Prospective Impact of Environmental Regulations, and other Policies on Fertiliser use in Ireland.

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Abstract (draft)

This paper examines the implications for Irish fertiliser use of both market and policy developments over the next 10 years. Two different types of analysis are used in the study. These may be summarised under the broad headings of

I Agricultural Sector Analysis
II Individual Farm Analysis

Each form of analysis enriches the other to provide policy makers with a valuable suite of analytical tools.

The sectoral or aggregate level analysis relates to work, which is being presently conducted with the FAPRI-Ireland econometric model of the Irish agricultural sector. In this context Irish fertiliser use is modelled as a function of overall developments in the different commodity markets including dairy, beef, sheep and arable. Two different sets of results are generated with the FAPRI-Ireland model. One is a baseline, or 'no policy' change, type of result where existing agricultural policy is held constant, and the second type of result is the evolution of fertiliser consumption under a particular policy change scenario. The effects of the scenario are measured relative to the baseline result. The scenario analysed in this context is a move towards greater extensification in the livestock sectors. Demand for grass and other animal feed declines in both scenarios with the decline in output from herbivores, however, this decline is steeper in the extensification scenario. Decline in usage of phosphatic fertilisers reflects output trends, and, as usage settles to rates needed to maintain adequate soil conditions, the decline of recent years is moderated. In contrast, the projected 8 percent decline in baseline usage of nitrogen by 2010 would be amplified by regulations to relate applications to the level of output. The paper also examines the role of prices and other influences on the sales prospects for these two types of fertiliser. The emphasis is on use of fertilisers for grass production.

The second part of this paper uses farm level analysis to examine the likely impact of the Nitrates Directive. Particular attention is paid to the work of Lally and Riordan on its effects on dairy farms as the group most likely to be affected. Two levels of constraint are compared, that of 210kgN/ha (2.5LU/ha) and 170 kgN/ha (2LU/ha). Applying an overall limit of 2.5 Livestock Units (LU)/ha would affect approximately 2,130 dairy farms nation wide or less than 10 percent of these farms. In contrast applying an overall limit of 2 LU/ha would affect far more farms and to a far greater degree. This was indicated by sample data on dairy farms in Munster's five dairying counties. Data from the Teagasc National Farm Survey, indicated that about 39 percent of these farms would have to reduce numbers of dry stock to abide by a 2 LU/ha limit. Such a limit would also reduce their farm income and fertiliser use considerably. In addition, application of no more than recommended levels of fertiliser under the code of *Good Farming Practice*, would further reduce fertiliser use below the 8 percent baseline decline projected in Part I.

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1. Introduction

This paper seeks to present a general overview of projections of fertiliser usage in Irish agriculture over the next 10 years. In particular two different approaches will be availed of to arrive at a general picture of the likely evolution of fertiliser consumption in Irish agriculture. These two different approaches are focussed on the aggregate or national level, and at the micro or farm level. Both types of approaches can answer different types of questions thereby yielding a more comprehensive overview of fertiliser consumption than what would otherwise be the case.

Fertiliser consumption in Irish agriculture was until 1998 the second largest variable input item behind commercially traded feed in the national accounts for agriculture. Table 1 presents an overview of variable input items in Irish agriculture between 1998 and 2001 along with the ratios of variable input expenditure to overall agricultural output values and fertiliser consumption to overall input expenditure.[4]

Table 1: A Summary of Variable Input Expenditure in Irish Agriculture 1998 - 2001

	1998	1999	2000	2001
	€ million			
Intermediate Consumption	2,907	2,981	3,109	3,236
of which:				
Feeding Stuffs	831	860	830	876
Fertiliser	329	338	337	350
Energy	307	341	450	470
	Percentage			
Fertiliser percentage of variable Inputs	11.3	11.4	10.8	10.8
Variable Inputs percentage of Agricultural Output Values	58	62	63	62

Whilst spending on fertilizers has been overtaken in recent years by the very significant increases in the levels of expenditure on energy it is still clearly a very important component of overall Irish input expenditure – averaging about 11 per cent of total input expenditure.

Attempting to model input usage in agriculture is a particularly difficult task. Most input items are treated as 'derived demands' i.e. farmer usage of these items is strictly determined by the contribution of the input to the productivity of the output produced on the farm. This situation is relatively straightforward in a free-market environment where producers would simply respond to

[4] A comparison over a longer period is not really appropriate given the changes in the presentation and compilation of the national accounts for agriculture in 2000 by the Central Statistics Office (CSO).

output and input price signals. However within the context of the EU Common Agricultural Policy (CAP) framework the situation is complicated significantly by the presence of different policy levers within the different output sectors, which can have significant consequences for the production decision of the producer. Two such policy issues within an Irish context for example are the quota within the dairy sector and the extensification measures introduced in the McSharry reforms of 1992 and expanded upon in the Agenda 2000 reforms of 1999.

The paper is structured as follows; part I provides an overview of fertiliser consumption in Irish agriculture over the past 15 to 20 years. An introduction is provided to the FAPRI-Ireland model of the agricultural sector with two different sets of fertiliser projections from the FAPRI model presented. Part II of the paper examines the likely impact of the Nitrates Directive on future fertiliser application using a farm level perspective.

