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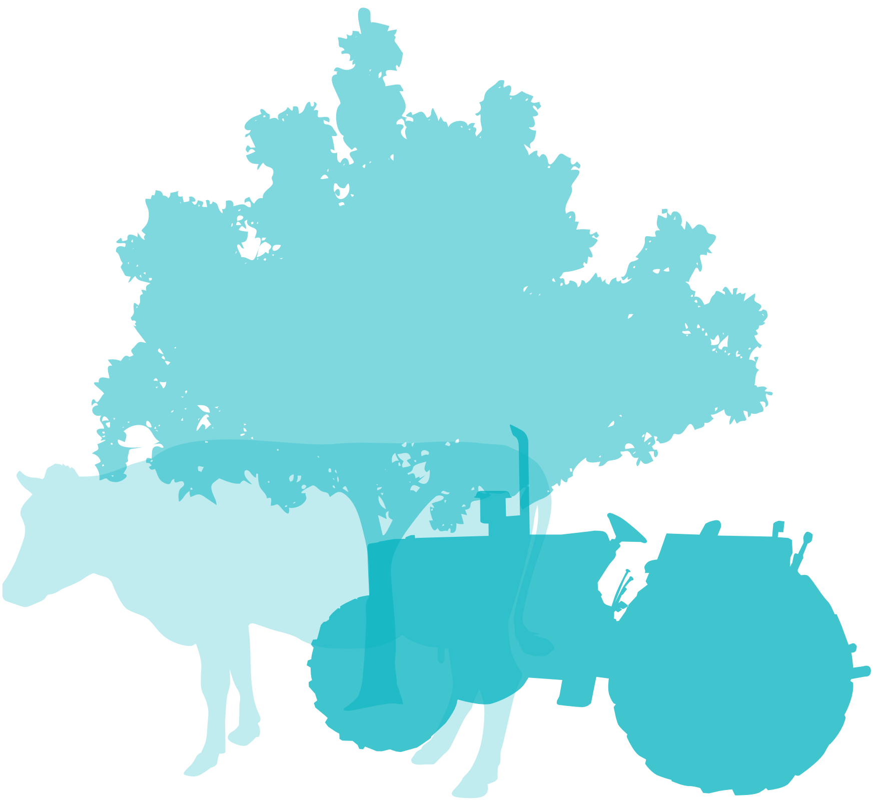
Uncertainty analysis of mineral excretion and manure production



Statistics Netherlands

Explanation of symbols

.	data not available
*****	provisional figure
******	revised provisional figure (but not definite)
x	publication prohibited (confidential figure)
–	nil
–	(between two figures) inclusive
0 (0.0)	less than half of unit concerned
empty cell	not applicable
2011–2012	2011 to 2012 inclusive
2011/2012	average for 2011 up to and including 2012
2011/’12	crop year, financial year, school year etc. beginning in 2011 and ending in 2012
2009/’10–2011/’12	crop year, financial year, etc. 2009/’10 to 2011/’12 inclusive

Due to rounding, some totals may not correspond with the sum of the separate figures.

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Summary

Background
Since the beginning of the nineties, standard factors for manure production and nutrient excretion per livestock category have been determined by the Working group on the Uniformisation of the calculation of Manure and minerals figures (WUM). The WUM consists of representatives of the Ministry of Economic affairs, Agriculture and Innovation, LEI Wageningen UR, Netherlands Environmental Assessment Agency (PBL), Livestock Research (Wageningen UR-LR), National Institute for Public Health and the Environment (RIVM) and Statistics Netherlands (CBS). The accounting methodology used by the working group is based on a nutrient balance per animal in which the excretion of nutrients is calculated from the difference between the intake of nutrients with the feed and the retention of nutrients in animal products. The results on manure production and mineral excretions are input to other calculations such as calculation of ammonia emissions and greenhouse gas emissions from agriculture. Data on ammonia emissions and greenhouse gas emissions are used by the Netherlands Pollutant Release and Transfer Register (PRTR) in international reports. Within the framework of these reports, assessment of uncertainties is necessary. The Netherlands Pollutant and Transfer Register therefore asked WUM to assess uncertainties in manure production and mineral excretions.

Results
The uncertainty in the total excretion of N and P_2O_5 is rounded up to 4 percent. There are large differences in uncertainty between livestock categories. The uncertainty in mineral excretion for dairy cattle is around 5 percent, but for horses, ponies and broilers it is more than 20 percent.
Eighty percent of the uncertainty in the total excretion of N and P_2O_5 is accounted for by dairy cows and fattening pigs. The contribution of dairy cows to total uncertainty is slightly larger than the contribution of this category to total mineral excretion. The uncertainty in excretion factors originates particularly from feed requirement and mineral contents in silage grass and compound feed.
For fattening pigs both the uncertainty in number of animals and the uncertainty in excretion factors play a role. Although the contribution to the total mineral excretion is about 15 percent, the contribution to overall uncertainty turns out to be much larger. Uncertainty in the excretion factors is caused mainly by uncertainty in feed intake (feed conversion) and feed composition. Uncertainty in the mineral content of animals hardly contributes to total uncertainty. This also applies to other pig categories.

The total uncertainty in the produced manure volume is approximately 6 percent. Dairy cows contribute over 80 percent. Just as in the case of manure production in most animal categories, the uncertainty in the manure volume of dairy cows is also based on a rough estimate.

Contents

1 Introduction

The Working group on the Uniformisation of the calculation of Manure and minerals figures (WUM) calculates annual nitrogen and phosphate excretion and manure production on farms. Mineral excretion and manure production of animals on hobby farms and at riding stables are not taken into account.
Calculation of mineral excretion is based on a balance per animal: intake of N and P with animal feed, minus retention in animal products (milk, meat, eggs) = excretion of N and P.
Manure production per animal is defined as the amount of manure (in kg) present in the stable storage, including feed waste, rinsing water and spilled drinking water. For cattle and sheep it also includes the amount of manure produced while grazing outside. Total minerals and manure production per animal category in a calendar year is calculated by multiplying minerals and manure production per animal by the number of animals in the annual agricultural census.

2 Methods

The uncertainty in mineral excretions and manure production in agriculture is composed of uncertainty in manure production and mineral excretion factors per animal category on the one hand, and uncertainty in animal numbers on the other. The IPCC guidelines (IPCC, 2000 and 2006) offer two methods for determining uncertainty:

1. Uncertainties in factors and activity data (animal numbers) are combined with formulas for propagation of errors.
2. Monte Carlo simulation. This method delivers an uncertainty in the form of a probability distribution with a mean, a standard deviation and a 95 percent confidence interval. When running a Monte Carlo simulation, the variation in parameters must be known in detail in the form of probability distributions. The simulation is then made up of an x number of model calculations using parameter values on the basis of the probability distributions of these parameters.

As the data needed for an uncertainty analysis using method 2 are not available, method 1 was chosen. The main principles of method 1 are (IPCC, 2006 p. 3.27):

1. Correlation between parameters should be avoided as much as possible by aggregation of data to a level where correlation is of less influence;
2. Preferably the standard deviation divided by the average should not exceed 0.3;
3. In a trend analysis, the uncertainty percentages in both excretion factors and animal numbers in the base year and in year t should be in the same order of magnitude.

To determine uncertainties for parameters that play a key role in the calculation of excretion factors, available data on variations in parameter values are used where possible. Examples include annual variations in feed composition and variations in the mineral content of animal products. In determining uncertainties in the manure production of indoor livestock (kg/animal) data from *Dienst Regelingen* (DR) on manure transports per farm are used where possible. For grazing animals, this approach is not possible because of the production of meadow manure. For uncertainties in animal numbers, studies are used in which registrations of animal numbers are based on other sources than the agricultural census.
Lastly, all available information on variation in parameter values is translated as realistically as possible into uncertainty rates. These rates are expressed as 'plus or minus x percent' where the percentage corresponds to half of the 95 percent confidence interval, i.e. 2 * standard deviation. For some parameters uncertainty is presumed to be asymmetrical. In these cases the highest difference in terms of percentage between the average and the confidence limit is taken.

3 Uncertainty in excretion factors

3.1 Parameters

Excretion factors are calculated on the basis of a mineral balance per animal: *intake* with feed minus *retention* in animal products gives *excretion*. The mineral intake with feed depends strongly on the volume of animal production in the form of meat, milk and eggs. For both intake and retention, the relevant parameters are identified and their uncertainty is assessed.

Uncertainty in feed intake can be divided into a number of parameters which in terms of relative size are linked to the animal category and the quality of the source data:

- Feed requirement/feed intake: feed intake may be calculated on the basis of fodder requirement standards e.g. for cattle and other grazing animals, or based on measured consumption e.g. for pigs and hens. Feed requirement/feed intake depends not only on the level of animal production such as milk and eggs, but also on rearing method (organic or traditional), which requires more or less maintenance feed.
- Diet composition: the diet may consist of several components (roughage, compound feed, wet products, raw materials).
- N and P content of the various diet components.

For retention of N and P in animal products, uncertainty is calculated using the following elements:

- N and P content of animal products.
- Volume of animal production (milk production, start and end weights of beef cattle, egg production, breeding cycle length).

The uncertainty in feed intake caused by uncertainty in cattle energy requirements or in the energy valuation of feed is presumed to be independent of the N and P content of animal feed. The uncertainties in N and P content of animal products are also presumed to be independent of uncertainties in the other parameters. Because of the correlation between feed intake and retention in animal products, no individual uncertainties are identified for these two parameters. In the calculation model, an adjustment in the level of milk production, for example, automatically leads to an adjustment in feed intake.

