BETTERRETURNS

Managing nutrients for Better Returns

Manual 7

Contents

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Additional information from ADAS and Creedy Associates.

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Introduction

Nutrient management can often be forgotten on beef and sheep farms, yet there is considerable scope to reduce costs and improve output through the use of home-produced and bought-in nutrients.

All crops need a good nutrient supply from the soil to grow and thrive. Feeding grass and forage crops properly with manufactured fertilisers or slurries and manures can boost growth. This means bought-in feed requirements can be reduced with potential savings to the business.

Regular soil testing on all agricultural land is a legal requirement through the new Farming Rules for Water. By measuring and then managing nutrients, farmers can optimise their output while reducing the potential negative impacts of any oversupply.

Minimising losses of nutrients, such as nitrates, nitrous oxide and phosphates through appropriate and accurate fertiliser applications, can create a win-win situation for both beef and sheep farmers and for the environment.

James Holmes
AHDB Senior Scientist

Managing nutrients

Grass growth and quality can be improved significantly by planning the careful use of nutrients. In turn, nutrient management can result in significant financial savings and help protect the environment.

Your plan should be based on the nutrient demand of the crop you are growing, be that grass or forage. It is important to take account of the nutrients available in the soil and the content of manures, digestate or biosolids you plan to apply. If required, you can apply the difference as a manufactured fertiliser.

There are two options for creating a nutrient management plan, either paper-based or using computer software. Creating a new plan is time-consuming but valuable and, whichever option you choose, the plan can be reviewed and updated.

The Tried & Tested paper-based Nutrient Management Plan includes farm and field record sheets that are straightforward to complete. Free sheets and supporting information can be downloaded from **www.nutrientmanagement.org**

There are a number of software packages available to help you plan the use of nutrients:

- PLANET software keeps records as well as providing nutrient use recommendations
- MANNER-NPK tells you the nutrient content of manures and other organic materials and is useful for understanding how to make best use of them
- The Farm Crap App also tells you the nutrient content of manures and enables you to visually assess application rates

You can download PLANET and MANNER-NPK free of charge from **www.planet4farmers.co.uk**

The Farm Crap App is available to download for free in the App or Google Play stores.

For nutrient management purposes, useful records include:

Farm

- Area of grass and of any other forage crops
- Livestock numbers (for stocking rate)
- Purchased feeds (to calculate proportion of diet that is grass or forage. They are also a source of imported nutrients)
- Details of any imported manures
- Dates of calibration and tray testing of fertiliser and manure spreaders
- Risk map for manure application

Field

- Soil nitrogen supply (SNS) status (low, medium or high) and results of soil analysis
- Date of reseeding (if applicable)
- Amounts and dates of fertiliser and manure applications
- Nutrient contents of fertilisers and manures applied
- Method of manure application
- Notes on grass growth and any visible nutrient deficiencies
- Amount of silage or hay produced if cut (loads, bales or tonnes)

Where to start

Use a recognised fertiliser recommendation system such as the ***AHDB Nutrient Management Guide (RB209)***. Take account of requirements of the stock. Do not use fertiliser nitrogen (N) to grow more grass or forage than needed.

Before calculating how much fertiliser nitrogen to apply, check SNS status and consider other sources: soil, clover, deposition by grazing animals or spread organic manures. Take account of field history – permanent pasture has more soil nitrogen than a short-term ley or field that is always cut. Use standard tables for the crop-available nitrogen contributed by any manures applied and deduct this from fertiliser requirement.

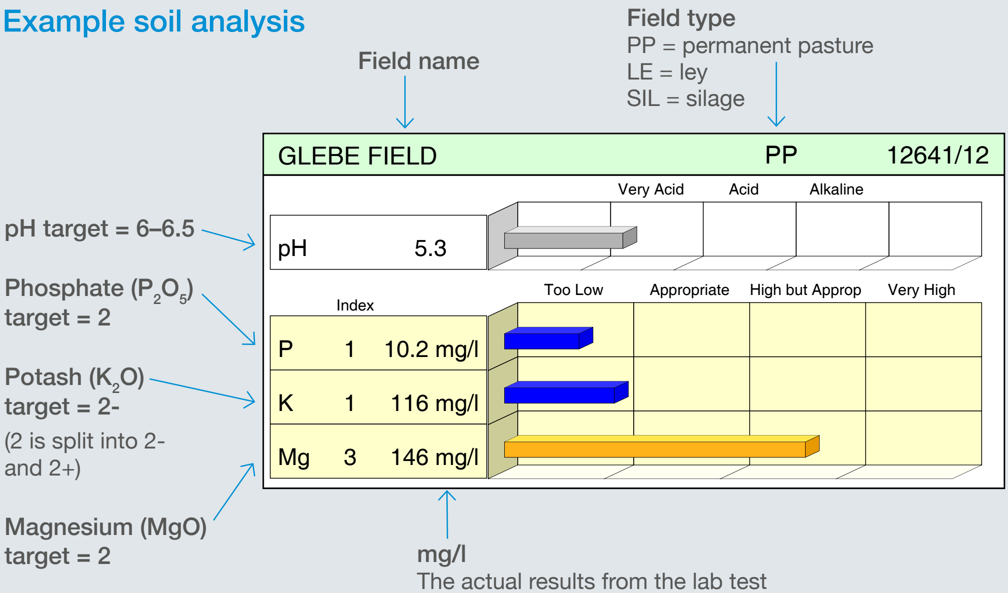
If clover is important, restrict fertiliser to no more than 100–150 kg N/ha over the season. If grass accumulates in grazed areas, cut back on fertiliser nitrogen for a while. Make sure you comply with rules for nitrogen use if in a nitrate vulnerable zone (NVZ).

See Appendix 2 (page 31) for sources of more information.

Soil test results

Taking a representative soil sample, having it tested by a reputable laboratory and acting on the analysis and recommendations can have long-term benefits for the farming business and the environment.

Example soil analysis



From the example above, Glebe Field needs lime and some phosphate and potash (see the recommendation in Table 1).

There are more advanced tests available. They are more expensive but will go into detail about organic matter, soil type and total and available nutrients. To reap the full benefit, they will need additional interpretation and should be used in conjunction with advice from an adviser.