Part I

Fertiliser Consumption in Ireland

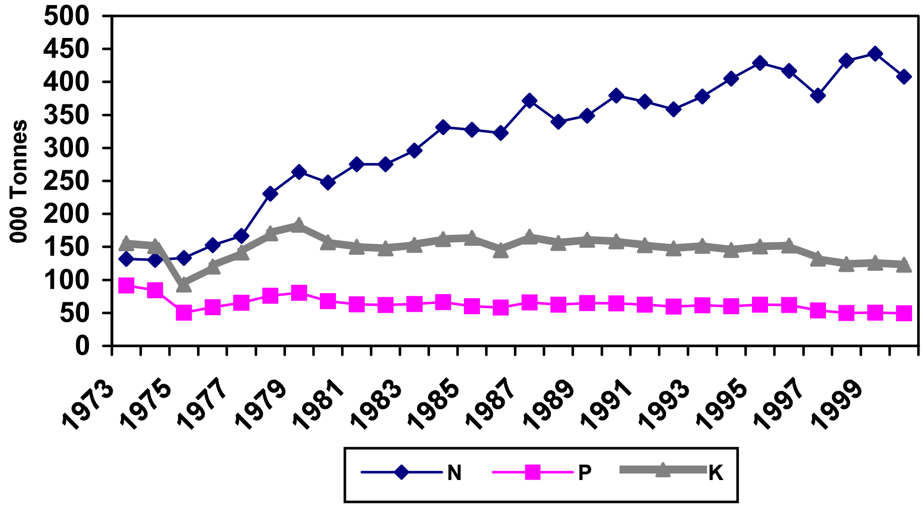
2. Developments to date

Agriculture's choice of fertilisers has changed notably during this century. The major practice in the developing fertiliser industry was the separate production of straight fertilisers, each containing only one primary nutrient. However, changing farming practices, crop rotation, improved soil fertility and conditions, higher yields and greater productivity have led to an increasing popularity of compound fertilisers Steen (1997). Over the last 50 years the manufacture of mineral fertilisers developed towards crop and soil specific products. Higher nutrient concentration of fertilisers was requested and compound fertilisers became more and more common. The increased use of mechanical application equipment called for improved quality and, as a result, chemically mixed and granulated fertilisers became increasingly popular amongst farmers in Europe.

The International Fertiliser Industry Association (IFAI) suggests that the world's leading nitrogen products are Urea and Ammonium Nitrate, which together hold a third of the nitrogen consumption globally. The most used phosphate containing fertiliser is Ammonium Phosphate. For potash there is one leading product, Potassium Chloride, whose total use is about 60%. Generally, for nitrogen and phosphate, 2/3 is used as compound fertilisers and the global $N:P_20_5:K_20$ ratio seems to have stabilised at 20:8:5. The west European $N: P_20_5:K_20$ ratio is around 21:8:9. In Ireland, Urea and Calcium Ammonium Nitrate hold some 55% of the nitrogen market. Phosphate and potash are used almost entirely in the form of compound fertilisers and the average Irish $N: P_20_5:K_20$ ratio is approximately

21:7:9. Figure 1 plots the consumption patterns of the different fertiliser types in Irish agriculture.

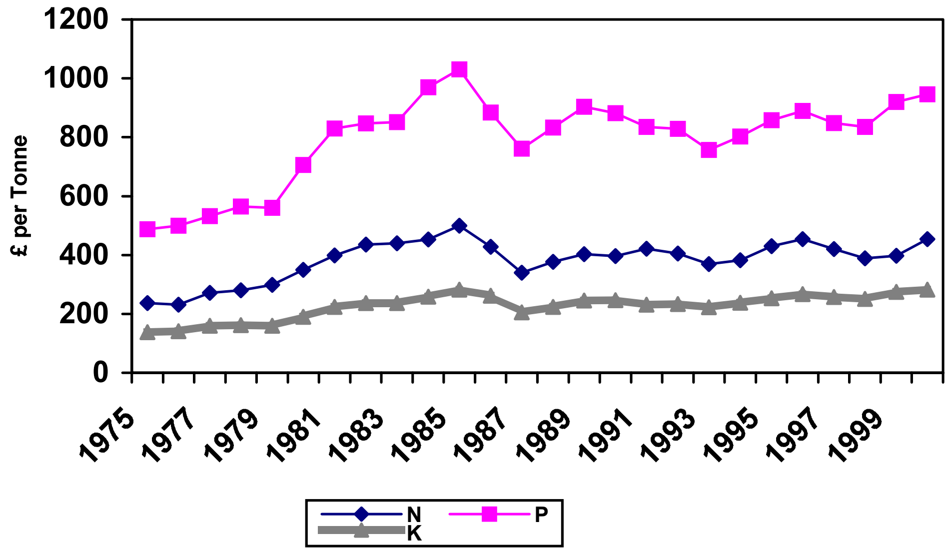
Figure 1: N, P & K Usage in Irish Agriculture



As far back as 1983, Kearney (1983) was articulating a widespread concern about the stagnation in P and K consumption and the large relative increase in N application. As indicated in Figure 1, the trend in N usage since 1973 has been a gradual increase, with N outpacing the other nutrients in terms of growth.