With respect to the uncertainty in cattle energy requirements (expressed as VEM requirements) because of uncertainty in the VEM system, the level of animal production is not adjusted. Here the uncertainty lies in the energy requirements of animals or in the VEM valuation of feed, which means that feed intake at a certain level of animal production is under or overestimated (Bannink, 2010).

For each uncertainty in the parameters, excretion factors are re-calculated and expressed as a deviation (as a percentage) from the original excretion factors (reference value).
Ultimately, the total uncertainty factor in the excretion factor per animal category is computed with the formula for the propagation of errors.

$$U_{total} = \sqrt{(U_1^2 + U_2^2 + \ldots U_n^2)}$$

where

U_{total}: uncertainty in terms of percentage calculated from the sum of the individual uncertainties, where the uncertainties are defined as half of the 95 percent confidence interval, i.e. 2 * standard deviation.
U_i: uncertainty in terms of percentage (2 * standard deviation) of the individual parameters.

3.1.1 Uncertainty in parameters for grazing animals

	Cattle total	Dairy cow	Female young stock		Male young stock	Breeding bull	Fattening calve		Beef bull		Suckler cow	Sheep	Goat	Horse and pony
			<1 year	≥1 year	<1 year	≥1 year	white-meat	pink-meat	<1 year	≥1 year				
	%													
VEM-requirement/feed intake		2	2	2	2	2	5	5	10	10	2	10	10	20
Available roughage and compound feed														
silage grass	10													
silage maize	5													
compound feed	10													
Feed composition														
N and P content of silage grass		5	5	5	5	5					5	5	5	
N and P content of silage maize		5	5	5	5		5	5	5	5			5	
N and P content of fresh grass		5	5	5	5						5	5		10
N and P content of compound feed		5	5	5	5	5	5	5	5	5	5	5	5	10
N and P content hay/straw for horses														10
Retention														
milk production		2									20		10	
N and P content of meat		10	10	10	10	10	10	10	10	10	10	10	10	10
N content of milk		2									5		5	
P content of milk		5									5		5	

Explanation of these figures: see section 3.2.

3.1.2 Uncertainty in parameters for indoor livestock

	Fattening pig	Sow	Breeding sow	Breeding boar	Parent animal broiler		Laying hen		Broiler	Duck	Turkey	Rabbit	Mink
					<18 wk	≥18 wk	<18 wk	≥18 wk					
	%												
Feed intake/retention (feed conversion)	5	5	5	5	5	5	5	5	5	5	5	5	10
N and P content of diet	3	5	5	5	2	2	2	2	7	3	4	2	2
Retention (N and P content of animal products)													
N and P content of meat	5	5	5	5	10	10	10	10	10	10	10	10	10
N and P content of eggs						5		5					

Explanation of these figures: see section 3.3.

The assumption here is that the effects of the uncertainties in the individual parameters on the excretion factors are not correlated and are to be understood as additive. This assumption is the basis for the parameter choice for grazing animals in 3.1.1 and for indoor livestock in 3.1.2.
The uncertainty rates are explained in sections 3.2 and 3.3.

3.2 Grazing animals

VEM-requirement/feed intake

For dairy cows, the uncertainty in VEM intake at a certain milk production is estimated at 2 percent (Bannink, 2010). Bannink (2010) bases this uncertainty on research which showed that the VEM system somewhat underestimates the VEM requirement of the present-day dairy cow. The uncertainty in the VEM requirement of young cattle and suckler cows because of the inaccuracy of the VEM system is assumed to be of the same order of magnitude. In the calculation of the excretion factors for young female cattle for meat production the WUM uses the same principles as for young cattle for milk production. The uncertainty in feed intake of female cattle younger than 2 years is therefore somewhat larger. However, because this category is smaller than that of young cattle for milk production, no separate uncertainty estimate has been carried out. The uncertainty in the VEM requirement is thus applied to the entire dairy livestock including young female cattle for meat production.
In addition to uncertainty in feed intake of dairy cattle because of the inaccuracy of the VEM system, there is also uncertainty in feed intake because of the uncertainty in the level of animal production. See also 'Retention of N and P in animal products' in this chapter.
In assessing the uncertainty in feed intake of veal calves, bulls, sheep, goats, horses and ponies, the relationship between feed intake and retention was taken into account, by aggregating both parameters to the parameter 'feed conversion', i.e. the ratio between feed consumption in kg and animal production in kg. The uncertainty in feed conversion is translated into x percent more/less feed intake at the same level of animal production.
The technical indicators for veal calves are regularly adjusted as a result of new insights. White-veal calves and rose-veal calves are fairly homogeneous groups with fattening periods of 6 and 8 months respectively. The uncertainty in feed conversion is set at 5 percent.
For fattening bulls there are large differences between individual farms. Farms can fatten cross-bred bulls but also pure beef breeds. In recent years there has been a trend towards pure beef breeds. In addition, there seems to be a longer fattening period after which animals are delivered at a higher weight. The WUM methodology is still largely based on the indicators in WUM (2010, section 3.4.4), except for the ratio of pure beef breeds and cross-bred bulls. The uncertainty in feed conversion is set at 10 percent.
Large differences between individual farms are also found for sheep and goats. The differences may be related to differences in animal breeds or in operational management. For these categories, too, a 10 percent uncertainty in feed conversion seems reasonable.

For horses and ponies there is a large variety of farming systems. In the study of Kemme et al. (2005) for the derivation of excretion forfeits, horses and ponies are classified in a number of weight classes. Based on the indicators in Kemme et al. and information from the *Sector Raad Paarden* (LTO) about the distribution of horses and ponies in the weight classes, the WUM derives excretion factors for horses and ponies. The uncertainty in feed intake therefore depends largely on the reliability of the distribution of the animals across the different weight classes. Not much can be said about the uncertainty in feed intake except that it is probably larger than for the other categories of grazing livestock. The uncertainty in feed conversion (feed intake) is set at 20 percent. With this uncertainty percentage and an average excretion of 58.5 kg N per year per horse, the confidence interval for N excretion is 46-70 kg N per animal. This is well within the limits of 35-90 kg N/year that is taken as an average N excretion for horses (Kemme et al., 2005).

Except for dairy cows, all grazing animals have fixed diets. For all animal categories, with the exception of dairy cows, a higher or lower feed intake is proportionally divided between compound feed and roughage. For dairy cows the consumption of roughage and compound feed depends on the feed consumption of other grazing animals. When the diet of a certain grazing animal category is adjusted, this thus also affects the available amount of compound feed and roughage for dairy cows (2010, WUM section 3.4.1). The change in the excretion factors of dairy cows as a result of uncertainty in the diet of other grazing animals is, however, very limited and not taken into account in the uncertainty analysis.

Available roughage and compound feed

The total amount of available roughage is based on Statistics Netherlands surveys of grassland use (grass silage and hay) and data from the LEI (silage maize yield). The available compound feed is based on data on the production of compound feed according to manufacturers' estimates and corrected for imports and exports. Consumption of wet products and single dry compound feed is added to this. In the model, total feed consumption of cattle, sheep and goats is determined by the feed requirements of these animals. However, the shares in total feed consumption may vary due to uncertainties about the availability of that feed. Change in the availability of grass silage, silage maize or compound feed will automatically lead to a change in meadow grass intake. Because of the low N and P content of silage maize the amount of available silage maize thus has a strong influence on the total excretion of N and P of grazing animals. Uncertainty about the share of grass silage has a small effect on excretion. Although the N and P contents of fresh grass are higher than those of grass silage, the VEM value of fresh grass is also higher, so a smaller intake will meet the animal's feed requirement.

No major fluctuations have been observed in the total production of compound feed for cattle in recent years. It is unlikely that the uncertainty in the production of compound feed exceeds 5 percent. What does contribute to the uncertainty of domestic compound feed consumption is the lack of reliable data on imports and exports. The uncertainty in the consumption of compound feed is therefore set at 10 percent. The consumption of grass silage and hay is based on Statistics Netherlands' survey of grassland use. Maize consumption is calculated from the yield per hectare of farms in the Business Information Network (BIN) of the LEI and the maize area in the agricultural census. For both grass silage and maize a correction is made where necessary for co-fermentation.
The largest uncertainty in the available amount of silage maize lies in the calculation of yields per hectare. For grassland and maize areas according to the agricultural census uncertainty is not expected to exceed 1 to 2 percent. In a study by RIVM and LEI of agricultural practices on farms signed up for derogation, the maize yield on 142 farms amounted to an average of 16 tonnes dm/ha in 2009, ranging from 14.8 tonnes of dm/ha on peat soils to 16.4 tonnes on clay and loess soils (Zwart et al., 2011). There was a difference of more than 2 percent between the average yield per hectare in 2009 according to the BIN, and according to Statistics Netherlands crop estimates. However, for the northwest the difference is approximately 6 percent and for the southeast 1 percent. The uncertainty in the available amount of silage maize is set at 5 percent, equal to the value in Bannink (2010, section 3.2.2). An uncertainty of 5 percent at an average yield of 16 tonnes dm/ha represents a confidence interval of 15.2 to 16.8 tonnes/ha. This already seems quite large for a national average.
For grass silage the uncertainty in availability is greater because the yield is greatly determined by grassland management (mowing/grazing). The variation in management systems on farms can be very

large. Therefore, a 10 percent uncertainty is assumed (Bannink, 2010 section 3.2.2). The total gross grassland production is calculated annually by the WUM at 10 to 11 tonnes dm/ha. Zwart et al. estimate gross production in 2009 at 9.7 tons dm/ha. However, the WUM takes slightly higher conservation and grazing losses into account than Zwart et al.