Soil sampling

It is a legal requirement to soil sample every three to five years. The best time to test soil is between October and March. Take multiple cores across the field (ideally 25) to a 7.5 cm depth in grassland (15 cm if the field is going to be cultivated). Avoid areas that are not representative, such as around feeders or close to hedges. Mix samples thoroughly, bag up 0.5–1 kg and then send to a soil laboratory. Discuss results of tests with an adviser.

Table 1. Recommendation for Glebe field

Field name/ref/ soil type	Last crop/ next crop		P_2O_5	K_2O	MgO		Lime
GLEBE FIELD/12641/12/ Heavy	P Pasture/ P Pasture	units/acre	40	24	0	t/acre	2.4
		kg/ha	50	30	0	t/ha	6.0

Note: P Pasture = permanent pasture

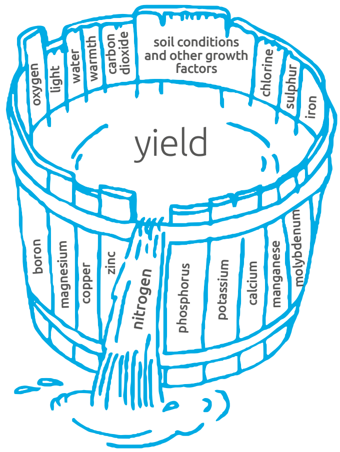
Nutrients for grass and livestock

Grass and clover need around a dozen mineral nutrients to live and grow. Only a few of these have to be applied as fertilisers.

Macronutrients (major elements)	
Nitrogen Phosphate Potash	Application usually needed for growth
Sulphur	Application of sulphur likely for cutting systems
Calcium	Applied calcium is not needed except as a liming agent
Magnesium	Magnesium sometimes needed for livestock diet but does not increase plant yield
Micronutrients (trace elements)	
Boron Cobalt Copper Manganese Molybdenum Selenium Sodium Zinc	Application very rarely needed for growth Copper, cobalt, selenium and sodium are sometimes needed for livestock diet

Breakdown of organic matter, weathering of soil mineral particles and return of manures and plant residues to the soil can provide most of the nutrients required.

Some nitrogen and sulphur falls in rain and bacteria associated with the clover can fix nitrogen from the air. As the bacteria and clover roots die, this becomes available to the grass.



The capacity of a barrel with unequal staves is limited by the shortest stave. The same principle applies to all nutrients and factors influencing crop growth. Yield is limited by the nutrient in shortest supply.

Nutrients are introduced to the farm in purchased feeds and bedding and then reach the soil in manures. The role of fertiliser is to make up the difference between the requirement for a nutrient and its supply from these other sources.

Crop requirement − (Supply from soil, Supply from manures, Supply from air, Supply from clover) = Fertiliser requirement

Lime

Applying lime to correct the pH status of the soil is a simple and effective way to increase grassland productivity. The optimum pH range for grass is 5.5–6.5 on most soils. On peaty soils, pH can be lower at 5.0–5.5 (see recommendation in table 2). If reseeding, apply lime after ploughing but before final cultivation so that it mixes into the rooting zone.

If ground conditions permit, apply lime 2–3 weeks before spring nitrogen application to fields destined for silage.

Lime choice

The most common liming product is chalk or ground limestone – calcium carbonate ($CaCO_3$). Some forms contain magnesium.

The quality of liming material is based on neutralising value (NV) and reactivity. The NV is expressed in terms of the percentage of calcium oxide equivalent; 100 kg of a liming material with a neutralising value of 50% will have the same neutralising value as 50 kg of pure calcium oxide (CaO).

Off-farm wastes, such as paper crumb (NV = 5–10%), lime-treated sewage cake (10–20%), sugar beet waste (22–32%) and green waste compost (up to 5%), can have a liming effect.

Basic slag is a source of lime (NV = 58%) plus a source of phosphate and trace elements. It can be cost-effective but can contain high levels of iron.

Reactivity

Reactivity is the speed of action which is related to the particle size. Generally, the smaller the particle size, the larger the surface area and the quicker the action. For example, granular lime contains fine particles which disperse after application, so it has a high reactivity (>98%). It can be spread by a fertiliser spreader and is useful when pH needs to be changed rapidly.

Gypsum

The application of gypsum has limited or no impact on soil pH (depending on the source and feedstock). It can help improve soil condition/workability, particularly on heavy clay soils and where coastal/saline flooding has occurred.

Table 2. Guidelines for lime application on grass (t/ha)

Initial soil pH	Sands and loamy sands	Sandy loams and silt loams	Clay loams and clays	Organic soils	Peaty soils
6.2	0	0	0	0	0
6.0	0	0	0	0	0
5.5	3	4	4	3	0
5.0	5	6	7	7	6

To calculate tonnes/ha to tonnes/acre, multiply by 0.4046. Apply no more than 7 t/ha at one time.
Source: *AHDB Nutrient Management Guide (RB209)*

Phosphate and potash

Phosphate and potash can accumulate on grassland farms. Large amounts can be imported in purchased feed and bedding as well as in fertilisers. For grassland, target soil Indices are 2 for phosphate and 2- for potash. These soil Indices usually only change slowly over the years.

Where a soil Index is lower than target, the recommended application amount of the nutrient is increased to build up soil reserves, as well as to meet crop requirement. Where the soil Index is above target, recommended application is reduced or omitted to allow the Index to fall slowly. If applications continue and Indices are at target, there is a risk to the environment, especially for phosphate (see page 23).

Dung and urine

Applying manure is a good way to correct low Indices. Phosphate and potash in collected manure and slurry can be returned to the soil evenly. Recycling by grazing animals is less effective, as nearly all of the phosphate excreted is in the dung, which is concentrated in small areas.

Dung pats do not have good soil contact, so the phosphate they contain is inaccessible to the grass for months. Grazing over many years will raise soil phosphate across the field but will not reduce the need for applied phosphate in a short-term ley.

Livestock urine contains nitrogen and potash in readily available forms and the patches are much larger. So recycling of potash by grazing cattle is more effective than it is for phosphate.

For nitrogen, the recovery from dung and urine ranges from 9 to 56% for urine and 4 to 27% for dung. Most of the nitrogen from urine is available in the first three months, while the nitrogen from dung can be released over three years.

Cattle and sheep dung is distributed unevenly with poor soil contact

Urine patches cover a larger area and the nutrients are in available forms

Nutrient imbalances

Grass cut for silage can remove large amounts of nutrients. Every tonne of grass at 30% dry matter (DM) will remove around 2.1 kg of phosphate and 7.2 kg of potash. These nutrients will eventually be returned to the soil via manures if used. However, a silage cut can leave the soil with too little readily available potash to support further mowing. So, it is important to replace the potash removed by applying fertiliser or manure.