A number of features can be adduced for this differential trend of nutrient usage. Firstly, expansion in silage production has been cited as the reason for the more robust performance of K relative to P since the mid-seventies. Secondly, while there may have been some substitution of N for P and K, the relatively greater growth in N consumption is consistent with intensification occurring on a relatively small proportion of farms, despite little change in the aggregate. The trends in beef carcass weights and dairy output per cow would correlate with the persistent trend increase in nitrogen application rates. Another potential reason for increased fertiliser application is an increase in the product/fertiliser price ratio. However, one could argue that farmers when deciding to increase carcass weights and output per cow already take relative output/input price movements into account. Figure 2 illustrates movements in the prices of the three different fertiliser types.

Figure 2: Nominal Prices of Fertiliser N, P & K



As expected, the prices of the N, P & K types tend to track each other fairly closely with the phosphate price at an added premium to the nitrogen and potassium prices. The close correlation between the three prices merely reflects their overall correlation with the price of international oil. The last oil shock in 1979 resulted in a shock to all three prices. However, the international price of phosphate was most affected and consequently, the domestic price jumped by almost £250 per tonne over a 3-year period. These relative price movements may also have played a part in determining the continued increased consumption of nitrogen relative to phosphate post 1980.

The next section provides an introduction to the FAPRI-Ireland model of the Irish agricultural sector. In particular the modelling of fertiliser application is discussed and two of the more recent results from the model are presented.

3. FAPRI-Ireland Partnership Projections

The FAPRI-Ireland model of the Irish agricultural sector is a joint effort of the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri, Columbia and Teagasc.[5] It is a dynamic, partial equilibrium model consisting of 200 econometrically estimated equations (see Binfield *et al.* (2000a)). The model comprises a series of interlinking commodity models for the Irish beef, dairy, crops and inputs sectors. Since 1998 the model has been successfully used to generate an annual series of projections referred to as a baseline result. This result serves as a benchmark as it is the projection of key variables in the absence of any policy

[5] The Irish Agriculture and Food Development Authority.

change. In tandem with the baseline result is the analysis of the effects of a particular policy change on the Irish agri-sector. This result – the scenario, allows policy makers to quantify the effects of the particular scenario relative to the baseline. For instance, the model was originally developed to examine the potential impacts of the Agenda 2000 reforms of the Common Agricultural Policy (CAP) (see McQuinn and Riordan (1998)). Subsequent analysis has been conducted on the effects of alternative euro/dollar exchange rates on Irish agriculture (Binfield *et al.* (2000b)) as well the effects of the 2001 BSE scare on Irish agriculture (Binfield *et al.* (2001)). Owing to the continued collaboration between FAPRI at the University of Missouri and Teagasc, the FAPRI-Ireland model has the considerable advantage of being linked both to the FAPRI EU and World modelling system. This enables changes in world markets to be traced down through to the equivalent domestic Irish markets.

One of the sector models developed within the FAPRI-Ireland framework is the inputs model. A series of equations are specified for each of the main input items in Irish agriculture. In the case of fertiliser N, P and K are each modelled separately. Furthermore they are each modelled on a per hectare basis – total N for example is divided by total agricultural area[6] to arrive at a N per hectare figure. This per hectare application level (NPH) is then modelled as a function of the following:

$$\mathrm{NPH} = \mathrm{f}(\mathrm{INT}, \mathrm{GRASS}) \quad (1)$$

where INT is an intensity per hectare variable and GRASS is a regionally weighted grass growth variable denoting the level of grass growth nationally, which is a weighted sum of grass growth in different regions of the country.[7] The INT variable is calculated in order to capture the productivity decision of the producer i.e. it is compiled to take into account decisions such as the carcass weight per animal, the amount of milk produced per cow and the stocking density decision of the producer. In such a fashion both the market and policy signals which may influence a producer's production decision and hence their fertiliser application are captured by the model. By taking projections of total agricultural area and multiplying this by the projections of the per unit application (NPH) total fertiliser applications for N, P and K can be obtained.

The FAPRI-Ireland model is simulated annually to produce two different sets of projections. One result is the baseline or no policy change result which projects all the relevant variables in the

[6] Using definitions of agricultural area from the CSO.
[7] The grass growth figures were taken from a grass growth model compiled by Tony Brereton (Teagasc, Moorepark).

agricultural sector over a ten year horizon holding existing policy constant. This result is then used as a benchmark result and the impacts of alternative policy measures may be gauged relative to the baseline result. Thus the second result generated every year is a scenario result, which changes an existing policy measure and assesses the impact of the policy measure on the agricultural sector relative to the baseline result.

Baseline Results[8]

The most recent baseline result generated with the FAPRI-Ireland model was published in April of 2002. This section summarises the results for the main sectors in Irish agriculture. These results in turn drive the demand for fertiliser along with projections of fertiliser prices derived from the Economic and Social Research Institute's (ESRI) long-term forecasts. It is worth pointing out that no specific assumption is made in relation to nitrogen application due to issues such as the implementation of the Nitrates Directives.

Dairy. Dairy sector output is limited by a quota. Thus, increases in productivity will lead to a reduction in the dairy herd. It is expected that by 2010, the dairy cattle herd will decline by approximately 127,000 head or 10 per cent relative to the numbers in 2000.

Cattle. It is expected that the non-dairy beef herd will contract by approximately 200,000 head or 3 per cent over the period 2000-2010. This decline is reflected in a fall in the number of beef cows, heifers, steers and bulls. This is mainly brought about by a decrease in market margins resulting from the fall in beef prices, as well as by an increase in extensification payments guaranteed under the Agenda 2000 CAP reform.

