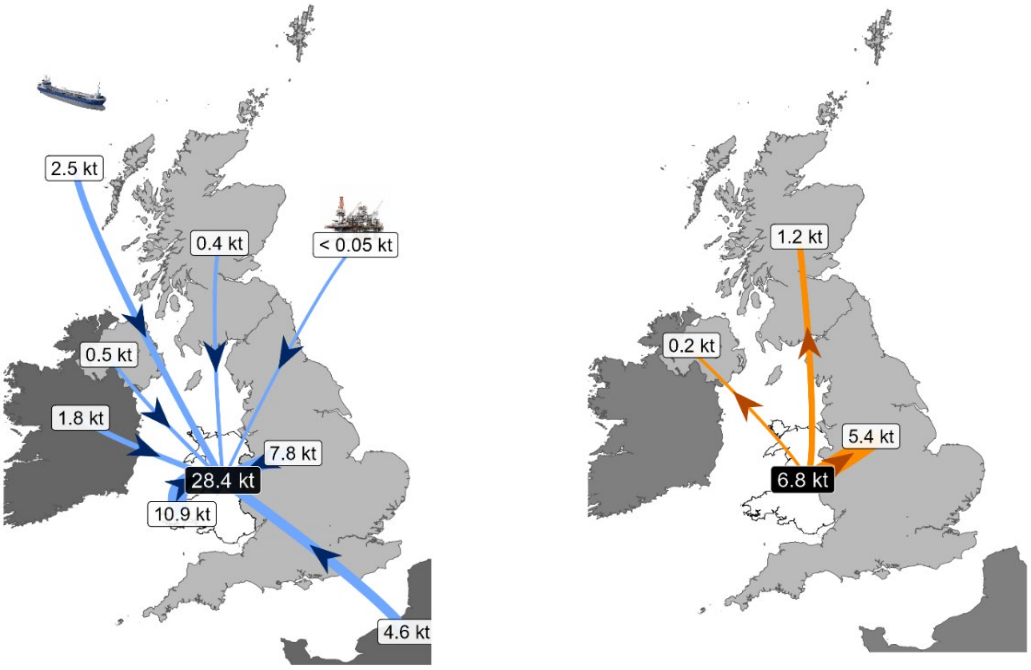

Figure 2-1 Estimated N deposition input to Wales from sources within and outside of Wales (left) and total N deposition export from emission sources within Wales to the rest of the UK (right). N.B. values may not add up to totals in Table 3-2 due to rounding. Additional unquantified exports to beyond the UK are excluded from the total exported emissions estimate.

2.2 Ammonia vs NO2 Sources of N Deposition in Wales

The total estimated amount of N deposition that both originated in Wales and was deposited within Wales in 2018 (~10.9 kt N yr^{-1}) was mostly due to ammonia (NH_3) emissions from within Wales (90%), with only 10% from NO_x emissions within Wales (Table 2-2. Emissions of ammonia (NH_3) and oxides of nitrogen (NO_x, expressed as NO_2). Data from the UK National Atmospheric Emissions Inventory reported for the emission years 2018 and 2022 (downloaded 25/7/2025, latest available year. NH_3 and NO_2 emissions were converted to N for comparison, using molecular weights). These atmospheric N inputs which originate from within Wales are the fraction that can be tackled with policy development by the Welsh Government.

When taking into account atmospheric N input from all sources (Wales-internal and beyond), the majority (63%) of the total N deposition received by Wales originates from reduced N sources, i.e. largely from NH_3 emissions (Table 2-1,Figure 2-2). 55% of these emission sources were estimated to be located within Wales. However, N deposition originating from NO_x sources (i.e. largely combustion) in 2018 was mostly (90%) produced by sources outside of Wales (Table 3-3, Figure 2-2). Of the NO_y deposition received by Wales, 3% is estimated to originate from sources located in the rest of the UK, 2% from the Republic of Ireland, 30% from the rest of Europe and remaining 24% comes from offshore sources and international shipping.