Clover

Low potash supply can restrict the growth of clover even when there seems to be enough for grass. This means correcting low soil potash Indices is even more important if the sward contains grass and clover.

Phosphate is also critical for nitrogen fixation and clover growth is often limited in low-phosphate situations.

Potash and staggers

Excessive potash in the soil can affect magnesium uptake by grass and increase the risk of staggers (hypomagnesaemia) in cattle. Rapidly growing grass will take up potash quickly and in greater quantity than actually needed, interfering with the uptake of magnesium. Large single applications should be avoided on grazed swards. Little and often is better practice.

Cow with hypomagnesaemia

Magnesium

Magnesium deficiency rarely affects grass and clover growth. The concentration of magnesium in herbage, however, can be a problem for livestock. To avoid staggers, aim for 0.2% magnesium in the DM. Excessive application of potash can reduce magnesium concentration in the grass.

Testing the soil Index can indicate a need for magnesium, but analysing the grass gives results that are better related to livestock requirement.

Liming materials containing magnesium will help raise a low soil magnesium Index. Magnesium can be applied as a fertiliser or supplemented feeds can be offered.

Summary

- Use a recognised fertiliser recommendation system such as the ***AHDB Nutrient Management Guide (RB209)***
- Lime grassland on mineral soils to pH 6.2 and on peaty soils to pH 5.3
- Aim for soil phosphate Index 2 and potash Index 2-
- Apply manures where possible to fields with Indices below target
- Replace potash removed in grass cut for silage
- Avoid large single applications of potash in spring or in fields used for grazing

Sulphur

Sulphur after cutting

First-cut silage benefits from sulphur in the air and from mineralised soil organic matter. Later cuts from the same area are likely to be sulphur-deficient and will benefit from an application of sulphate-containing fertilisers at around 40 kg SO_3/ha for each cut.

Yield responses are less common in grazed grass. Sulphur deficiency in grass looks like nitrogen deficiency from a distance. But if grass looks yellow after the recommended amount of nitrogen has been applied, it is probably deficient in sulphur (see page 17).

A tissue sample needs to be taken to test for deficiency. In grass cut for silage, a concentration of less than 0.25% sulphur or an N:S ratio greater than 13:1 in the grass dry matter indicates sulphur deficiency.

As well as reducing grass yield, sulphur deficiency affects nitrogen uptake and the formation of protein in grass.

Micronutrients

Copper (Cu), selenium (Se) or cobalt (Co) supply does not affect grass growth, but low concentrations of these elements can cause problems for the livestock eating it.

Copper deficiency in farm animals can occur even where concentrations in the grass seem adequate. On soils high in molybdenum (Mo), it reacts inside the animal so that the copper becomes unavailable. The reaction is promoted by high sulphur in the diet.

Risk seems to be greatest where grass DM concentrations are greater than around 3 mg Mo/kg and 0.4% sulphur. Normal applications of sulphur to meet sward requirements are unlikely to significantly increase the risk of copper deficiency on these soils.

Copper, sulphur and cobalt deficiencies are usually corrected by treating animals directly. These nutrients can also be supplied in small amounts in fertilisers. The difference between deficiency and toxicity can be small, so do not over-supplement or over-apply.

Summary

- Apply a sulphur-containing fertiliser to supply 40 kg SO_3/ha for second- and third-cut silage
- Where copper, selenium or cobalt deficiency occurs in livestock, consider the options of direct treatment of the animals or applying the nutrient in fertiliser. Do not over-supplement or over-apply
- Remember, what is measured in soil analysis is not always available to the growing crop or grazing animal

Crop requirements

To convert 'kg per ha' to 'units per acre', multiply by 0.8. So, 50 kg per ha x 0.8 = 40 units per acre.

Apply 100 kg/ha MgO at Mg Index 2 if there is a risk of hypomagnesaemia.

Grazed grass

	Index	
pH	>6.2	No lime required
	6–6.2	TARGET – Monitor, may need a small amount
	<6	Lime is required – PRIORITY
Phosphate	2	Apply 20 kg/ha
	1	Apply 50 kg/ha
	0	Apply 80 kg/ha
Potash	1	Apply 30kg/ha
	0	Apply 60 kg/ha
Magnesium	2 or >	Don't apply
	0	Apply 50–100 kg/ha every 3–4 years

If phosphate index is 3 or over, do not apply

If potash index is 2 or over, do not apply

Do not apply more than 80–90 kg/ha of potash in spring

One-cut silage = 6 tonnes DM/ha

	Index	
pH	>6.2	No lime required
	6–6.2	TARGET – Monitor, may need a small amount
	<6	Lime is required – PRIORITY
Phosphate	3	Apply 20 kg/ha
	2	Apply 40 kg/ha
	1	Apply 70 kg/ha
	0	Apply 100 kg/ha
Potash	3	Apply 30 kg/ha in spring + 60 kg/ha after cutting
	2+	Apply 60 kg/ha in spring + 60 kg/ha after cutting
	2-	Apply 80 kg/ha in spring + 60 kg/ha after cutting
	1	Apply 30 kg/ha in previous autumn + 80 kg/ha in spring
	0	Apply 60 kg/ha in previous autumn + 80 kg/ha in spring
Magnesium	2 or >	Don't apply
	0	Apply 50–100 kg/ha every 3–4 years

If phosphate or potash index is 4 or over, do not apply

Do not apply more than 80–90 kg/ha of potash in spring

If there is no incentive to build up phosphate or potash Indices, for example on rented land, apply just enough to meet crop requirements and maintain the soil Index, i.e. use the recommendation for Index 2.