Other livestock. The recorded decline in sheep numbers over the past decade is expected to continue over the projection period. The total number of sheep is projected to be approximately 700,000 or 9 per cent less by 2010. The fall in numbers is projected despite the significant increase in market prices in 2001, brought about mainly by the Foot and Mouth crisis in the UK. One of the main reasons for the decline in sheep production is its labour intensive nature and the continued expected increase in the opportunity cost of labour for those engaged in sheep production during the projection period.

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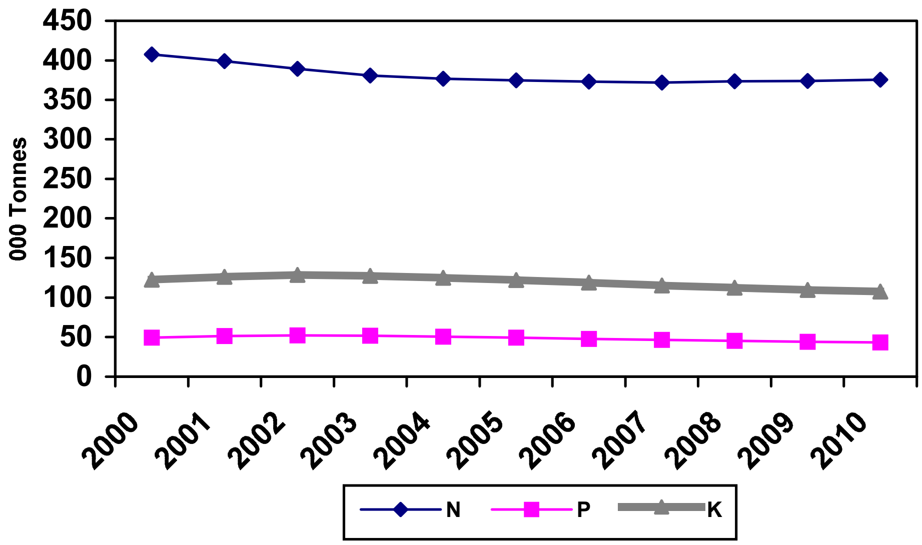
[8] Full details of the baseline results may be obtained in Binfield et al. (2002a)

The cumulative effect of the results is an expected decline in the consumption of N use on Irish farms of 8 per cent between 2000 and 2010. This is primarily driven by the expected decline in both dairy cow and suckler cow numbers for the same period. P and K levels are also expected to decline over the same period. Note that while total application levels of all fertilisers are expected to fall by about 9 per cent between 2000 and 2010, the expected long term increase in energy prices and hence fertiliser prices results in expenditure on Irish fertiliser actually increasing by 4 per cent between 2000 and 2010. The plot of expected N, P and K application levels is presented in Figure 4.

Figure 4: Baseline Projected N, P & K Usage in Irish Agriculture 2000-2010



Scenario Results

Under the Agenda 2000 reform, two extensification limits were introduced to influence the level and type of EU beef production. The basic concept behind extensification is to provide incentives for beef producers to hold fewer animals per hectare of land. Producers are compensated for the loss of receipts from these animals by the introduction of extensification payments, which are on a per animal basis. The payments introduced under the extensification scheme are conditional on adherence by the producer to two different stocking density limits. In an Irish case, producers have the option to stock their farms at either less than 1.4 livestock units (LU) per hectare or between 1.4 and 1.8 LU per hectare. The lower the stocking density the higher the rate of payment.

Under the scenario performed on the FAPRI-Ireland model as part of its 2002 output (see Binfield *et al.* (2002b) for more details), the two extensification limits of 1.4 and 1.8 LU per hectare are reduced by 0.2 LU. Thus, the new limits for receipt of extensification payments are at a stocking density level between 1.2 and 1.6 LU per hectare and a stocking density of less than 1.2 LU per hectare. By lowering the stocking density limits and increasing the associated payments, the aim of the scenario is to quantify the reduction in beef animals likely to be associated with these new limits.[9]

A significant number of producers are expected to reduce their herd size, in order to comply with the more constraining livestock density limits. The reduction in herd size is particularly observed in beef and sheep sectors. Beef cows are down three per cent relative to the baseline level due to the new extensification level while total cow numbers are down two per cent relative to the baseline. The Irish ewe flock witnesses a decline of four per cent in 2010 under the scenario relative to the baseline amount. This larger reduction in the ewe flock relative to the other livestock sectors is because while ewe numbers are used in the calculation of the stocking density level they are not eligible for extensification payments in their own right.

All things being equal, a decline in the number of animals per hectare leads to a reduction in the amount of inputs consumed. The further move towards extensive production in the livestock sector results in the quantity of N being consumed falling on a per animal basis and through the decline in cattle and ewe numbers. Thus overall total fertiliser application falls by one percent under the scenario relative to the baseline level. Therefore, between 2000 and 2010 under the further extensification scenario, total fertiliser application levels fall by 10 per cent.

A large macro or aggregate tool, such as the FAPRI-Ireland model, is very useful for capturing the likely effects of movements in the commodity markets and fertiliser prices on future fertiliser consumption. However the framework is not ideal for analysing the effects of more micro level considerations such as the impact of the Nitrates Directive, for example, on individual producer's fertiliser consumption. Part II of this paper addresses some of the questions for future fertiliser use left unanswered by the FAPRI-Ireland approach.