Feed composition

For all roughage with the exception of fresh grass for horses, an uncertainty of 5 percent is taken for N and P content. This percentage gives a margin of N and P content equivalent to the average content of recent years. Average levels are provided by AgroXpertus BLGG. If farms with deviating management systems are over-represented in the analyses, the average may differ systematically. However, no information is available in this respect. On the basis of variations in recent years, there is no reason to use different uncertainties for N and P. Although grazing periods and thus uncertainties in fresh grass composition are more difficult to assess, for fresh grass, too, uncertainty is set at 5 percent. Analyses results for the last five years show that N and P content in two consecutive years never differ by more than 5 percent. Nutrient content of meadow grass for horses is not taken from annual analyses, but based on an average value for state horse grazing. Uncertainty is set at 10 percent. This value is also used for hay and straw.

Since 2006, deliveries by feed suppliers of compound feed for grazing livestock (cattle, sheep and goats) have no longer been registered by *Dienst Regelingen*. Since then, therefore, N and P content is established using an alternative method (WUM, 2010 section 3.2.2). With an average N content in low-protein feed of 25 g N/kg and an uncertainty of 5 percent, this puts the N content at between 23.8 and 26.3 g N/kg. An average P content of 5.0 g P/kg represents a margin of 4.75 to 5.25 g P/kg. A higher degree of uncertainty seems unlikely. For compound feed for horses, uncertainty in nutrient content is greater because of the large differences in farming systems within the sector. The composition is not adjusted annually because recent information is lacking. The uncertainty is set at 10 percent.

Retention of N and P in animal products

Volume of animal production
The volume of the animal production can change, for example as a result of a higher milk yields or higher slaughter weights. Changes in livestock production are accompanied by changes in feed requirements. Therefore, for all categories of grazing livestock, except dairy and suckler cows, the uncertainty in feed intake and retention is converted into uncertainty in feed conversion (see preceding text under 'VEM-requirement/feed intake'). For dairy and suckler cows, up to now only uncertainty in feed intake caused by uncertainty in the VEM system has been taken into account. Uncertainties in retention are not included for each age category of dairy cattle (0–1 year, 1–2 years) because of the relationship between starting and final weights of the various age categories. Therefore, only the difference in excretion at an uncertainty of 5 percent in the final weight of dairy cows is considered. Several studies on average minerals excretion of dairy cows have not given cause to revise the final weight of 600 kg. This means that with an uncertainty of 5 percent, the average final weight of, for example, a dairy cow is in the range of 570 to 630 kg. The effect on excretion appears negligible.

For dairy cows the replacement of animals is based on a database of CRV Delta and on slaughter data. The uncertainty of these sources is estimated to be no more than 5 percent. For suckler cows the age of replacement and thus the share of replacement is not exactly known. For dairy cows and suckler cows the effect on excretion is very small, even if for suckler cows the uncertainty in replacement is set at 25 percent. Uncertainty in the slaughter age of dairy cows and suckler cows is therefore further left out of account.

Milk production by dairy cows is known quite accurately from the Commodity Board for Dairy Products. Total milk production consists of the delivery to factories and an estimate for milk processing on the farm. The amount of milk kept at farms is calculated at about 4 percent per year. At the moment the figures on milk production are used by the WUM, they are not yet definite. The production figures are sometimes corrected later by the Commodity Board, but this correction does not exceed 1 percent. In the analysis the total uncertainty in milk production is set at 2 percent. In the model the uncertainty in milk production is converted into a higher feed requirement.

The milk production of suckler cows is 1,700 kg/year, and is based on an estimate of milk production of cows reared extensively (Heeres, 2002). The milk production of intensively reared cows was estimated at 2,000 kg/year. Heeres' study presents productions ranging from 1,500 to 2,000 kg per year. More recent estimates are not available. The exact ratio of intensively to extensively reared animals is not known, but it is certain that the majority of suckler cows are reared extensively. The uncertainty in milk production is set at 20 percent.

The technical indicators for dairy goats have recently been adjusted (Evers et al., 2011). Average milk production is set at 900 kg milk per goat per year. Although Evers et al. conclude that the milk production per milk goat has increased from 800 to 900 kg per year, they also indicate that because of measures to combat Q fever, there are no recent figures from agricultural practice to substantiate estimates. The uncertainty in the level of milk production is estimated at 10 percent. Goat feed requirement in the model is fixed at a given (fixed) milk production. To evaluate the effect of a higher/lower milk production, the feed requirement should therefore also be adjusted. Based on principles in the Handbook *Quantitative Information on Animal Husbandry* (KWIN-V) the difference in consumption of compound feed is estimated at the established uncertainty in milk production. This shows that at a fixed roughage consumption, the change in consumption of compound feed is proportional to the change in milk production. This is used to calculate uncertainty in the excretion factor.

N and P content of animal products
Since the start of the WUM calculations in 1990, no new information has become available on N and P content in meat of grazing livestock. The total variation in N content of cattle categories is 6 g N/kg (22.5–28.5). This corresponds to an uncertainty of about +/-10 percent. For P, the situation is similar. It is assumed that the uncertainty in the nutrient content per animal category is not greater than the variation in content among all cattle categories.

The N content of cow's milk is determined annually based on measurements of protein content in milk supplies to milk factories. The P content is a fixed indicator. Uncertainty is set at 2 percent (N content) and 5 percent (P content). The composition of milk supplied to milk factories is also used in the calculations for milk of suckler cows. The uncertainty in N and P content of suckler cow milk is estimated at 5 percent. The composition of goat's milk is not adjusted annually. Here, too, uncertainty is set at 5 percent for both nutrients.

3.3 Indoor livestock

Feed intake/animal production

For indoor livestock, the uncertainty in feed intake and animal production is translated into uncertainty in feed conversion. The uncertainty in feed conversion is calculated as more or less feed intake at a constant volume of animal production.

Feed intake and retention of fattening pigs and sows are based on figures from Agrovision. This database includes data from several hundred farms. The uncertainty originates mainly from the representativeness of the participating farms. Jongbloed and Kemme (2005) studied the variation in feed conversion of fattening pigs in the 2002 Agrovision database. About half of the farms reported feed conversions of approximately 8 percent lower or higher than average. Although this dispersion says nothing about the uncertainty of the mean, an uncertainty in the average feed conversion of 5 percent is assumed. This percentage is also used for the other categories of pigs.
Jongbloed and Kemme (2005, section 3.4.3) noted a difference in technical results on farms with laying hens in battery cages and therefore calculated the effect on the excretion of a change in feed conversion of +/–5 percent. For feed intake it is also relevant whether the hens are kept in battery cages or in free-range areas. The WUM therefore bases the distribution of animals across housing systems on information from the agricultural census. In the uncertainty analysis, a total uncertainty of 5 percent in feed intake of hens is assumed.
For broilers, Jongbloed and Kemme (2005) also determined the effect of a change of 5 percent in feed conversion on excretion. For the other categories of indoor livestock, except mink, an uncertainty of the same order of magnitude was used. Indoor livestock, except mink, are kept in a controlled manner and there is a uniform feed regime among the various animal categories. The uncertainty in feed conversion of mink is estimated at 10 percent.

Feed composition

The feed composition of indoor livestock is largely (over 90 percent) based on registered compound feed supplies to farmers (*Dienst Regelingen*). As registered compound feed supplies are classified into animal categories at a higher level of aggregation than the classification of the agricultural census, several actions are necessary to determine the average composition of compound feed per animal category. First, the supplies register is checked for outliers. Supplies that are definitely not compound feed because they have very high or very low nutrient content are excluded. This operation is necessary because sometimes supplies of wet feed or raw compound feed materials are registered as compound feed. Next, compound feed supplies per farm are linked to the agricultural census. By linking compound feed supplies to the animal categories, the average composition of compound feed per animal category

3.3.1 Uncertainty in average N and P content of compound feed

Livestock category	N content	P content
	%	
Fattening pigs	0.3	0.4
Breeding pigs	4.0	4.3
Sows including piglets	1.7	1.8
Boars	3.3	5.4
Broilers	0.8	0.8
Parent animals of growing broilers	2.3	1.9
Parent animals of broilers	0.6	1.3
Breeding hens	1.0	1.4
Laying hens	0.4	0.7
Turkeys	3.4	3.5
Ducks	1.4	3.0
Rabbits	2.1	2.2
Mink	1.5	1.6

can be calculated. This procedure works well for poultry categories, because poultry farms often farm only one poultry category. For breeding pigs it works least well, because there are almost no farms with only one animal category. The uncertainties in the average N and P content of mixed feed supplies in 3.3.1 are calculated by halving the 95 percent confidence interval for the mean and dividing the result by the mean.

Uncertainty in diet composition is not only determined by the composition of compound feed but also by the share of single dry and wet feedstuff. These feedstuffs might be supplied to the farm but some farms provide part of the diet themselves, for example on combined arable/cattle farms.

For fattening pigs the uncertainty in compound feed is small. For example, the P content amounts to 4.6 to 4.7 g/kg annually, usual values for feed for these pigs. The uncertainty is increased by allocating single dry and wet feed. Wet feed for pigs is allocated to fattening pigs (90 percent) and sows (10 percent). N and P content is not known for some wet feed, for example because the *Centraal Veevoeder Bureau* reports several compositions for the same feed, or reports no composition at all. Wet feed accounts for about 10 percent of the diet based on dry matter. Total uncertainty in N and P content of feed for fattening pigs is set at 3 percent. For pigs for breeding, sows with piglets up to 25 kg, and serving boars the uncertainty is set at 5 percent.