Hay

	Index	
pH	>6.2	No lime required
	6–6.2	TARGET – Monitor, may need a small amount
	<6	Lime is required – PRIORITY
Phosphate	2	Apply 30 kg/ha
	1	Apply 55 kg/ha
	0	Apply 80 kg/ha
Potash	3	Apply 20 kg/ha
	2+	Apply 65 kg/ha
	2-	Apply 90 kg/ha
	1	Apply 115 kg/ha
	0	Apply 140 kg/ha
Magnesium	2 or >	Don't apply
	0	Apply 50–100 kg/ha every 3–4 years

If phosphate index is 3 or over, do not apply

If potash index is 4 or over, do not apply

Grass reseeds

	Index	
pH	>6.2	No lime required
	6–6.2	TARGET – Monitor, may need a small amount
	<6	Lime is required – PRIORITY
Phosphate	3	Apply 30 kg/ha
	2	Apply 50 kg/ha
	1	Apply 60 kg/ha
	0	Apply 120 kg/ha
Potash	2+	Apply 40 kg/ha
	2-	Apply 60 kg/ha
	1	Apply 80 kg/ha
	0	Apply 120 kg/ha
Magnesium	2 or >	Don't apply
	0	Apply 50–100 kg/ha every 3–4 years

If potash index is 3 or over, do not apply

The amount applied for establishment should be deducted from the first season requirement

Nitrogen

Only grow what is needed

Nitrogen is the most important nutrient for grassland because it has such a strong effect on yield.

Generally, 1 kg of nitrogen will grow between 10–15 kg of grass DM in older swards, but in high-performing swards (less than 10 years old) the response is between 15–25 kg DM.

Swards containing high levels of ryegrass will be more responsive to nitrogen than swards containing weed grasses, such as Yorkshire Fog and Creeping Bent.

The response will depend on the timing, season, soil fertility and moisture.

The ***AHDB Nutrient Management Guide (RB209)*** approaches nitrogen recommendations by asking how much grass you need to produce in terms of grazing and silage or hay production.

Nitrogen recommendations are based on the amount required, with factors such as soil nitrogen supply (high, moderate or low) and grass growth class (very poor, poor, average, good or very good) taken into consideration.

It is important to think about the total amount of grass needed to feed the stock. Then use nitrogen to boost yield and, finally, feed concentrates to supplement the grass where necessary. Often, the full productive potential of grass is not realised. However, there is no point in growing more grass than can be eaten.

Total nitrogen supply

There are several sources of nitrogen coming from:

- The breakdown of soil organic matter
- Deposition from the air (usually included with that from soil organic matter as ‘soil nitrogen’)
- Dung and urine deposited by grazing animals
- Applied manures
- Clover
- Fertilisers

These all add up to the total nitrogen supply. However, only some of this will be readily available to the plants and it is this that controls grass yield.

The maximum limit (Nmax) for farms in NVZs is 300 kg N/ha.

Soil nitrogen

Soil nitrogen supply (SNS) status cannot easily be measured, but fields can be put into categories, depending on their history, to estimate SNS (see Table 3).

In grazing situations, there is usually no need for bagged nitrogen on clover-rich swards, apart from a little (50 kg N/ha) to stimulate grass growth in the spring.

Grass growth during the season

Where there is ample water supply, less nitrogen is needed to achieve a given grass yield.

Grass responds to fertiliser nitrogen in two stages. At first, it is taken up quite rapidly and the grass greens up. Then, DM yield increases, which happens more slowly.

In rotational grazing or where growing for silage, it is important to allow time after an application of nitrogen for the DM response to develop fully. Allow at least one day of growth for every 2.5 kg N/ha applied.

Nitrogen uptake is less affected by the amount of daylight than DM growth. So grass will green up after a nitrogen application late in the year but will not necessarily grow much and so the full value will not be accrued from the nitrogen applied.

Plans for nitrogen use during the season may change because of weather conditions. If grass accumulates in grazed areas, cut back on nitrogen applications.

Fertiliser nitrogen and clover

Fertiliser nitrogen and clover do not always mix well. The nitrogen inhibits fixation by the clover and promotes grass growth, which can shade out the clover.

Where there is a large amount of clover in the sward, nitrogen applied in fertiliser will be substituted for that fixed by the clover and overall grass yield will not change greatly.

Where white clover is vigorous and makes up 20–30% of the sward DM, fertiliser nitrogen requirement can be reduced by 100–150 kg N/ha over the season. A sward that typically contains less than 10% white clover by late spring can be treated as a grass-only sward.

Red clover can fix up to 250 kg N/ha and needs to be grown with a grass that is capable of capturing as much of this as possible.

Table 3. The definitions of soil nitrogen supply (SNS) status

Previous management	Previous nitrogen use (kg N/ha/year)	SNS status
Long-term grass, including grass after one-year arable break	More than 250	High
As 1 with lower nitrogen use, or grass after two years arable (last crop potatoes, oilseed rape, peas or beans, not on light sandy soil)	100–250 or substantial clover content	Medium
As 1 with lower nitrogen use, or grass after two years arable (last crop cereal, sugar beet, linseed or any crop on light sandy soil)	Up to 100	Low

Example of nitrogen requirements (kg N/ha) for a beef enterprise

Assumptions

- Average growth class:
  - Light soils with high summer rainfall (>400 mm)
  - Medium soils with 300–400 mm of summer rainfall
  - Peaty, silty soils with up to 300 mm of rain during the summer
- Yield = 7–9 t DM/ha

	SNS status		
	Low	Moderate	High
Grazing only	160 kg	130 kg	100 kg
One cut then grazing	95 kg for silage	80 kg for silage	65 kg for silage
	75 kg for grazing	60 kg for grazing	45 kg for grazing
Two cuts then grazing	90 kg for 1st cut	80 kg for 1st cut	70 kg for 1st cut
	70 kg for 2nd cut	50 kg for 2nd cut	30 kg for 2nd cut
	30 kg for grazing	30 kg for grazing	30 kg for grazing

Notes: Increase total fertiliser nitrogen input by 30 kg/ha in a low-SNS situation. Decrease total fertiliser nitrogen input by 30 kg/ha in a high-SNS situation.

For high-SNS sites, apply 10 kg N/ha less for first cut and 20 kg N/ha less for second cut. For low-SNS sites, apply 10 kg N/ha more for first cut and 20 kg N/ha more for second cut.

For first-cut rates over 80 kg N/ha, split application: 40 kg N/ha in mid-February to early March, with the remainder in late March to early April and at least six weeks before cutting.