[9] This scenario was initially devised in February of 2002 as a possible CAP Mid-Term Review policy scenario. The actual CAP review proposal, announced in July, went a step further by advocating the full decoupling of direct aid payments.

Part II

Nitrates Directive scenarios[10]

4. Introduction to the Nitrates Directive

At times the relationship between agricultural inputs and outputs shifts, often due to technological or legislative changes. These shifts have to be imposed on the models that generate the projections reviewed in Part I above. Thus, for instance, the projections now take account of the shift in usage of phosphatic fertilizers that occurred in the recent past. Another such shift may be about to occur in the usage of nitrogenous fertilizers. Such a shift would be a response to several impulses, these we have put under the heading 'Nitrates Directive'. This part of the paper notes the impulses and the farming implications of two legislative scenarios. In the end, however, we would look to experts in this area to suggest the scale of impact the Nitrates Directive scenarios would have on the projections for fertilizer use in Ireland.

Unacceptable deterioration in water quality

The Nitrates Directive was designed to address specific concerns about the contribution of agriculture to the deterioration of water quality. It was validated as a realm of action under the European Treaties 'since pollution of water due to nitrates in one Member State can influence waters in other Member States.'[11]

The main concerns were:

- Risks to human health caused by elevated and rising levels of nitrates in drinking water;
- Risks to aquatic ecosystems, particularly from eutrophication[12]
- Safeguarding of other legitimate uses of water;
- The contribution to 'water pollution resulting from the spreading or discharge of livestock effluents and the excessive use of fertilizers'[13].

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[10] The main Directive to be considered here is Council Directive 91/676/EEC of 12 December 1991 'concerning the protection of waters against pollution caused by nitrates from agricultural sources', *Official Journal* L375,31/12/1991, others are listed in Department of Agriculture Food and Rural Development (2001), and Department of the Environment and Local Governament, 2002.

[11] Preamble to the Directive cited above.

[12] "Eutrophication is the over enrichment of waters by nutrients causing excessive plant growth and consequential oxygen depletion in waters thereby reducing water quality and the capacity of the affected waters to sustain flora and fauna. Eutrophication occurs when sufficient quantities of phosphorus, nitrogen, carbon and trace elements are available in the water to generate and support excessive plant growth." (Department of the Environment and Local Government, 2002).

[13] Preamble to the Directive cited above

European Union Response

In agriculture the major response to the concerns noted above was the 'Nitrates Directive'. This aimed to reduce the risks of water pollution from agriculture by requiring Member states to:

- Establish a code or codes of good agricultural practice[14];
- Establish action programmes, including water quality monitoring and recurrent adaptation of the programme to local conditions[15].

In addition, under the Agenda 2000 Agreement, a farmer's receipts of payments under many of the provisions of the Common Agricultural Policy are conditional on their compliance with standards and codes of good practice[16].

Ireland

The Department of Agriculture, Food and Rural Development (DAFRD) published "*Good Farming Practice*" in 2001. Farmers receiving payments under EU schemes run by DAFRD are required to abide by the rules in *Good Farming Practice*. In addition, those enrolled in the Rural Environment Protection Scheme (REPS) are required to go further and abide by rules that are more protective of the environment. In particular they have to have a Nutrient Management Plan (NMP) and abide by it. Failure to comply with the relevant rules can lead to the forfeiture of part of the payments due to the farmer. Where the above rules apply as a condition for receiving direct payments, i.e. through 'cross-compliance' provisions, the penalty will only be applied after the farmer has been found to be in breach of the rules by a court or the authority implementing the relevant regulations.

Good Farming Practice and recommended fertilizer usage in Ireland

Applications of plant nutrients under the code of Good Farming Practice are those recommended by Teagasc. For grassland Teagasc recommendations are for application of fertiliser (manufactured) Nitrogen related to the farm's average stocking rate measured in Livestock Units/hectare of highly productive soils, as follows:

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[14] Nitrates Directive cited above, Article 4.

[15] Nitrates Directive cited above, Article 5.

[16] Department of Agriculture, Food and Rural Development (DAFRD), 2001 and 2002, p19.

Table 2: Application rates for manufactured fertiliser Nitrogen on grassland

Whole Farm Stocking Rate[1,2] LU/ha	N Fertiliser Advice for grazing (kg/ha) Pasture 3 years or older No Clover	Pasture less than 3 years No Clover
Less than 1.2[3]	45	45
1.2-1.5[3,4]	60	75
1.8[4]	80	100
2.1[4]	100	125
2.4	225	280
2.8	320[5]	390[5]
3.0	390[5]	400[6]

1. The stocking rate is averaged over the grazing and silage area of the farm. A LU is defined as a lactating cow or its equivalent in cattle or sheep which has the metabolisable energy requirement from grass of a 550kg dairy cow yielding 5,000 litres of milk and fed 500kg of concentrates per head per year. If more than 500kg of concentrates are fed, less grass area will be required to supply the required energy. Thus, to derive the correct N-rate for standard merit cows, decrease the whole farm-stocking rate by 0.1 LU/ha for each kg/head/year of concentrate above 500kg/annum fed. Conversely, increase the stocking area if less than 500 kg/head/year is fed.
2. Only fertilise to the stock carrying capacity of the soil. This may vary within the farm; if it does, the stocking rate for the different sections may be determined and a rate for each section obtained from the above table.
3. At stocking rates up to 1.5 LU/ha, management should promote clover growth, which makes N fertiliser unnecessary. Below 1.2 LU/ha, apply up to 45kg/ha N in the spring if there is no clover in the sward.
4. With less productive soils at stocking rates up to 2.1 LU/ha, agriculture advisors may need to increase these N rates by up to 20% to suit local conditions. However, observe note 2 above.
5. Present research indicates that there is a risk of loss of nitrate to ground water in permeable soils with N fertiliser applications to grazed grassland of more than 300kg/ha.
6. No economically worthwhile responses to N application rates above 400kg/ha are found, even on the best soils. High rates should be avoided to reduce potential losses to the environment.