As stated before, the derivation of average N and P content in compound feed is most accurate for chickens. With the exception of broilers, the supply of single dry feed plays no major role here. On the basis of variations in 3.3.1, the uncertainty in the average composition is set at 2 percent. However, from information in the BIN it is estimated that 20 to 30 percent of the diet of broilers consists of simple wheat. With such variation in the share of simple wheat, the uncertainty in the average N and P content of broiler feed is about 5 percent. The total uncertainty is set at 7 percent.

For ducks, turkeys, rabbits and mink the mixed feed category equals the animal category in the agricultural census. The average feed composition for these animal categories can therefore directly be calculated from the mixed feed supplies. For turkeys the uncertainty is set at 4 percent, for ducks at 3 percent and for rabbits and mink at 2 percent.

Retention of N and P in animal products

Unlike for grazing animals the N and P content of indoor livestock have regularly been adjusted on the basis of literature studies. In Jongbloed and Kemme (2005) the N and P contents of pigs in two studies are compared with each other. The average N and P content of fattening pigs appears to differ by a few percent. For sows and serving boars the N and P content is based on dated studies. On the basis of a recent literature study (Jongbloed, 2010) the standard P content of sows has been adapted. Jongbloed (2010) concludes that it is not correct to use the same P retention standards for sows as for fattening pigs. The study resulted in an increase of the P content of sows by about 8 percent. At the same time Jongbloed concludes that additional research is needed to determine up-to-date and correct mineral levels in sows. The uncertainty is set at 5 percent for all categories of pigs.

Jongbloed and Kemme (2005, section 3.9.1) conclude that the N and P content of poultry is dated or based on insufficient data. The uncertainty for all categories of poultry and for rabbits and mink is set at 10 percent.

The N and P content of eggs has been updated several times in the past. An uncertainty of 5 percent is used.

3.4 Results for uncertainty in excretion factors

For each of the above-listed parameters with associated uncertainty of plus and minus twice the standard deviation (3.1.1 and 3.1.2), the excretion factors are recalculated using the calculation model (WUM). This gives 95 percent confidence intervals for the excretion of N and P for a certain uncertainty parameter. These confidence intervals are converted into uncertainty percentages by halving them and then dividing the results by the average excretion factor (reference value). Lastly, total uncertainty in the excretion factors is calculated with the formula in section 3.1. The result is shown in the right-hand column of 3.4.1.

The total uncertainty in the propagation of errors is strongly determined by the uncertainty which leads to the greatest relative change in the excretion factor.

3.4.1 Uncertainty in excretion factors per livestock category and per parameter

Livestock category	Nutrient	Excretion factor (reference)	Uncertainty in excretion factor as a result of uncertainty in parameter													
			feed intake				feed composition					retention				total uncertainty of excretion factor
			total intake	share in diet: silage grass	share in diet: silage maize	share in diet: compound feed	silage grass	silage maize	fresh grass	compound feed	hay/straw	content of meat	milk production	content of milk	content of eggs	
		kg/animal	*% uncertainty in excretion factor*													
Cattle																
Dairy cows	N	130.2	3.6	0.3	1.8	0.2	2.3	0.9	1.0	2.7		0.1	1.5	0.2		5.8
	P	43.0	3.1	0.1	1.6	1.5	2.4	1.0	1.2	3.5		0.2	1.2	2.1		6.4
Female young stock <1 year	N	36.0	2.6				3.2	0.3	1.1	1.5		1.8				4.9
	P	10.1	3.0				4.0	0.5	1.0	3.0		4.5				7.4
Female young stock 1 year and over	N	73.2	2.3				2.9	0.1	1.6	0.1		0.7				4.1
	P	22.1	2.0				3.2	0.2	1.6	0.2		1.8				4.5
Male young stock <1 year	N	33.2	3.5				2.3	1.1	1.7	1.4		2.7				5.5
	P	8.6	3.5				3.5	1.2	1.7	2.3		7.0				9.1
Male young stock 1 year and over	N	83.4	2.3				4.7			0.5		0.5				5.3
	P	26.1	2.3				5.0			0.8		1.1				5.7
Fattening calves, in white meat production	N	12.4	9.3					1.2		7.7		8.5				14.8
	P	4.8	9.4					1.0		8.3		9.4				15.7
Fattening calves, in pink meat production	N	28.2	6.7					1.1		5.3		3.9				9.5
	P	8.8	8.5					1.7		6.3		7.4				13.0
Beef bulls <1 year	N	26.8	9.0					2.6		4.7		4.3				11.3
	P	8.3	10.8					3.6		6.6		8.4				15.7
Beef bulls 1 year and over	N	53.8	7.5					2.0		3.9		2.0				8.9
	P	19.1	8.4					2.1		5.0		3.7				10.6
Suckler cows	N	83.3	2.2				2.4		2.2	0.1		0.2	3.5	0.5		5.3
	P	27.1	2.4				2.8		2.2	0.2		0.4	3.1	0.7		5.4

3.4.1 Uncertainty in excretion factors per livestock category and per parameter (end)

Livestock category	Nutrient	Excretion factor (reference)	Uncertainty in excretion factor as a result of uncertainty in parameter													
			feed intake				feed composition					retention				total uncertainty of excretion factor
			total intake	share in diet			silage grass	silage maize	fresh grass	compound feed	hay/straw	content of meat	milk production	content of milk	content of eggs	
				silage grass	silage maize	compound feed										
		kg/animal	*% uncertainty in excretion factor*													
Sheep	N	14.1	3.2				0.4		5.0	0.7		0.7				6.0
	P	4.6	2.2				1.1		4.3	0.0		0.0				5.0
Dairy goats	N	17.5	13.1				1.7	1.1		3.4		0.3	4.6	1.1		14.5
	P	6.9	14.5				1.4	1.4		4.3		0.0	5.8	1.4		16.4
Horses	N	58.5	20.4						5.2	1.5	3.0	0.3				21.4
	P	22.6	20.8						4.4	2.4	3.1	0.0				21.6
Ponies	N	32.1	20.2						6.5	0.8	2.3	0.0				21.4
	P	11.8	20.3						5.5	2.1	3.0	0.0				21.4
Pigs																
Fattening pigs	N	12.2	8.2							4.5		3.3				9.9
	P	4.9	8.2							4.1		4.1				10.0
Sows	N	30.2	7.9							7.6		3.0				11.4
	P	15.1	7.9							7.3		3.0				11.2
Breeding pigs	N	15.4	6.8							6.8		1.9				9.8
	P	6.7	7.5							6.7		2.2				10.3
Boars	N	23.3	5.6							5.6		0.6				7.9
	P	12.3	5.7							6.1		0.4				8.4
Poultry																
Parent animals of broilers, under 18 weeks	N	0.35	8.6							2.9		5.7				10.7
	P	0.21	7.1							2.4		2.4				7.9
Parent animals of broilers, 18 weeks and over	N	1.11	6.3							2.3		0.5			0.9	6.8
	P	0.56	5.4							1.8		0.0			0.0	5.6
Laying hens, under 18 weeks	N	0.34	7.4							2.9		7.4				10.8
	P	0.17	8.8							2.9		2.9				9.8
Laying hens, 18 weeks and over	N	0.80	7.5							2.5		0.0			2.5	8.3
	P	0.41	4.9							2.4		0.0			0.0	5.5
Broilers	N	0.50	11.0							15.0		11.0				21.6
	P	0.17	11.8							11.8		11.8				20.4
Ducks	N	0.79	9.5							5.7		9.5				14.6
	P	0.38	7.9							3.9		7.9				11.8
Turkeys	N	1.91	8.6							6.8		7.1				13.1
	P	0.94	7.4							6.4		5.3				11.2
Rabbits	N	7.7	7.1							3.2		5.2				9.4
	P	3.6	8.3							2.8		5.6				10.4
Mink	N	2.2	11.4							2.3		2.3				11.8
	P	1.2	8.3							4.2		0.0				9.3

Explanation of these figures: see text

4 Uncertainty in manure production factors

4.1 Introduction

Manure production factors represent manure production (manure volume) in kg per animal per year. The manure production per animal is defined as the amount of manure (in kg) present in the stable storage, including feed waste, cleaning water and spilled drinking water. For cattle and sheep the amount of manure excreted in the meadow has to be added to this. All meadow manure is counted as slurry. Manure production factors are occasionally adjusted when new information becomes available.
For the calculation of the manure volume of cattle, except that of suckler and grazing cows, production of slurry is assumed.

4.2 Manure volume of grazing livestock

Cattle (including veal calves)

The manure production factors for cattle have been brought into line with the results of the *BedrijfsBegrotings-Programma Rundveehouderij* (BBPR) of Wageningen UR Livestock Research. For dairy cows and young stock use is made of underlying data on urinary and faeces production in stable and grazing periods. The manure production of dairy cows in the pasture period is divided between stable and meadow according to the grazing system. The BBPR assumes a fixed milk production per cow and two types of stable diets: one of 100 percent grass silage and one of 50 percent maize silage and 50 percent grass silage. The WUM calculated the manure production per region by correcting for the actual ratio of silage grass/silage maize in the diet and by correcting for the actual level of milk production.
The average annual manure production of dairy cows does not differ significantly from the amount applied from 2004 onwards by the WUM (WUM, 2010 section 6.2.1). Only the manure production of young stock of 1 year and older increased, from 11,500 to 12,000 kg/year based on BBPR data in 2009. So despite the use of BBPR data, the manure production per animal has virtually remained unchanged. According to De Boer (2012) the source data (BBPR) of Livestock Research contain so many assumptions in parameters and indicators which affect the manure production that no well-founded uncertainty margin can be derived. The uncertainty is estimated to be 10 percent at the most.
For young female cattle for meat production the same manure production factors are used as for young dairy cattle. The uncertainty in manure production factors for these categories is therefore set slightly higher, at 15 percent. The uncertainty in the manure production of meat bulls is increased by the delivery of heavier animals; it is set at 20 percent.