Example of nitrogen requirements (kg N/ha) for a sheep enterprise

Assumptions

- Average growth class (see above)
- Yield = 7–9 t DM/ha

	SNS Status		
	Low	Moderate	High
Grazing only	160 kg	130 kg	100 kg
Grazing from Feb, shutting up from April for silage and grazing from July	50 kg for grazing (early/mid Feb)	40 kg for grazing (early/mid Feb)	30 kg for grazing (early/mid Feb)
	100 kg for silage	80 kg for silage	60 kg for silage
	30 kg for grazing	30 kg for grazing	30 kg for grazing
Grazing from March, shutting up from June for hay and grazing from August	50 kg for grazing (early/mid Feb)	40 kg for grazing (early/mid Feb)	30 kg for grazing (early/mid Feb)
	90 kg for hay	70 kg for hay	50 kg for hay
	30 kg for grazing	30 kg for grazing	30 kg for grazing

Notes: No clover assumed. If red or white clover is present, the recommendations need to be reduced.

Nutrient deficiencies

Sometimes a grass crop shows visible symptoms of nutrient deficiency. It can just be disappointing growth and if this is the case, it is not possible to identify the problem without carrying out a herbage or soil analysis. If the deficiency is more marked, there can be distinctive signs.

Deficiency in	Looks like	Typically occurs	What to do
Nitrogen	If severe: yellow older grass leaves	Where soil is poached or waterlogged	Apply nitrogen when soil has dried
Phosphate	Purple tinge to grass	In spring At phosphate Index 0 or 1	Check soil Index Apply phosphate fertiliser or manure
Potash	Brown tips to grass leaves Wilted grass Small white spots on clover leaves	In second- or third-cut growth At potash Index 0 or 1	Check soil Index Apply potash fertiliser or manure
Sulphur	Yellowish younger grass leaves	In second- or third-cut growth	Apply sulphur fertiliser for next cut

Analysing some plants can help diagnosis and confirm if the crop will meet the livestock's dietary needs.

Clean samples of the herbage, with no soil contamination, should be cut and sent immediately to a laboratory for testing.

Where there are patches of good and poor growth in a field, take samples from good and poor areas. The comparison of results will be more useful than samples taken just from the poor area.

Summary

- Use a nutrient recommendation system, for example, ***AHDB Nutrient Management Guide (RB209)***
- Develop a nutrient management plan, such as Tried & Tested or PLANET
- Sample soils for pH, phosphate, potash and magnesium every three to five years
- Check the grass through the season for any visible problems
- For diagnosis, take soil or herbage samples from good and poor areas of the field
- Use a FACTS Qualified Adviser for help with nutrient management

Manures as fertilisers

Slurry and manures contain all the nutrients needed by grass and clover, though not necessarily in the ideal ratios for any particular field. They are fertilisers, not waste and their nutrients are valuable.

Nutrients

Typical nutrients from common manure types are listed in the ***AHDB Nutrient Management Guide (RB209)***.

If soils have a phosphate index of 2 and a potash index of 2-, then total values should be used when calculating the nutrient value of manures.

It is worth getting a sample of manure or slurry analysed, especially if groups are being fed different rations, for example, suckler cows vs finishers. It is important that it is representative of the whole heap or lagoon. It is also important to work with the figures for 'available' nutrients, i.e. those that grass plants can access and use, rather than the 'total' figures.

Spread it around the farm

Spread manure around the farm, not always on the same few fields. Target manure applications to fields with a low phosphate or potash Index. Try to avoid fields where the phosphate Index is higher than 2, even if the potash Index is low.

When and where?

Applying manure just before a period of rapid grass growth will make best use of the available nutrients. This means early spring or immediately after a cut of silage.

Do not apply more than 250 kg N/ha in manures over a year, or more than 50 m^3/ha of slurry at any one time. This will minimise the risk of run-off and prevent smothering the regrowth.

If the farm is in an NVZ, do not spread more than 30 m^3/ha of slurry or 8 t/ha of poultry manure in a single application from the end of the organic manures closed period until the end of February.

Avoid run-off

Do not apply manure to frozen, waterlogged and snow-covered ground or within 10 metres of surface water or 50 metres of a borehole, well or spring, or on sloping ground.

The risk of disease transmission can be reduced by storing manures for at least one month before application and leaving at least one month after application before grazing.

Calculating nutrient value

The nutrient value of manure can be calculated using current prices for fertiliser nitrogen, phosphate and potash as in the example on page 19.

Sulphur and magnesium

Manures also contain useful amounts of sulphur and magnesium. Availability of sulphur can vary widely, from around 15% of total SO_3 for cattle FYM and 35% for slurry applied in the spring.

Table 4. Fertiliser examples showing the cost of the nutrient

Fertiliser examples	Available nutrients (kg/t)* A	Price (£/t) B	Cost of nutrient (£) B/A
Ammonium nitrate (34.5% N)	345	250	0.72
Triple superphosphate – TSP (46% P_2O_5)	460	300	0.65
Muriate of potash – MOP (60% K_2O)	600	275	0.46

*For example, ammonium nitrate is 34.5% N, so for every 100 kg, there will be 34.5 kg of nitrogen available.

Table 5. Nutrient value in manure

Nutrient	Cost of nutrient (£) C	Cattle FYM nutrient content D	Manure value (£/t) CxD
Nitrogen	0.72	0.6	0.44
Phosphate	0.65	1.9	1.24
Potash	0.46	7.2	3.30
		Total	**4.98**

Summary

- Treat manures as fertilisers, not wastes
- Use standard tables in the ***AHDB Nutrient Management Guide (RB209)*** or laboratory analysis to estimate the total nitrogen, phosphate and potash contents of manures
- Use standard tables in the ***AHDB Nutrient Management Guide (RB209)*** for calculating the crop available nitrogen in applied manures (see NVZ guidance at **www.gov.uk**)
- Target manure applications to fields with low phosphate or potash Indices, but try to avoid fields where the phosphate Index is higher than 2
- Do not apply manures within 10 m of a watercourse or 50 m of a borehole, well or spring
- Better to use low application rates over a wide area than heavy rates on a few fields
- If farming in an NVZ, comply with the rules for manure storage and application

Nutrient application examples

TSP = Triple superphosphate (45–46% P_2O_5)
MOP = Muriate of potash (60% K_2O)

Grazed grass

	Index	
pH	5.5	4 t/ha of lime as clay loam soil type
Phosphate	1	50 kg/ha of phosphate. 109 kg of TSP would supply 50 kg of phosphate per ha
Potash	1	30 kg/ha of potash. 50 kg of MOP would supply 30 kg of potash per ha
Magnesium	2	No requirement

Alternatively, 170 kg of 0-30-20/ha would supply 51 kg phosphate per ha and 34 kg potash per ha. Manures and slurry have higher potash levels than phosphate, so many may not be suitable for this situation. For example, 10 tonnes of cattle manure per ha would supply 19 kg of available phosphate and 72 kg of available potash.