Table 2-2. Emissions of ammonia (NH_3) and oxides of nitrogen (NO_x, expressed as NO_2). Data from the UK National Atmospheric Emissions Inventory reported for the emission years 2018 and 2022 (downloaded 25/7/2025, latest available year. NH_3 and NO_2 emissions were converted to N for comparison, using molecular weights

Wales	2022					2018				
Emissions (kt)	**NO_2**	**NH_3**	**NO_2-N**	**NH_3-N**	**total N**	**NO_2**	**NH_3**	**NO_2-N**	**NH_3-N**	**total N**
Energy & industry	16.8	0.2	5.1	0.2	5.3	18.3	0.2	5.6	0.2	5.7
Transport	15.8	0.2	4.8	0.2	5.0	20.5	0.3	6.3	0.2	6.5
Other combustion	5.9	0.05	1.8	0.04	1.8	7.6	0.05	2.3	0.04	2.4
Agriculture	2.4	20.9	0.7	17.2	18.0	3.0	21.1	0.9	17.4	18.3
Waste	0.06	0.3	0.02	0.2	0.25	0.06	0.3	0.02	0.3	0.3
Other	0.02	0.9	0.01	0.7	0.7	0.02	0.8	0.01	0.6	0.6
Total	**40.9**	**22.6**	**12.5**	**18.6**	**31.0**	**49.5**	**22.7**	**15.1**	**18.7**	**33.8**

Table 2-3 Modelled estimates of dry, wet and total nitrogen deposition received by Wales and deposition originating from sources within Wales for the year 2018. N.B. The modelling only quantified export of atmospheric N from the four UK countries to each other, but not to the Republic of Ireland or continental Europe.

Country/ area of origin	Deposition to land in Wales			Deposition originating from sources in Wales to elsewhere		
	(kt N yr^{-1})			(kt N yr^{-1})		
	Dry deposition	**Wet deposition**	**Total N deposition**	**Dry deposition**	**Wet deposition**	**Total N deposition**
Wales	8.9	2.0	10.9	-	-	-
England	2.6	5.2	7.8	2.1	3.3	5.4
Northern Ireland	0.2	0.3	0.5	<0.05	0.1	0.2
Scotland	0.1	0.2	0.4	0.2	1.0	1.2
Republic of Ireland	0.8	0.9	1.8	?	?	?
Continental Europe	0.6	4.0	4.6	?	?	?
International Shipping and Offshore	0.6	1.9	2.5	?	?	?
Total	**13.8**	**14.6**	**28.4**	**Unknown without additional modelling**		

"?" refers to information that is currently unquantified without additional modelling.