The manure production factors for suckler cows and grazing cows are based on estimates for solid manure of suckler cows dating from 1994 (WUM, 2010 section 6.2.2). The uncertainty is set at 25 percent

For veal calves, the effect of changes in diet on the manure production are taken into account. Data from *Dienst Regelingen* (DR) are used to calculate manure production factors in 2010. (see section 4.3). For white veal calves, roughage has replaced milk substitutes for some time now. Therefore the manure production factor has been reduced step by step from 3,500 to 2,800 kg. Based on data from over 200 farms, the average manure production per animal in the period 2008–2010 amounted to approximately 2,600 kg. This figure does not include the effect of vacancy as a result of which fewer animals are present on average. The indicators in KWIN suggest that vacancy is 14 days per production cycle (approx. 7 percent). Adjusted for vacancy, manure production appears to be about 2,800 kg, which is equal to the current manure production factor. The uncertainty therefore seems relatively small and is set at 5 percent.
Average manure production of rose veal calves in 2008–2010 varies from 3,500 to 4,500 kg/animal per year (excl. vacancy). The data are based on approximately 25 farms. According to KWIN vacancy is about 14 days (just over 5 percent). Adjusted for vacancy, the average manure production is 4,200 kg/animal. In view of the large range in the annual results, and the small number of farms whose data are available, the manure production of 4,500 kg is not adjusted. The uncertainty is set at 10 percent.

Other grazing livestock

The manure production of sheep and goats is based on historical research data of the manure production of sheep (WUM, 2010 section 6.2.3). The uncertainty in manure production is arbitrarily set at 25 percent.

The manure production of horses and ponies is based on the fixed production factors in manure policy and on additional information from the Dutch advisory group on horses on the distribution of the animals by different weight classes (WUM, 2010 section 6.2.4). The difference in manure production between the two weight classes for ponies is 10.4–18.0 kg/day. For horses the difference in manure production is 22.2–28.8 kg/day.
The weight distributions from the Dutch advisory group on horses are used to calculate average manure production during stabling, including straw, per horse and per pony. In addition, information is received on the distribution of the number of horses and ponies by weight class among the various farming systems. The uncertainty in manure production factors depends largely on the assumed distribution of the number of animals by weight class. Additional urine production during grazing is not taken into account, because there are no data on this. Given the wide variation in horse and pony farming systems, the uncertainty of the manure production factor is set at 25 percent.

4.3 Manure volume of indoor livestock

Introduction

Manure production factors for indoor livestock are partly based on historical research data (WUM, 2010 section 6.3 and 6.4). To calculate manure production factors for 2010 an assessment has been made using data from *Dienst Regelingen* (DR) of the Ministry of Economic Affairs, Agriculture and Innovation. To calculate average manure production per animal, data are used from farms that have to remove basically all produced manure, so that the amount of transported manure equals the amount produced. Farms that meet this criterion are assumed to have a maximum of 3 ha of UAA, and the stocking density is greater than 15 livestock units per hectare. Furthermore, there must be a unique link between type of manure (manure code) and livestock category according to the classification of the agricultural census. To restrict the effects of annual fluctuations in manure transport, data for a continuous period (2008-2010) are used.

Pigs

On the basis of data from over 500 farms, average manure production per fattening pig in the period 2008–2010 is estimated at 1,000 kg/animal. The annual average varies between 985–1,020 kg/animal. Vacancy is estimated to be 7 days per production cycle (approx. 6 percent). Adjusted for vacancy, manure production amounts to approximately 1,060 kg/animal. The manure production factor in 2010 is rounded to 1,100 kg/animal. The uncertainty is set at 10 percent.

Manure production per sow including piglets up to 25 kg is difficult to assess because of the small number of about 20 farms reporting. Average manure production of these farms for the last three years is over 4,000 kg. This differs significantly from the current factor of 5,100 kg. The current production factor has not yet been adjusted, but there is a strong suspicion that manure production is overrated. The uncertainty is set at 20 percent.

No information is available on sows and bears for breeding at farm level. Just as for sows the uncertainty is estimated at 20 percent.

Poultry

Breeding hens
Average manure production per breeding hen counted on approximately 40 farms for agricultural census in 2008-2010 is 7.8 kg/bird after adjustment for vacancy. Some farms also indicated the average number of birds actually present. The manure production per bird present was on average 7.9 kg. The difference with the current manure production factor (7.6 kg/animal) is small. The uncertainty is set at 10 percent.

Laying hens
Based on the number of birds in the agricultural census the average manure production per laying hen in 2008–2010, adjusted for vacancy, is 18.3 kg. This figure is based on the data from some 200 farms. For about 50 farms the average number of birds present is also known. At these farms the manure production is 17.7 kg per bird. This figure is also below the current production factor of 18.9 kg/bird. A lower manure production per bird may be the result of increased manure incineration which makes it favourable to supply manure with high dry matter content. The uncertainty is set at 10 percent.

Broilers, breeding parents under 18 weeks
The average manure production per bird (agricultural census) on approximately 25 farms in 2008–2010, adjusted for vacancy, is 9.5 kg. The current indicator (8.2 kg/bird) seems to be rather low. The uncertainty is set at 15 percent.

Broilers, breeding parents, 18 weeks or older
The average manure production per bird (agricultural census) on some 80 farms in 2008–2010, adjusted for vacancy, is 21.1 kg/bird. The manure production per bird present is 21.6 kg on average. The current production factor is 20.6 kg. The uncertainty is set at 10 percent.

Broilers
The manure production at more than 100 farms, adjusted for vacancy, is on average 12.4 kg per animal counted in the agricultural census. Some 20 farms reported the average number of birds present. The manure production at these farms averaged 12.7 kg/bird. The current production factor (10.9 kg/bird) is well below this, but corresponds to values found in previous studies based on *Minas* reports. There is no explanation for the difference in outcomes. The uncertainty is set at 15 percent.

Turkeys
The average manure production factor of 52 kg per animal counted in the agricultural census in 2008–2010 (15 farms) is well above the current manure production factor of 45 kg/bird. The average number of birds present in this period is also known for a few farms. The manure production at these farms amounts to as much as 55 kg/bird. The uncertainty is set at 20 percent.

Ducks
The number of farms with available data is very small. The average manure production per bird counted in the agricultural census is 44 kg. Corrected for 20 percent vacancy this is 55 kg/bird. This is well below the current figure of 70 kg/bird. The uncertainty is set at 25 percent.

Rabbits: does
The average manure production per animal counted in the agricultural census is 397 kg. This figure is based on data from more than 25 farms. Almost the same number of farms know how many animals they have on average. The manure production per animal present is 322 kg on average. The current value (377 kg/animal) is between these two values. The uncertainty is set at 20 percent.

Mink: mother animals
The average manure production per mink mother increased from 104 kg to 155 kg/animal in 2010. The new production factor is based on the data from approximately 60 farms. The higher manure production is explained by changes in the manure drainage systems. In the traditional systems the manure fell on the soil, where the aqueous fraction drained or evaporated. The manure was disposed of as solid manure. Now the manure falls on manure belts or into drain pipes. Most of the manure is disposed of as slurry and part of it as solid manure (straw manure) from night quarters/nests. The variation between farms can be large due to rain water in outdoor cages. The uncertainty is set at 20 percent.

4.4 Results for uncertainty in manure production factors

In 4.4.1 a summary is given of the uncertainties in manure production volume per animal category.

4.4.1 Uncertainty in manure production factors

Livestock category	Uncertainty
	%
Cattle for milk production	
Female young stock <1 year	10
Male young stock <1 year	10
Female young stock 1 year and over	10
Dairy cows	10
Bulls 1 year and over	10
Cattle for meat production	
Fattening calves, in white meat production	5
Fattening calves, in pink meat production	10
Female young stock <1 year	15
Beef bulls <1 year	20
Female young stock 1 year and over	15
Beef bulls 1 year and over	20
Suckler cows, feedlot cows and grazing cows	25
Sheep	25
Goats	25
Horses	25
Ponies	25
Pigs	
Fattening pigs	10
Sows	20
Breeding pigs	20
Boars	20
Poultry	
Parent animals of broilers, under 18 weeks	15
Parent animals of broilers, 18 weeks and over	10
Laying hens, under 18 weeks	10
Laying hens, 18 weeks and over	10
Broilers	15
Ducks	25
Turkeys	20
Rabbits	20
Mink	20

Explanation of these figures, see text.

5 Uncertainty in livestock numbers

5.1 Introduction

Livestock numbers in the agricultural census (reference date 1 April) are assumed to represent the average number of livestock in a calendar year. Sources of uncertainty are (see also section 2.5 WUM, 2010):

- Vacancy on the census date is not taken into account accurately. Although farmers should report zero livestock in the case of vacancy on the census date, some may report the average number of livestock present or pen capacity, thus introducing not a random error, but a systematic one. This could affect counts of livestock categories with a short production cycle in particular.
- Livestock numbers change in the course of the year as a result of addition and removal.
- Other factors causing under or over-reporting of the number of livestock actually present.

In the case of uncertainty in livestock numbers, it is assumed that the numbers in the various animal categories are not correlated. Strictly speaking this is not correct for certain animal categories. For example, there is a biological relationship between numbers of breeding hens and laying hens, and between sows, piglets and fattening pigs. This is not taken into account because natural and market-technical processes may disrupt this relationship, for example animal disease, exports of live animals and delayed reaction to market developments.