6 kg of nitrogen would also be applied

One-cut silage

	Index	
pH	5.5	4 t/ha of lime as silt loam soil type
Phosphate	1	70 kg/ha of phosphate. 152 kg of TSP would supply 70 kg of phosphate per ha
Potash	1	30 kg/ha of potash. 50 kg of MOP would supply 30 kg of potash per ha for the autumn dressing 80 kg/ha of potash plus 133 kg of MOP in spring would supply 80 kg of potash per ha 60 kg/ha of potash plus 100 kg of MOP after the cut or by the autumn would supply 60 kg of potash per ha
Magnesium	2	No requirement

Alternatively, 30 m³/ha (2,700 gallons/acre) of 6% cattle slurry in the spring would supply around 18 kg of phosphate and 83 kg of potash per ha, which reduces the amount of TSP product used to 113 kg/ha and removes the need for a spring dressing of MOP.

THIS IS A SAVING OF AROUND £43/ha.

23 kg of nitrogen would also be applied

Hay

	Index	
pH	5.5	4 t/ha of lime as silt loam soil type
Phosphate	1	55 kg/ha of phosphate. 120 kg of TSP would supply 55 kg of phosphate per ha
Potash	1	115 kg/ha of potash. 192 kg of MOP would supply 115 kg of potash per ha
Magnesium	2	No requirement

Alternatively, 30 m³/ha (2,700 gallons/acre) of 4% pig slurry would supply around 27 kg of phosphate and 66 kg of potash per ha, which reduces the amount of TSP product to 61 kg/ha and the amount of MOP product to 82 kg/ha.

THIS IS A SAVING OF AROUND £48/ha

51 kg of nitrogen would also be applied

Grass reseeds

	Index	
pH	5.8	3 t/ha of lime, if not already corrected
Phosphate	1	80 kg/ha of phosphate. 174 kg of TSP would supply 80 kg of phosphate per ha
Potash	1	80 kg/ha of potash. 133 kg of MOP would supply 80 kg of potash per ha
Magnesium	2	No requirement

Alternatively, 10 tonnes of cattle FYM/ha would supply around 19 kg of phosphate and 72 kg of potash per ha, which reduces the amount of TSP product to 132 kg/ha and removes the need for the MOP product.

THIS IS A SAVING OF AROUND £49/ha

6 kg of nitrogen would also be applied

Minimising nutrient losses

Nutrients can be lost from the soil to water and in the case of nitrogen, to the air. Losses of nitrogen and phosphate can cause environmental issues, so any potential losses need addressing. Problems like these have not been associated with potash and sulphur. Losses are greater when nutrients applied exceed crop requirements or applications are made in high-risk situations or in poor soil conditions.

Nitrate leaching

Nitrogen in nitrate form can be leached or washed out of soil and end up in ponds, streams, rivers, lakes or aquifers, affecting water quality and sensitive habitats. The European Union (EU) limit of 50 mg nitrate/litre, originally introduced for drinking water, now applies to surface and ground waters. In surface waters, nitrate can also contribute to eutrophication (nutrient enrichment) and the excessive algal growth and oxygen depletion this causes, which damages aquatic wildlife.

NVZ have been designated where nitrate concentrations are high or increasing, or where waters are, or may become, eutrophic.

Ammonia

Ammonia emissions have significant implications for human health and contribute to acid rain. Acid rain can lead to unwanted inputs of nitrogen to soils and vegetation that can badly impact sensitive sites.

The storage and application of livestock manures is a significant source of ammonia emissions from agriculture.

Between 10% and 80% of the readily available nitrogen in slurry can be lost during and after application. So there is an economic as well as environmental reason for trying to retain as much as possible.

Most of the loss occurs in the first few hours after application, so injection by trailing shoe equipment or, where possible, rapid incorporation will minimise losses.

Nitrogen oxide

Where the soil is anaerobic (oxygen starved), nitrate can be converted by microorganisms to nitrous oxide, which is a potent greenhouse gas. Poaching, poor drainage or waterlogging can make soil anaerobic and will increase nitrogen loss.

Poaching promotes loss of nitrogen by denitrification and of phosphate by soil erosion

Phosphate in water

If phosphate reaches surface water, even in very small amounts, it can promote excessive algal growth and blanket weed in ponds (eutrophication). The water can then become depleted of oxygen when the algae or weeds die and decompose.

Phosphate is naturally low in freshwater so that is why even small amounts can cause problems.

Phosphate does not leach from soil, except at very high Indices. However, it does move across the soil surface and through drains attached to soil particles or in manure that has not been incorporated.

Minimise phosphate loss

- Allow any soils with high phosphate Indices to fall to the target 2
- Avoid manure application close to surface water or when rainfall is expected
- Inject or, where possible, carry out rapid incorporation of manures

Table 6. Summary of the issues with nutrient losses

Problem	Why?	What to do?
Nitrate leaching or run-off	Breach of EU 50 mg/l water limit Eutrophication of ponds, lakes, rivers and estuaries Affects biodiversity in water bodies	Match fertiliser manure application rate and timing to crop needs and observe spreading controls
Ammonia volatilisation	Public health Acid rain Enrichment of natural soils and vegetation	Inject slurry or use trailing shoe equipment Incorporate slurry on bare land within 24 hours, preferably within six hours
Nitrous oxide emission	Greenhouse gas – climate change	Match fertiliser and manure applications to grass need Avoid poaching
Phosphate run-off	Eutrophication of ponds, lakes, rivers and estuaries Affects biodiversity in water bodies	Use soil phosphate Index for fertiliser and manure decisions Do not apply manure within 10 m of surface water or manufactured fertiliser within 2 m of the centre of a watercourse or field ditch Avoid manure application to wet or sloping land or if rainfall is expected Avoid poaching Avoid soil run-off and erosion (maintain good soil structure and condition)

Accurate spreading

If spreading is inaccurate, all the work put into deciding which fertilisers or manures to use and how much to apply will be wasted.

There are two kinds of inaccuracy:

- Wrong rate of application
- Uneven spreading

The inaccuracies above affect grass yield, quality and can increase nutrient losses to water or air.