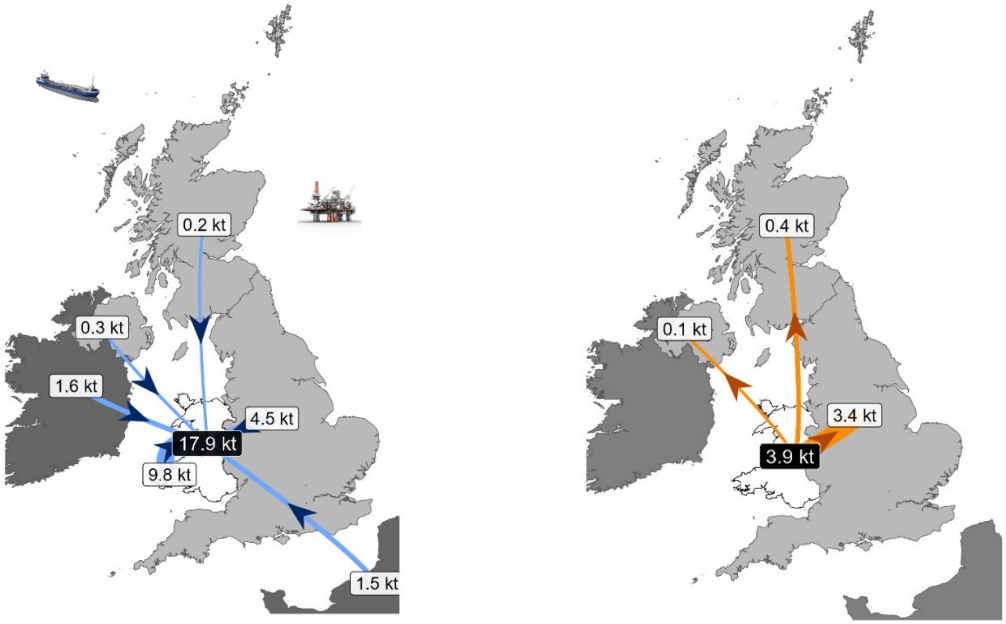

Figure 2-2: Estimated reduced nitrogen (NHx) deposition input to Wales from sources within and outside of Wales 2018 (left) and estimated export of NHx deposition from emission sources within Wales to the rest of the UK 2018 (right). N.B. values may not add up to totals in Table 3-2 due to rounding. Additional unquantified exports to beyond the UK are excluded from the total exported emissions estimate. Units are kt N yr-1.

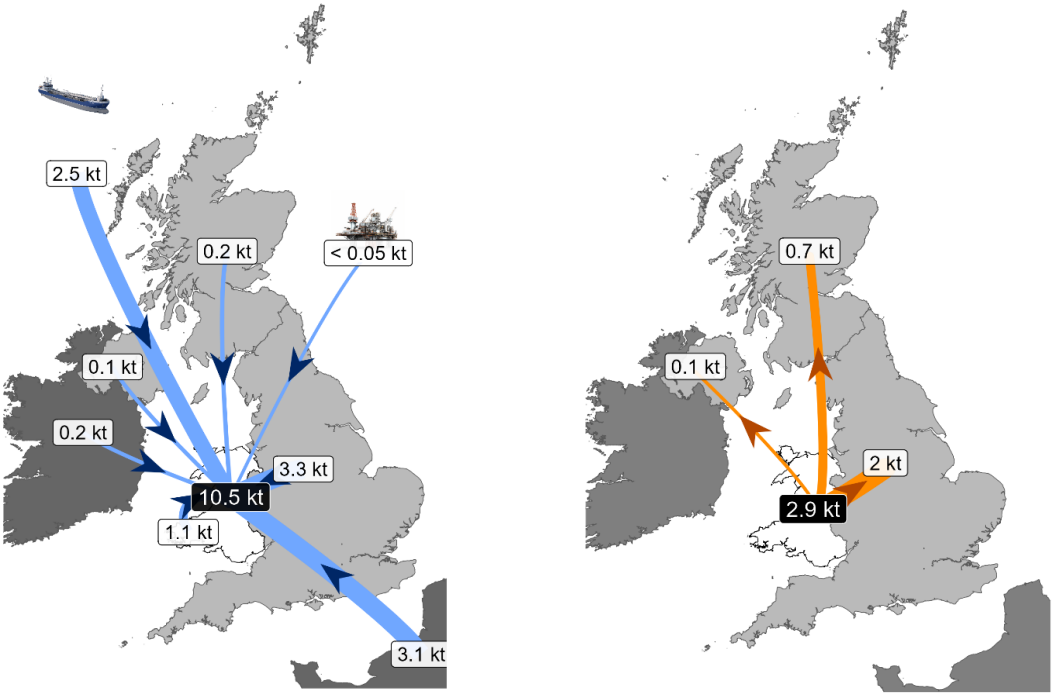

Figure 2-3 Estimated oxidised nitrogen (NOy) deposition input to Wales from sources within and outside of Wales 2018 (left) and estimated export of NOy deposition from emission sources within Wales to the rest of the UK 2018 (right). N.B. values may not add up to totals in Table 3-2 due to rounding. Additional unquantified exports to beyond the UK are excluded from the total exported emissions estimate. Units are kt N yr-1.