A number of past uncertainty studies assumed 5 percent uncertainty in livestock numbers regardless of animal category (Ramirez et al., 2006 and Olivier et al., 2009). Van Gijlswijk et al. (2004) adopted a default value of 130 percent uncertainty in manure production, which should be interpreted as a combination of uncertainty in livestock numbers and uncertainty in manure production per animal.

In addition, studies are available in which differences between livestock numbers from the agricultural census and from other livestock registrations are discussed (Hubeek and de Hoop, 2004; Kuipers, 2007; Van Os et al., 2011). Van Os et al. (2011) used the uncorrected agricultural census. This includes all farms participating in the agricultural census, thus also farms below the economic size and farms which are not required to participate because they do not carry out commercial agricultural activities. On the other hand, the agricultural census does not include all livestock on farms required to participate in the agricultural census because some farms are missing from the survey or do not report non-commercial livestock.

This report uses information form the abovementioned sources to assess uncertainty in livestock numbers. It is stressed that the uncertainty in livestock numbers refers to livestock on farms required to participate in the agricultural census. The WUM does not calculate the excretion of animals kept outside agriculture, for example on non-commercial farms or riding stables. Livestock numbers outside agriculture are therefore not included in the uncertainty percentage.

5.2 Cattle

Kuipers (2007) calculated the difference in cattle numbers between the agricultural census and I&R data. The difference between total numbers of cattle was very small (less than 1 percent), but significant differences were found between numbers per age category. Van Os et al. (2011) found that the total number of cattle in registrations of the health service for animals (*Gezondheidsdienst voor Dieren,* GD) and in the I&R-system correspond almost completely to that according to the agricultural census. The number of livestock according to the GD was slightly higher because it counts every animal, while there is threshold for the agricultural census. The number of animals in the I&R deviates by about 1 percent from the number in the agricultural census. At farms in the agricultural census that could be linked to the I&R, the difference in the total number of animals was zero. Sometimes there may be larger differences between cattle categories because animal categories in the I&R are aggregated differently.
For all cattle categories, the uncertainty is set at 2 percent as a measure of the uncertainty in the size of total cattle numbers.

5.3 Sheep, goats, horses and ponies

On farms participating in the agricultural census, these livestock categories are often kept non-commercially. It is conceivable that farms do not always report these animals. In the case of sheep, both the number of ewes and the total number of animals in the GD registration are more than 10 percent higher than in the agricultural census. This is probably because in sheep farming there are more non-commercial farmers who are not required to participate in the agricultural census (Van Os et al., 2011 section 2.2). I&R counts 9 percent more ewes than the agricultural census, but the total number of sheep in I&R is 11 percent lower (Van Os et al., 2011, section 4.2.1). The difference between sheep numbers on farms both in the agricultural census and in the I&R amounted to 4 percent.
For dairy goats, I&R counts a total of 25 percent more animals than the agricultural census; for farms in both enumerations the difference is 12 percent. However, the registration of sheep and goats in the I&R is still under construction (Van Os et al., 2011). In the uncertainty analysis, an uncertainty of 5 percent is used for both sheep (ewes) and dairy goats.
Horses and ponies kept on farms are assumed to be kept non-commercially and thus not always to be reported. Just as for sheep and goats, the uncertainty in the number of horses and ponies is estimated to be 5 percent.

5.4 Indoor livestock

Hubeek and De Hoop (2004) noted differences between livestock numbers in the agricultural census and those according to the minerals declaration system *Minas*. The average number of animals according to *Minas* was systematically lower than the snapshot of the agricultural census. Figures for cattle were not comparable, as cattle farms are not required to report to *Minas*. For pigs and chickens, *Minas* registered 2–10 percent and for turkeys 5–12 percent fewer animals than the agricultural census. According to Klinker (2004), it is not easy to explain the differences or to indicate whether one of the two reports was systematically incorrect. The only objective explanation is that *Minas* did not measure the same population as the agricultural census. However, the *Minas* report corresponded better to the annual average, contained more conflicting interests, and was part of a comprehensive administration.

Van Os et al. (2011) observed that the number of sows and fattening pigs according to the GD was a few percent less than according to the agricultural census. I&R finds 3 percent more sows and 4 percent fewer fattening pigs than the agricultural census. For farms in both I&R and in the agricultural census, 1 percent fewer sows and 9 percent fewer fattening pigs are observed. These differences are difficult to assess because I&R counts are based on supply and removal data, and on assumptions about births and number of production cycles per year. In addition, Van Os et al. concluded after completing their study that in hindsight a better estimate of the average number of animals in I&R had been possible.
A tentative conclusion is that the difference between I&R and agricultural census figures for sows, that are longer present on the farm, is smaller than for fattening pigs with multiple production cycles per year. With regard to the difference between agricultural census and *Minas* declarations in the past, the uncertainty for the number of sows, breeding sows and boars is set at 5 percent and for the number of fattening pigs at 10 percent.

For poultry, I&R counts 12 percent more birds on average than the agricultural census. For farms in both I&R and the agricultural census the difference is 14 percent. The most obvious reason for this large difference seems to be the fact that the number of birds in I&R is calculated on the basis of only supply data. Van Os et al. (2011, section 3.4) concluded after the study that in hindsight a better estimate of the average number of broilers in I&R had been possible. An earlier comparison of bird numbers on the basis of the KIP system of the PPE, based on supply data in 2001 and 2002, showed significantly fewer birds than the agricultural census. Therefore counting on the basis of I&R data gives hardly any basis for the estimation of the uncertainty in poultry numbers. The assessment of uncertainty rates is therefore based on differences between agricultural census and *Minas* declarations. For livestock categories with a relatively short production period the uncertainty is set at 10 percent, for a longer production period (laying hens), it is set at 5 percent.

The uncertainty in numbers of rabbits and fur-bearing animals is also set at 5 percent.

5.5 Results for uncertainty in livestock numbers

In 5.5.1 the uncertainty in animal numbers per animal category is resumed.

5.5.1 Uncertainty in animal numbers

Livestock category	Uncertainty
	%
Cattle for milk production	
Female young stock <1 year	2
Male young stock <1 year	2
Female young stock 1 year and over	2
Dairy cows	2
Bulls 1 year and over	2
Cattle for meat production	
Fattening calves, in white meat production	2
Fattening calves, in pink meat production	2
Female young stock <1 year	2
Beef bulls <1 year	2
Female young stock 1 year and over	2
Beef bulls 1 year and over	2
Suckler cows, feedlot cows and grazing cows	2
Sheep	5
Goats	5
Horses	5
Ponies	5
Pigs	
Fattening pigs	10
Sows	5
Breeding pigs	5
Boars	5
Poultry	
Parent animals of broilers, under 18 weeks	10
Parent animals of broilers, 18 weeks and over	5
Laying hens, under 18 weeks	10
Laying hens, 18 weeks and over	5
Broilers	10
Ducks	10
Turkeys	10
Rabbits	5
Mink	5

Explanation of these figures, see text.

6 Uncertainty in total mineral excretion and manure production

6.1 Results

Table 6.1.1 combines the uncertainty in excretion factors and the uncertainty in livestock numbers to present the uncertainty in the total excretion of nitrogen and phosphate of farm animals on farms in the Netherlands. In 6.1.2 the total uncertainty in the production of manure is calculated.

The calculations are based on the calculation scheme for uncertainty analysis in the IPCC Guidelines (IPCC, 2006 table 3.2). The uncertainty in the trend is calculated using the year 2000 as arbitrarily chosen base year.

Explanatory notes for 6.1.1 and 6.1.2:

Column A:
Livestock category.

Column B:
Subject of the uncertainty analysis.

Column C:
Excretion/manure production in the base year.

Column D:
Excretion/manure production in the current year.

Column E:
Uncertainty in the number of livestock, expressed as half of the 95 percent confidence interval divided by the average, and expressed as a percentage.

Column F:
Uncertainty in the excretion factor and manure production factor respectively, expressed as half of the 95 percent confidence interval divided by the average, and expressed as a percentage.

Column G:
Combined uncertainty per animal category calculated from the values in
Columns E and F: $G_x = \sqrt{(E_x^2 + F_x^2)}$

Column H:
Uncertainty in Column G expressed as a share of total excretion and manure production in the current year respectively. Each row in Column H contains the square of the cell value in Column G multiplied by the square of the cell value in Column D, divided by the square of the total of Column D:

$$H_x = \frac{(G_x * D_x)^2}{\sum D_i)^2}.$$

The bold value at the bottom of Column H is the square root of the sum of Column H. This number denotes the uncertainty, expressed as a percentage, of the total mineral excretion and manure production in the current year respectively: $\sqrt{\sum H_i}$

Column I:
Column I shows how the percentage difference in excretion and manure production respectively changes in response to a 1 percent increase for both the base year and the current year. This calculation shows the sensitivity of the trend to a systematic uncertainty in the excretion/manure production, in other words the uncertainty in the base year is correlated between the base year and the current year.

$$I = \left| \frac{0{,}01 * D_x + \sum D_i - (0{,}01 * C_x + \sum C_i)}{(0{,}01 * C_x + \sum C_i)} * 100 - \frac{\sum D_i - \sum C_i}{\sum C_i} * 100 \right|$$

Column J:
Column J shows how the percentage difference in excretion and manure production respectively changes between the base year and the current year if excretion/manure production increases by 1 percent in the current year only. This calculation shows the sensitivity of the trend in excretion/manure production to a random uncertainty in the calculation, in other words the uncertainty between base year and current year is not correlated.

$$J = \left| \frac{0{,}01 * D_x + \sum D_i - \sum C_i)}{\sum C_i} * 100 - \frac{\sum D_i - \sum C_i}{\sum C_i} * 100 \right|$$

Column K:
The information in Columns I and F shows the uncertainty in the trend as a result of the uncertainty in excretion factors/manure production factors under assumption that the same factors are used in both years and the uncertainty between both years is correlated. The formula would then read: $K_x = I_x * F_x$.