Before spring use, check the condition of fertiliser, manure spreaders and replace worn parts. The cost in time and money will be recovered during the year through more accurate spreading and less waste.

Fertiliser spreaders

Applying 25 kg N/ha less than required can reduce first-cut yield by 0.25–0.75 t DM/ha. Applying more than required will increase fertiliser cost unnecessarily. Spreader manufacturers provide advice on calibration for accurate application.

Unevenness of spreading fertiliser nitrogen is shown as a coefficient of variation (CV) measured in a tray test. For perfectly even spreading, the CV is 0%. Visibly uneven growth can occur where the CV is greater than 20%.

A properly maintained, set-up and operated fertiliser spreader should achieve a CV of 10–15%. However, values of 30% are often found when spreaders are tested. The loss of yield due to uneven spreading is small, up to a CV of 10%, but then increases sharply.

Tray tests of fertiliser spreaders can be done on the farm. The cost of professional testing can usually be recovered by improved effectiveness of the fertilisers used.

Manure spreaders

Manure spreaders can be calibrated by weighing empty and full, then spreading a full load over a known area at a known forward speed. This speed can then be adjusted to get the required rate of application.

When spreading, check that the bout width allows even application. Typically, the ideal bout width is half the spreading width for broadcast spreaders.

A variable amount of nitrogen is lost to the air during manure spreading. Losses will be minimised by keeping trajectories low and, where possible, using trailing shoe or injection equipment for slurry. Work rate can be lower with these full-width spreaders, but nutrients will be applied more accurately. When applying manures to land before a reseed, aim to incorporate within 24 hours to reduce losses.

In winter, check expected compliance with Nmax, the livestock manure nitrogen farm limit and the organic manure nitrogen field limit. In autumn, check again that the limits are not breached.

Summary of NVZ rules for manures (always check the NVZ guidance)	
Storage capacity	Five months for cattle slurry. Includes any rain or wash water entering the store
Construction standards	New or substantially altered storage must comply with Silage, Slurry and Agricultural Fuel Oil (SSAFO) Regulations. Environment Agency must be notified at least 14 days before construction or reconstruction begins
FYM storage	On impermeable base with run-off containment, in roofed building or in temporary field heap
Temporary field heaps	Field heaps must occupy as small a surface area as is practically required to support the heap and prevent it from collapsing. They must not be sited within 10 m of surface water (30 m if the land is steeply sloping), 50 m of spring, well or borehole, on land that might flood or become waterlogged, on same site for >12 months. Leave at least two years before return to site. Mark site on risk map
Risk map	Must show fields and areas, surface waters, boreholes, springs, wells, areas of sandy or shallow soils, slope >12 degrees, land within 10 m of water or 50 m of spring, well or borehole, land drains and field manure heaps
Spreading equipment	Must be low trajectory (<4 m from ground)

Summary

- Check fertiliser and manure spreaders before use in spring
- Calibrate manure spreaders before use
- Calibrate fertiliser spreaders for rate of application in spring and whenever the product being spread changes
- Tray test fertiliser spreaders for evenness of application in spring – aim for a CV of 10–15%

Manufactured fertilisers

With so many types of manufactured fertilisers, the right choice depends on suitability and price. There are straights that contain one nutrient, for example ammonium nitrate (N), triple superphosphate (TSP) or muriate of potash (MOP).

Diammonium phosphate (DAP) and monoammonium phosphate (MAP) are often called straights but, strictly speaking, are compounds. Compound fertilisers contain more than one nutrient (for example, 20-10-10) and can be blends of straights or complex fertilisers, in which every particle has the same nutrient content.

Ammonium nitrate

Straight nitrogen is usually ammonium nitrate or urea. Ammonium nitrate is less susceptible to loss of nitrogen compared with urea after application, but as it is an oxidising agent it has special storage requirements. There must be a hazard warning sign at the farm entrance if more than 25 t of ammonium nitrate is stored and an oxidising agent sign on the store. The local fire brigade and the Health and Safety Executive must be informed of its presence.

Ammonium nitrate should not be stored with combustible materials or carbon sources, including urea. It should only be bought from a member of the Fertiliser Industry Assurance Scheme (FIAS).

There is a 'Five-Point Plan' for the storage of all fertilisers on farms, which can be downloaded for free (see page 31).

Fertilisers should be stored securely and any losses reported promptly to the police. They should also be stored at least 10 m from any watercourse and 50 m from a borehole.

Urea

Urea can be cheaper than ammonium nitrate on a unit of nitrogen basis, but some nitrogen can be lost as ammonia after application. Urea has a higher nitrogen content than ammonium nitrate (46% compared with 34.5%) but has a lower bulk density, so a spreader hopper will contain the same amount of nitrogen with both materials.

Phosphates

Straights and compound fertilisers are suitable as phosphate fertilisers for grassland. When using a compound, choose one that has the most suitable ratio of nitrogen, phosphate or potash for the crop's needs.

There are some water-insoluble phosphate fertilisers that are suitable for grassland, especially where soil pH is lower than 6.0. Rock phosphate is effective in acidic soils. The availability of phosphate from ashed poultry manure is less affected by soil pH.

These products are especially useful for raising a low phosphate Index. The slag that comes from the steel-making industry contains around 1.5% phosphate – much less than traditional basic slag which contains 12–15% phosphate. It is, however, also a liming agent.

Potash

Muriate of potash (MOP) is the main source of potash for grass and is used as a straight or in compounds. At the rates recommended, the chloride will not cause any problems. It is easily leached from the soil so does not accumulate.

Sulphur

Ammonium sulphate or the N/S compounds available are good sources of sulphur. Gypsum (calcium sulphate) is less soluble but is suitable if applied in spring. Pelleted elemental sulphur is slower-acting and more suited to autumn application.

Calculations

To calculate rate of fertiliser product needed to provide a specified rate of nutrient required, divide by the analysis %.

For example:

$$\frac{\text{50 kg/ha of phosphate required}}{\text{TSP (with 46\% phosphate)}} = \frac{50}{46} \times 100 = \text{109 kg of triple superphosphate (TSP) needed}$$

To calculate rate of nutrient supplied by specified application rate of fertiliser product, multiply by the analysis %.