Source: Coulter, 2001

5. Stocking rate limitation scenarios

Stocking rate limitations have been a condition for participation in the Rural Environment Protection Scheme (REPS) and have also been attached to Extensification Payments. However, a Nitrates Directive action programme could impose mandatory limits on the amount of animal sourced nitrogen applied per hectare and in effect restrict stocking rates. In Ireland, the Directives ultimate restriction on applications of nitrogen of animal origin to 170kg per hectare is equated to two Livestock Units (LU) per hectare[17]. The Directive also permits a higher rate of 210kg N/ha or 2.5 LU/ha in the first four years. Subsequently, the limit is 170kg N/ha, or other limit appropriate to protecting water from pollution by nitrates of agricultural origin.

The likely implications of these constraints and those of Good Farming Practice for farms specializing in milk production, have been examined in two reports Lally (2002), Lally and Riordan (2001). Both focus on farmers in dairying, as these tend to be relatively heavily stocked (Teagasc, NFS), and to spread more fertilizer nitrogen than farms of any other type (Coulter et al 2002).

The first study applied a 2.5 LU/ha limit to all dairy farms in the Teagasc National Farm Survey[18]. The Second study focused on dairy farms in five Munster counties, and the implications for them of a limit of 2 LU/ha. These counties were chosen to represent the area of particularly intensive dairying with a high level of fertilizer applications.

These studies show the potential very different impacts on farm output and incomes of two levels of constraint on stocking rates and associated limits on fertilizer use.

5.1. A 2.5 LU/ha limit on farm livestock intensity

Assuming the application of a 2.5 LU/ha limit on stocking rates, and Teagasc recommendations on fertilizer applications under the code of the Good Farming Practice, how many farms would be affected and to what extent?

Extent and scale of impact

Breda Lally derived estimates from data collected by the Teagasc National Farm Survey in the year 2000. Out of the 1,150 farms surveyed, only 30 dairy farms were stocked at more than 2.5 LU/ha.

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[17] A livestock Unit is defined for this and other purposes in EU schemes as equivalent to a cow or other cattle over 2 years of age. Cattle over 6 months are rated as 0.6LU and those under 6 months are not counted. Ewes are reckoned to equate to 0.15LU per head.

[18] The category 'Dairying' in the NFS is defined as specialist milk producing farms, these account for the bulk of milk production.

These represented 2,125 farms in the country, or 10 percent of dairy farms and 2 percent of all farms. Their average size at 44 ha (Table 3) was above the average for dairy farms of 36 ha. Their average usage of Nitrogen fertilizer at 268 kg N/ha, was below the 390kg recommended for their average stocking rate of 2.8 LU/ha., assuming use of short rotation grassland with no clover.

Table 3: Summary Statistics for dairy farms in the NFS at 2.5 LU/ha or more (30 Farms)

	Average
Utilised Agricultural Area (hectares)	44 ha
Milk Quota	309,305 litres (68,047 gals)
Livestock Units/ha	2.8 LU/ha
Dairy Livestock Units as a percentage of total LU	57%
Manufactured Fertiliser Applied (kg/hectares)	268 kg/ha

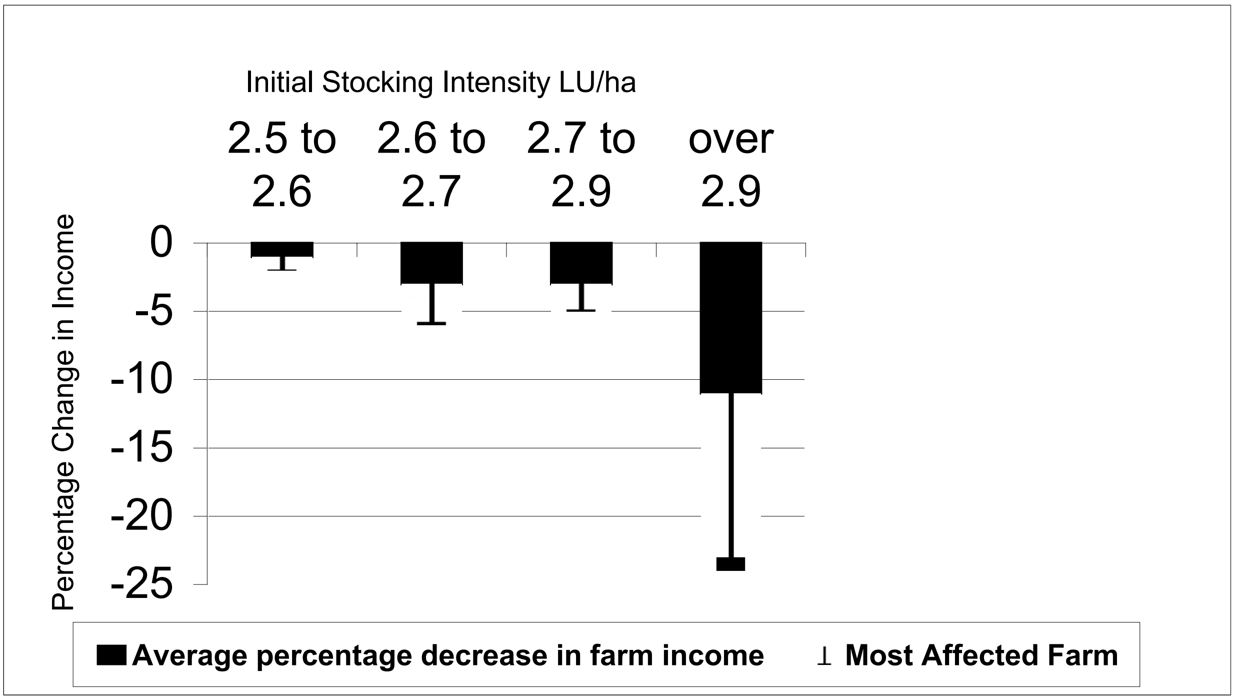
Data: Teagasc, NFS (2000)