If there is no correlation between emission factors, the formula is: $K_x = J_x * F_x * \sqrt{2}$. This formula is applied in 6.1.1 and 6.1.2. For the derivation of the formula, see IPCC (2006 p. 3.58).

Column L:
The information in Columns J and E shows the uncertainty in the trend as a result of uncertainty in livestock numbers. If we assume that the uncertainty in livestock numbers is the same in the base year and the current year and the number of animals in the base year is independent of the number of animals in the current year, the formula is: $L_x = J_x * E_x * \sqrt{2}$. (IPCC, 2006 p. 3.58). This formula is applied in 6.1.1 and 6.1.2. If correlation is assumed between the livestock numbers in the base year and the current year, the formula is: $L_x = I_x * E_x$.

Column M:
In this Column, the uncertainty in factors and livestock numbers is combined: $M_x = K_x^2 + L_x^2$.
The bold value at the bottom of Column M is the square root of the total of Column M. This number represents the uncertainty, expressed as a percentage, in the trend in total mineral excretion and manure production respectively: $\sqrt{\sum M_i}$.

6.1.1 Results of the uncertainty analysis for nitrogen and phosphorus excretion in animal husbandry

A Livestock category	B Nutrient	C Excretion base year (2000)	D Excretion year t (2010)	E Uncertainty in animal numbers	F Uncertainty in excretion factor	G Combined uncertainty	H Contribution to uncertainty in year t	I Type A sensitivity	J Type B sensitivity	K Uncertainty in trend by excretion factor	L Uncertainty in trend by animal numbers	M Uncertainty in trend total
		million kg		*%*			*share*	*%*				
Cattle for milk production												
Female young stock <1 year	N	23.6	19.6	2	5	5	0.00000	0.0027	0.0357	0.25	0.10	0.0007
Male young stock <1 year	N	1.4	1.0	2	5	6	0.00000	0.0005	0.0017	0.01	0.00	0.0000
Female young stock 1 year and over	N	62.4	47.6	2	4	5	0.00002	0.0146	0.0868	0.51	0.25	0.0032
Dairy cows	N	205.3	192.5	2	6	6	0.00058	0.0169	0.3505	2.86	0.99	0.0917
Bulls 1 year and over	N	3.6	1.8	2	5	6	0.00000	0.0025	0.0033	0.02	0.01	0.0000
Cattle for meat production												
Fattening calves, in white meat production	N	7.6	7.9	2	15	15	0.00001	0.0020	0.0143	0.30	0.04	0.0009
Fattening calves, in pink meat production	N	5.0	8.3	2	9	10	0.00000	0.0070	0.0151	0.20	0.04	0.0004
Female young stock <1 year	N	1.7	1.4	2	5	5	0.00000	0.0002	0.0025	0.02	0.01	0.0000
Beef bulls <1 year	N	2.2	1.3	2	11	11	0.00000	0.0012	0.0024	0.04	0.01	0.0000
Female young stock 1 year and over	N	5.5	4.6	2	4	5	0.00000	0.0005	0.0083	0.05	0.02	0.0000
Beef bulls 1 year and over	N	5.5	3.0	2	9	9	0.00000	0.0034	0.0055	0.07	0.02	0.0001
Suckler cows, feedlot cows and grazing cows	N	15.5	9.6	2	5	6	0.00000	0.0076	0.0175	0.13	0.05	0.0002
Sheep	N	15.9	7.9	5	6	8	0.00000	0.0115	0.0143	0.12	0.10	0.0003
Goats	N	1.9	3.9	5	15	15	0.00000	0.0040	0.0071	0.15	0.05	0.0002
Horses	N	5.0	5.4	5	21	22	0.00001	0.0017	0.0099	0.30	0.07	0.0009
Ponies	N	1.3	1.6	5	21	22	0.00000	0.0007	0.0029	0.09	0.02	0.0001
Pigs												
Fattening pigs	N	80.0	72.0	10	10	14	0.00043	0.0012	0.1312	1.84	1.86	0.0682
Sows	N	34.9	29.7	5	11	12	0.00006	0.0026	0.0541	0.87	0.38	0.0091
Breeding pigs	N	4.9	3.6	5	10	11	0.00000	0.0014	0.0066	0.09	0.05	0.0001
Boars	N	0.8	0.2	5	8	9	0.00000	0.0010	0.0003	0.00	0.00	0.0000
Poultry												
Parent animals of broilers, under 18 weeks	N	1.3	1.0	10	11	15	0.00000	0.0003	0.0018	0.03	0.03	0.0000
Parent animals of broilers, 18 weeks and over	N	6.1	4.9	5	7	8	0.00000	0.0009	0.0090	0.09	0.06	0.0001
Laying hens, under 18 weeks	N	3.6	4.4	10	11	15	0.00000	0.0023	0.0081	0.12	0.11	0.0003
Laying hens, 18 weeks and over	N	21.8	28.9	5	8	10	0.00003	0.0172	0.0527	0.62	0.37	0.0052
Broilers	N	26.0	22.4	10	22	24	0.00012	0.0014	0.0407	1.25	0.58	0.0188
Ducks	N	0.9	0.9	10	15	18	0.00000	0.0000	0.0016	0.03	0.02	0.0000
Turkeys	N	2.9	2.0	10	13	16	0.00000	0.0010	0.0036	0.07	0.05	0.0001
Rabbits	N	0.4	0.3	5	9	11	0.00000	0.0001	0.0005	0.01	0.00	0.0000
Mink	N	2.1	2.1	5	12	13	0.00000	0.0005	0.0039	0.06	0.03	0.0000
Total	N	549.1	489.7				0.00126					0.2007
Total uncertainty (in %)							**3.6**					**4.5**

6.1.1 Results of the uncertainty analysis for nitrogen and phosphorus excretion in animal husbandry (end)

A Livestock category	B Nutrient	C Excretion base year (2000)	D Excretion year t (2010)	E Uncertainty in animal numbers	F Uncertainty in excretion factor	G Combined uncertainty	H Contribution to uncertainty in year t	I Type A sensitivity	J Type B sensitivity	K Uncertainty in trend by excretion factor	L Uncertainty in trend by animal numbers	M Uncertainty in trend total
		million kg		*%*			*share*	*%*				
Cattle for milk production												
Female young stock <1 year	P_2O_5	5.9	5.5	2	7	8	0.00001	0.0004	0.0287	0.30	0.08	0.00096
Male young stock < 1 year	P_2O_5	0.3	0.2	2	9	9	0.00000	0.0003	0.0013	0.02	0.00	0.00000
Female young stock 1 year and over	P_2O_5	16.6	14.3	2	4	5	0.00002	0.0062	0.0750	0.48	0.21	0.00271
Dairy cows	P_2O_5	64.4	63.6	2	6	7	0.00057	0.0171	0.3333	3.02	0.94	0.10033
Bulls 1 year and over	P_2O_5	1.0	0.6	2	6	6	0.00000	0.0020	0.0029	0.02	0.01	0.00001
Cattle for meat production												
Fattening calves, in white meat production	P_2O_5	3.2	3.0	2	16	16	0.00001	0.0003	0.0159	0.35	0.05	0.00127
Fattening calves, in pink meat production	P_2O_5	1.8	2.6	2	13	13	0.00000	0.0047	0.0135	0.25	0.04	0.00064
Female young stock <1 year	P_2O_5	0.4	0.4	2	7	8	0.00000	0.0001	0.0020	0.02	0.01	0.00000
Beef bulls < 1 year	P_2O_5	0.6	0.4	2	16	16	0.00000	0.0009	0.0021	0.05	0.01	0.00002
Female young stock 1 year and over	P_2O_5	1.5	1.4	2	4	5	0.00000	0.0001	0.0072	0.05	0.02	0.00003
Beef bulls 1 year and over	P_2O_5	1.8	1.1	2	11	11	0.00000	0.0032	0.0056	0.08	0.02	0.00007
Suckler cows, feedlot cows and grazing cows	P_2O_5	4.6	3.1	2	5	6	0.00000	0.0063	0.0164	0.12	0.05	0.00018
Sheep	P_2O_5	4.4	2.6	5	5	7	0.00000	0.0079	0.0134	0.09	0.10	0.00018
Goats	P_2O_5	0.6	1.5	5	16	17	0.00000	0.0051	0.0080	0.19	0.06	0.00038
Horses	P_2O_5	1.8	2.1	5	22	22	0.00001	0.0020	0.0110	0.34	0.08	0.00118
Ponies	P_2O_5	0.5	0.6	5	21	22	0.00000	0.0007	0.0030	0.09	0.02	0.00009
Pigs												
Fattening pigs	P_2O_5	29.3	28.9	10	10	14	0.00052	0.0079	0.1515	2.14	2.14	0.09182
Sows	P_2O_5	16.1	14.9	5	11	12	0.00010	0.0014	0.0778	1.23	0.55	0.01817
Breeding pigs	P_2O_5	2.4	1.6	5	10	11	0.00000	0.0033	0.0083	0.12	0.06	0.00018
Boars	P_2O_5	0.4	0.1	5	8	10	0.00000	0.0015	0.0005	0.01	0.00	0.00000
Poultry												
Parent animals of broilers, under 18 weeks	P_2O_5	0.7	0.6	10	8	13	0.00000	0.0004	0.0032	0.04	0.05	0.00003
Parent animals of broilers, 18 weeks and over	P_2O_5	3.2	2.5	5	6	8	0.00000	0.0026	0.0130	0.10	0.09	0.00019
Laying hens, under 18 weeks	P_2O_5	1.6	2.2	10	10	14	0.00000	0.0037	0.0116	0.16	0.16	0.00052
Laying hens, 18 weeks and over	P_2O_5	13.7	14.8	5	5	7	0.00004	0.0105	0.0776	0.60	0.55	0.00660
Broilers	P_2O_5	11.2	7.6	10	20	23	0.00009	0.0151	0.0398	1.15	0.56	0.01636
Ducks	P_2O_5	0.4	0.4	10	12	15	0.00000	0.0002	0.0022	0.04	0.03	0.00002
Turkeys	P_2O_5	1.3	1.0	10	11	15	0.00000	0.0011	0.0051	0.08	0.07	0.00012
Rabbits	P_2O_5	0.2	0.1	5	10	12	0.00000	0.0001	0.0007	0.01	0.01	0.00000
Mink	P_2O_5	1.1	1.2	5	9	11	0.00000	0.0005	0.0060	0.08	0.04	0.00008
Total	P_2O_5	190.9	178.9				0.00138					0.24215
Total uncertainty (in %)							**3.7**					**4.9**