For example:

100 kg/ha of 20-10-10	For nitrogen	= 100 x 20/100 = 20 kg nitrogen applied
	For phosphate	= 100 x 10/100 = 10 kg phosphate applied
	For potash	= 100 x 10/100 = 10 kg potash applied

Summary

- Buy the right product for the job
- Compare prices of different products
- Follow the Five-Point Plan for fertiliser storage
- Buy fertiliser from a FIAS-registered supplier

Nitrate Vulnerable Zones (NVZ)

Summary of NVZ rules for grassland (always check Defra's website for current NVZ guidance)	
Nmax	Maximum nitrogen application per crop = 300 kg N/ha/year. Extra 40 kg N/ha if grass is cut at least three times in year. Includes manufactured fertiliser nitrogen, crop-available nitrogen from livestock manures and other organic manures
Field organic manure nitrogen limit	250 kg N/ha in any 12-month period per field. Includes total nitrogen in all organic manures
Livestock manure nitrogen farm limit	170 kg N/ha in calendar year across the farm. Includes all total nitrogen produced by livestock (must use standard tables). Derogation to 250 kg N/ha has been available for farms with >80% grass
Closed periods (no spreading of organic manures with high available nitrogen content, e.g. slurry, poultry manure, or digestate)	Manufactured fertiliser nitrogen: 15 September–15 January. Organic manure nitrogen: 1 September–31 December on shallow and sandy soils; 15 October–31 January (all other soils)
No spread areas	Not if soil is waterlogged, flooded, snow-covered or frozen more than 12 hours in previous 24. Manufactured fertiliser nitrogen: 2 m from surface water. Organic manures: 10 m from surface water, 50 m from borehole, well or spring and 6 m from surface water where precision spreading equipment is used

In winter, check expected compliance with Nmax, the livestock manure nitrogen farm limit and the organic manure nitrogen field limit. In autumn, check again that the limits are not breached.

All NVZ records must be kept for five years.

NVZ rules for manures are on page 25.

Appendix 1

Applying manures to grassland – a visual guide

25 t/ha or 10 t/acre

Nitrogen = 15 kg^
Phosphate = 48 kg^
Potash = 180 kg^
Value* = £124.80

50 t/ha or 20 t/acre

Nitrogen = 30 kg^
Phosphate = 96 kg^
Potash = 360 kg^
Value* = £249.60

Applying slurry to grassland – a visual guide

25 m^3/ha or 2,225 gallons/acre

Nitrogen = 16 kg^
Phosphate = 15 kg^
Potash = 73 kg^
Value* = £54.85

50 m^3/ha or 4,500 gallons/acre

Nitrogen = 32 kg^
Phosphate = 30 kg^
Potash = 146 kg^
Value* = £109.70

Source: ThinkManures (**www.nutrientmanagement.org**). ^Available nutrients supplied, based on cattle farmyard manure with 10% nitrogen availability/6% DM cattle slurry with 25% nitrogen availability (RB209). *Based on bagged fertiliser prices – 1 kg of nitrogen = £0.72, 1 kg of Phosphate = £0.65, 1 kg of Potash = £0.46.

Conversion factors

Metric to Imperial

1 tonne/ha	= 0.4 tons/acre
100 kg/ha	= 80 units/acre
1 m^3	= 220 gallons
1 m^3/ha	= 90 gallons/acre
1 kg/1m^3	= 9 units/1000 gallons
1 kg	= 2 units

Imperial to Metric

1 ton/acre	= 2.5 tonnes/ha
100 units/acre	= 125 kg/ha
1 bag/acre	= 125 kg/ha
1,000 gallons	= 4.5m^3
1,000 gallons/acre	= 11m^3/ha
1 unit	= 0.5 kg

To convert units/acre to kg/ha (for nutrients), multiply by 1.25.

For example:

160 units/acre x 1.25 = 200 kg/ha

To convert kg/ha to units/acre (for nutrients), multiply by 0.8.

For example:

200 kg/ha x 0.8 = 160 units/acre

To convert bags*/acre to kg/ha (for product), multiply by 125.

For example:

2 bags/acre of ammonium nitrate x 125 = 250 kg/ha of ammonium nitrate

*Refers to defunct hundredweight bags (cwt = 50 kg)

Source: *AHDB Nutrient Management Guide (RB209)*, Fieldfare Training

Appendix 2

Sources of information

AHDB

The ***AHDB Nutrient Management Guide (RB209)*** can be downloaded at:
ahdb.org.uk/rb209

The guide includes nutrient recommendations for grass and forage crops (section 3) and standard values for the nutrient content of manures (section 2), as well as short videos.

Improving soils for Better Returns has more information on interpreting soil test results. Call 024 7647 8834 for a free copy or download at:
beefandlamb.ahdb.org.uk/returns

AIC

Information on calibrating and tray testing fertiliser spreaders can be downloaded at:
www.nutrientmanagement.org/fertiliser-spreader-manual/

Information on the Fertiliser Industry Assurance Scheme (FIAS) at:
www.agindustries.org.uk

Defra

Find NVZ guidance and information at:
www.gov.uk/guidance/nutrient-management-nitrate-vulnerable-zones

The Defra code of good agricultural practice, Protecting our Water, Soil and Air, at:
www.gov.uk/government/publications/protecting-our-water-soil-and-air

FACTS

Information on training for nutrient management planning at:
www.factsinfo.org.uk/facts/home.eb

Health and Safety Executive (HSE)

The HSE booklet Storing and Handling Ammonium Nitrate at:
www.hse.gov.uk/pubns/indg230.pdf

NaCTSO

The Five-Point Plan for Fertiliser Security, drawn up by the National Counter Terrorism Security Office (NaCTSO), at:
www.gov.uk/government/publications/secure-your-fertiliser/secure-your-fertiliser

Natural England

Catchment Sensitive Farming advisers can provide free training, advice and grants to farmers in priority catchments to reduce water pollution. Find out more at:
www.naturalengland.org.uk/csf

Tried & Tested

Tried & Tested Nutrient Management Plan is free. There is information in Booklet 2: *Making better use of manure on grassland* and Booklet 3: *Spreading systems for Slurries and Solid Manures*, at:
www.nutrientmanagement.org

Beef and Sheep BRP Manuals

Whether you need an introduction to soil biology or a detailed guide to improving soil drainage, AHDB has information and guidance to support you.

Information for grassland and arable crops is available on our website at **ahdb.org.uk/greatsoils**

See the AHDB website **ahdb.org.uk** for the full list of Better Returns Programme publications for beef and sheep producers.

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