2.3 Wet vs Dry Deposition Sources of N Deposition in Wales

Dry deposition can be described as the transfer of gases and aerosols and the gravitational settling of aerosols to a surface. Wet deposition occurs when aerosols are washed out and deposited to the surface through precipitation.

Nearly two thirds of the dry N deposition to land in Wales was estimated to originate from emission sources within Wales (64%, Table 3-3, Figure 3-4). The majority (72%, 12.6 kt N yr^{-1}) of the total N deposition received by Wales from sources outside of Wales in 2018 (17.5 kt N) was in the form of wet deposition (Table 3-3, Figure 3-5). Similarly, most of the total N deposition originating from Wales deposited in the rest of the UK in 2018 (6.8 kt N yr^{-1}) was in the form of wet deposition (65%, 4.4 kt N yr^{-1}).

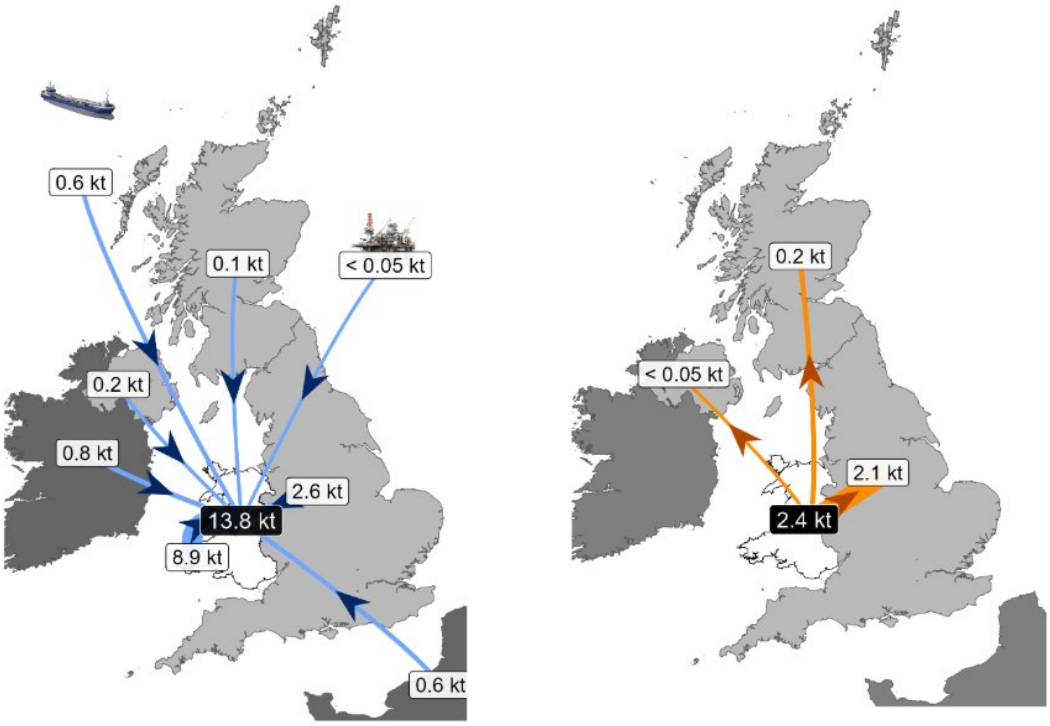

Figure 2-4 Estimated dry N deposition input to Wales from sources within and outside of Wales 2018 (left) and estimated export of dry nitrogen deposition from emission sources within Wales to the rest of the UK 2018 (right). N.B. values may not add up to totals in Table 3-3 due to rounding. Additional unquantified exports to beyond the UK are excluded from the total exported emissions estimate. Units are kt N yr^{-1}.