For estimation of the likely impact of limiting their stocking to 2.5LU/ha., the 30 farms were divided into four groups according to the intensity of stocking. The effect of the stocking rate constraint on each farm was then estimated and average results for each group calculated.

To reduce stocking rates to 2.5LU/ha, farmers are likely to remove animals starting with those with the lowest gross margin earned per hectare used. This strategy was clearly established as the profit maximising route in an earlier study (Lally and Riordan 2001). A constraint imposed on pursuit of this strategy was a ‘closed herd’ condition that enough heifers would be kept to replace cows in the herd after five lactations. In nearly all cases, stocking rates could be reduced to 2.5 LU/ha without reducing the number of cows milked. The exceptions were on two farms stocked at over 2.9. LU/ha and on both of them, dairy cows accounted for over 70 percent of the Livestock Units on the farm.

Thus of the 30 farms in the NFS with over 2.5 LU/ha, 28 could reduce their intensity to that level by reducing the number of dry stock on the farm while maintaining the size of their milking herd. In consequence the impact on the incomes of these farms was generally less than a six percent reduction.

Figure 5: Impact of a decrease in stocking intensity to 2.5 LU/ha on incomes of dairy farms in NFS sample



Data: Teagasc, NFS, 2000

Of the two farms facing a reduction in cow numbers to achieve the 2.5LU/ha limit, the worst affected would have an income reduction of 24 percent. Initially the cows accounted for 81 percent of the Livestock Unit inventory on this farm. With few other cattle to remove, much of the adjustment fell on the number of milking cows with serious consequences for farm income. This farm also applied the highest level of fertiliser at 480kg/ha. The required reduction in stocking intensity would indicate a reduction in fertilizer usage to about 280kg N/ha.

Impact on fertiliser use?

A 2.5LU/ha limit on stocking would be expected to have a relatively small impact for the following reasons:

1) Only a very small proportion of farms are currently in excess of this stocking rate;
2) Average fertilizer usage on dairy farms that were above 2.5LU/ha was less than that recommended for 2.5LU/ha, and dairy farms tend to be the heaviest users of fertiliser[19].

However, some of the farms with over 2.5 LU/ha would reduce fertiliser use in keeping with their reduction in the number of stock on the farm. In addition, some farms seem to have been using more than the recommended levels of fertiliser and would need to improve the efficiency of their usage. Yet

[19] Coulter (2002)p.18, table 4.

the overall impression that these intensive farms have been using close to the recommended levels of fertiliser is supported by the results of the survey by Coulter and others (2002). They found that, on average, applications of nitrogenous fertilisers on grassland were below recommendations on farms stocked in excess of 2.4LU/ha[20].

5.2. A 2LU/ha limit on farm livestock intensty

Ultimately, the Nitrates Directive specifies the amount of manure applied to the land shall not exceed that amounting to 170kg N/ha. In Ireland this is taken as equivalent to a limit of 2LU/ha. The implications of this constraint were examined in Lally and Riordan (2001). As in the study reported above, implications for farms having to reduce their stock numbers to conform to this limit were estimated for those in the Teagasc National Farm Survey (NFS) for 1996. In this case the sample was of dairy farms with 2LU/ha, or more, in five dairying counties of Munster, namely: Cork, Kerry, Limerick, Tipperary and Waterford.

Of the 120 dairy farms from these counties in the NFS, 49 were stocked at more than 2LU/ha. They represented 39 percent of all dairy farms in the five counties. The profit maximising adjustment of these farms to a 2LU/ha limit was estimated with Positive Mathematical Programming (PMP), a relation of linear programming. One of the advantages of PMP is that the simulations for each farm reflect its previous performance. The results clearly support the assumption, used in the analysis reported above, that the profit maximising strategy would be to remove livestock starting with those showing the lowest gross margin per hectare used.

Table 4: Estimates of stocking rates and fertilizer use on dairy farms: 5 Munster Counties

Size Quota	**Average Stocking Rate**	**Average N from Fertilizers**	**No. of Farms over 2 LU/ha**	**Total No. of Farms**
	LU/ha	kg N/ha		
Less Than 10,000	1.2	74	0	6
10,000 – 25,000	1.4	121	3	28
25,000 – 40,000	1.8	178	14	40
40,000 – 60,000	2.2	251	17	23
Over 60,000	2.2	254	15	23
Total	**1.8**	**183**	**49**	**120**

Source: Lally and Riordan (2001)

[20] Coulter (2002)p.22, table 10.

In this study the farms were categorised by size of milk quota. This reflected an observed tendency for farms with larger milk quotas to have higher stocking rates. Indeed, it was found that none of the six farms with less than 10,000 gallons (45,455 litres) had more than 2LU/ha while 15 of the 23 farms with over 60,000 gallons (272,727 litres) of quota were stocked in excess of this level. Thus a case study farm with 2.6LU/ha was in this group with over 60,000 gallons of quota. Other case study farms had 2.3 and 2.1 LU/ha. All these farms could reduce their livestock to 2LU/ha while maintaining the number of milking cows. Thus the income loss was limited to that from their dry stock enterprises. Even so this reduction from 2.6 LU/ha on the largest farm would have cut income there by 15 percent. For the farm at 2.3 LU/ha, the income reduction would be 9 percent and for that at 2.1 LU/ha, 1 percent, (Lally and Riordan, 2001). This study also indicated that application of nitrogen fertiliser on the farms stocked at less than 2.4 LU/ha far exceeded recommendations and that its reduction to conform to Good Farming Practice could amplify the effects of reducing stock to the 2LU/ha limit. These case study farms thus conform with results for 2000 from Coulter (2001) that, below 2.4 LU/ha, applications of N fertilizer were generally above recommended levels.

In conclusion, the imposition of a 2LU/ha limit on farm stocking intensity would affect far more farms and to a far greater degree than a 2.5LU/ha limit.

Implications for fertiliser use

Application of the Nitrates Directive as an overall limit of 2LU/ha on stocking intensity could have considerable impact on fertilizer use because:

1) A large proportion of dairy farms, in the region of 40 percent, would have to reduce their numbers of livestock, with a more than proportionate reduction in fertiliser use just to abide by recommendations;
2) Fertiliser use would also have to be cut back to recommended levels.

The disproportion between reductions in stocking rate and in applications of fertiliser may be seen by calculation from Table 2 giving the following result:

Table 5: Implications of Reducing Stocking Intensity to 2.1 LU/ha:

Relatively large reductions in recommended rates of fertilizer use.

Whole farm level Stocking rate	Recommendation for pasture under 3 years, no clover	Percentage changes due to reduction to 2.1LU/ha	
		Stocking rate	Fertilizer N
LU/ha.	Fertilizer N kg/ha	Percent change	Percent change
2.1	125	0%	0%
2.4	280	-13%	-55%
2.8	390	-25%	-68%

Source: data from Coulter, 2001

It follows that even for those farms applying no more than the recommended amounts of fertilizer, a reduction in stocking rate to 2LU/ha. will have a considerable impact on fertiliser use.

Indications of applications in excess of recommendations on the Lally and Riordan's case study farms are supported by the finding that these excesses were the norm on farms with stocking rates of 2.4LU/ha. and less (Coulter and others 2002). At 2.1 LU/ha., for example the average reported use of N fertilizer on grassland in 2000 was 182kg/ha while the recommendation was 100kg/ha.[21]

Thus while fertilizer use has declined in recent years there is still some way to go before all farmers are using no more than the rate recommended for their level of stocking. On top of this, a reduction in stocking rates that would be required should an action plan under the Nitrates Directive require a general reduction to 2LU/ha, would reduce use of nitrogenous fertilisers still further.

5.3. '*Good Farming Practice*' implications for fertiliser use

In addition to the possibilities of mandatory limits on stocking rates, considered above, the Nitrates Directive action programmes include rules relating to 'the limitation of the land application of fertilizers, consistent with good agricultural practice'[22]. This would seem to apply to all farms regardless of stocking rate and thus be a further depressant on fertiliser use as many of those with less that 2LU/ha are also applying more than N fertiliser than would be appropriate under the code of '*Good Farming Practice'*.

[21] Coulter and others 2002, P.22 Table 10 .

[22] Nitrates Directive AnnexIII,1.3.

6. Conclusions on the Nitrates Directive

Of the two key elements in the Nitrates Directive, the code of 'Good Farming Practice' has been introduced and the 'Action Programme' is about to be announced. Compliance with the code of Good Farming Practice is required of farmers in most of the schemes run by the Department of Agriculture Food and Rural Development (DAFRD). Most farmers are thus obliged to limit their applications of fertilisers to those appropriate for their intensity of production. The foregoing has shown that this will require a downward adjustment in usage relative to levels in the year 2000 and those currently in the FAPRI-Ireland Partnership's base line projections. Nitrogenous fertilizer usage would be likely to bear the largest reduction. If, in addition, stocking rates were to be generally limited to 2LU/ha., a further and considerable drop in usage of nitrogenous fertiliser and farm incomes would be indicated. In contrast, a 2.5LU/ha constraint would, of itself, seem to be unlikely to have a notable impact on fertiliser use.

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Annexes