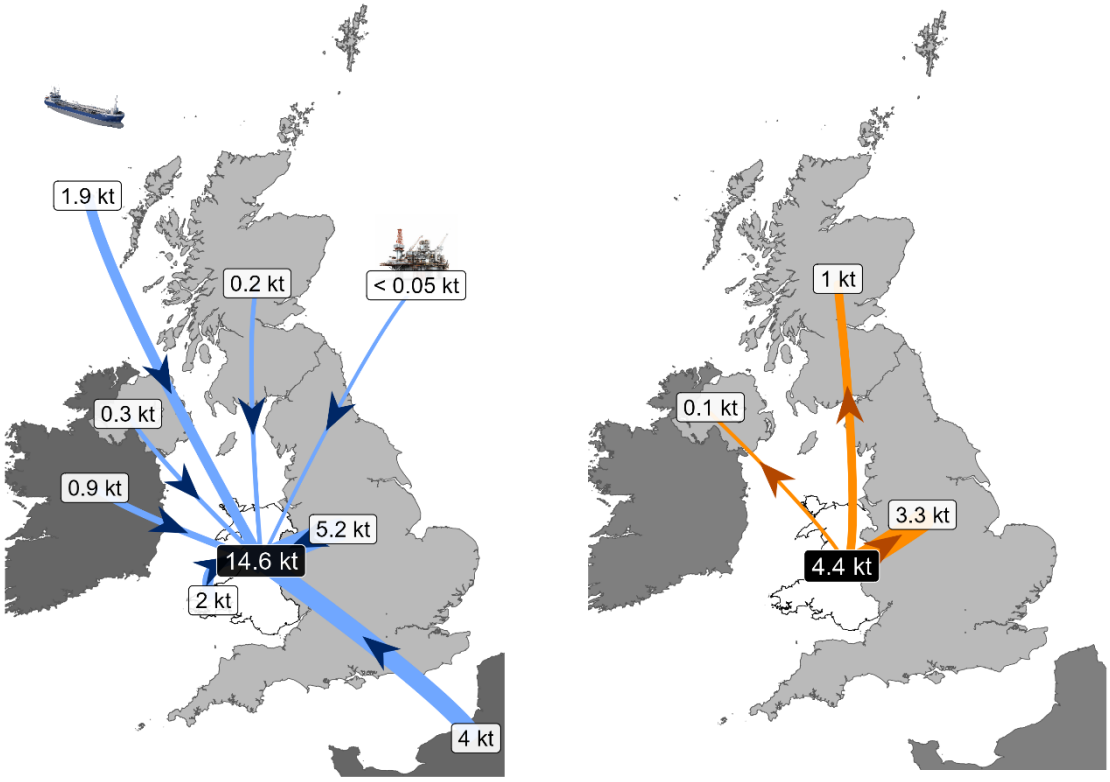

Figure 2-5: Estimated wet N deposition input to Wales from sources within and outside of Wales 2018 (left) and estimated export of wet N deposition from emission sources within Wales to the rest of the UK 2018 (right). N.B. values may not add up to totals in Table 3-3 due to rounding. Additional unquantified exports to beyond the UK are excluded from the total exported emissions estimate. Units are kt N yr^{-1}.

3 CONCLUSIONS

This study estimates that emissions within Wales were the largest contributors of N deposition to Wales (10.9 kt of 28.4 kt N yr^{-1}) in 2018. This constituted 38% of the N deposited in Wales. The next largest contributor to N deposition in Wales was England (27%), followed by continental Europe (16%), offshore/international shipping (9%). The Republic of Ireland (6%) and Scotland and Northern Ireland (<2% each). In the UK context, Wales was estimated to be a net importer of N deposition in 2018, with 6.8 kt N exported to vs. 8.7 kt N imported from the rest of the UK.

The N deposited in Wales originating from Welsh sources in 2018 was mostly from NH_3 emission sources (90%), with only 10% due to NO_2 emissions. These atmospheric N inputs produced within the country are the fraction that can be tackled by the Welsh Government with policy development for Wales.

When taking into account atmospheric N input from all sources (Wales-internal and beyond), a substantial proportion of the NH_x deposition is from sources within Wales (55%), while NO_y deposition may be harder to tackle, with 90% being imported from the rest of the UK, the Republic of Ireland and the rest of Europe, including from international shipping.

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