6.1.2 Results of the uncertainty analysis for manure production in animal husbandry

A Livestock category	B Manure production	C Manure production base year (2000)	D Manure production year t (2010)	E Uncertainty in animal numbers	F Uncertainty in manure production factor	G Combined uncertainty	H Contribution to uncertainty in year t	I Type A sensitivity	J Type B sensitivity	K Uncertainty in trend by manure production factor	L Uncertainty in trend by animal numbers	M Uncertainty in trend total
		million kg		*%*			*share*	*%*				
Cattle for milk production												
Female young stock <1 year	volume	2,813	2,727	2	10	10	0.00001	0.0005	0.0361	0.51	0.10	0.0027
Male young stock <1 year	volume	187	144	2	10	10	0.00000	0.0005	0.0019	0.03	0.01	0.0000
Female young stock 1 year and over	volume	8,035	7,811	2	10	10	0.00012	0.0018	0.1034	1.46	0.29	0.0222
Dairy cows	volume	37,602	38,445	2	10	10	0.00295	0.0332	0.5088	7.20	1.44	0.5384
Bulls 1 year and over	volume	422	259	2	10	10	0.00000	0.0019	0.0034	0.05	0.01	0.0000
Cattle for meat production												
Fattening calves, in white meat production	volume	2,229	1,775	2	5	5	0.00000	0.0047	0.0235	0.17	0.07	0.0003
Fattening calves, in pink meat production	volume	729	1,323	2	10	10	0.00000	0.0083	0.0175	0.25	0.05	0.0006
Female young stock <1 year	volume	206	196	2	15	15	0.00000	0.0000	0.0026	0.06	0.01	0.0000
Beef bulls <1 year	volume	375	220	2	20	20	0.00000	0.0018	0.0029	0.08	0.01	0.0001
Female young stock 1 year and over	volume	708	755	2	15	15	0.00000	0.0010	0.0100	0.21	0.03	0.0005
Beef bulls 1 year and over	volume	978	559	2	20	20	0.00000	0.0050	0.0074	0.21	0.02	0.0004
Suckler cows, feedlot cows and grazing cows	volume	2,442	1,730	2	25	25	0.00004	0.0080	0.0229	0.81	0.06	0.0066
Sheep	volume	1,581	1,418	5	25	25	0.00003	0.0012	0.0188	0.66	0.13	0.0046
Goats	volume	128	289	5	25	25	0.00000	0.0022	0.0038	0.14	0.03	0.0002
Horses	volume	669	788	5	25	25	0.00001	0.0020	0.0104	0.37	0.07	0.0014
Ponies	volume	163	205	5	25	25	0.00000	0.0007	0.0027	0.10	0.02	0.0001
Pigs												
Fattening pigs	volume	7,805	6,495	10	10	14	0.00016	0.0127	0.0860	1.22	1.22	0.0296
Sows	volume	5,759	5,016	5	20	21	0.00021	0.0064	0.0664	1.88	0.47	0.0375
Breeding pigs	volume	450	307	5	20	21	0.00000	0.0016	0.0041	0.11	0.03	0.0001
Boars	volume	113	23	5	20	21	0.00000	0.0011	0.0003	0.01	0.00	0.0000
Poultry												
Parent animals of broilers, under 18 weeks	volume	49	24	10	15	18	0.00000	0.0003	0.0003	0.01	0.00	0.0000
Parent animals of broilers, 18 weeks and over	volume	124	92	5	10	11	0.00000	0.0004	0.0012	0.02	0.01	0.0000
Laying hens, under 18 weeks	volume	150	109	10	10	14	0.00000	0.0005	0.0014	0.02	0.02	0.0000
Laying hens, 18 weeks and over	volume	1,065	713	5	10	11	0.00000	0.0040	0.0094	0.13	0.07	0.0002
Broilers	volume	560	488	10	15	18	0.00000	0.0006	0.0065	0.14	0.09	0.0003
Ducks	volume	67	76	10	25	27	0.00000	0.0002	0.0010	0.04	0.01	0.0000
Turkeys	volume	69	47	10	20	22	0.00000	0.0003	0.0006	0.02	0.01	0.0000
Rabbits	volume	20	15	5	20	21	0.00000	0.0001	0.0002	0.01	0.00	0.0000
Mink	volume	62	149	5	20	21	0.00000	0.0012	0.0020	0.06	0.01	0.0000
Total	volume	75,560	72,193				0.00354					0.6459
Total uncertainty (in %)							**5.9**					**8.0**

6.2 Conclusions

The uncertainty in the total excretion of N and P_2O_5 is rounded up to 4 percent. There are large differences in uncertainty between livestock categories. The uncertainty in mineral excretion for dairy cattle is around 5 percent, but for horses, ponies and broilers it is more than 20 percent. The uncertainty in the trend in total mineral excretions from 2000 onwards is 5 percent. The choice for 2000 as the base year is more or less arbitrary.

For all grazing animals, the combined uncertainty of livestock numbers and excretion factors is mainly determined by the uncertainty in excretion factors. For fattening pigs and most poultry categories, the uncertainty in livestock numbers also plays a role.
The uncertainty in the excretion factor is often determined by uncertainty in feed intake (feed conversion) and mineral content of the diet, but for indoor livestock with high feed efficiency levels, for example, the uncertainty in the mineral content of animals is also relevant.

In 6.2.1 the contribution to the total uncertainty is broken down by livestock category.

6.2.1 Contribution to total uncertainty in mineral excretion and manure production by livestock category

Livestock category	N excretion	P_2O_5 excretion	Manure production
	% contribution to uncertainty		
Dairy cows	46	41	83
Fattening pigs	34	38	5
Sows	5	8	6
Laying hens	3	3	0
Broilers	9	7	0
Other livestock categories	4	4	6
Total	100	100	100

Eighty percent of the uncertainty in the total excretion of N and P_2O_5 is accounted for by dairy cows and fattening pigs. The contribution of dairy cows to total uncertainty is slightly larger than the contribution of this category to total mineral excretion. Table 3.4.1 indicates that the uncertainty in excretion factors originates particularly from feed requirement and mineral contents in silage grass and compound feed. Substitution of feed materials and uncertainty in milk yield are less important. Uncertainty in the mineral content of compound feed can be reduced in the future if the proposed adaptation of the registration of feed deliveries within the framework of the P-feed policy is realised.

For fattening pigs both the uncertainty in number of animals and the uncertainty in excretion factors play a role. Although the contribution to the total mineral excretion is about 15 percent, the contribution to overall uncertainty, as shown in 6.2.1, turns out to be much larger. Uncertainty in the excretion factors is caused mainly by uncertainty in feed intake (feed conversion) and feed composition. Uncertainty in the mineral content of animals hardly contributes to total uncertainty. This also applies to other pig categories.

Although uncertainty is relatively large for the number of broilers, the combined uncertainty of number of birds and excretion factors is determined by the uncertainty in the excretion factors. Table 3.4.1 shows that especially the uncertainty in the composition of the feed is responsible. The share of single wheat in the diet of broilers is not known accurately. The proposed adaptation of the registration of feed deliveries within the framework of the P-feed policy may lead to improvement in the future.

At approximately 6 percent, the total uncertainty in the produced manure volume is slightly larger than the uncertainty in mineral excretion. Dairy cows contribute over 80 percent. Just as in the case of manure production in most animal categories, the uncertainty in the manure volume of dairy cows is also based on a rough estimate. The source data (BBPR) of Livestock Research are based on so many assumptions in parameters and index numbers that affect the manure production that no solid well-founded uncertainty estimate can be given (De Boer, 2012).

6.3 Discussion

Where possible, uncertainties in parameters that play a key role in the calculation of excretion factors are based on data about variation in parameter values and are ultimately translated into percentage uncertainties that are as realistic as possible. However, it is not inconceivable that the applied uncertainties present a too rosy or too pessimistic picture. This section examines the increase in total uncertainty in N and P_2O_5 excretion if the uncertainty in most parameters is doubled. The uncertainty in livestock numbers is not adjusted: first for most livestock categories the uncertainty in livestock numbers hardly contributes to total uncertainty in excretion; secondly, the uncertainty in the number of animals in 5.5.1 already seems rather large.

Bannink (2010) estimates the uncertainty in VEM intake to be 2 percent on average. This value does not seem large, given the variation between individual companies in VEM coverage. Uncertainty in the availability of silage grass and compound feed is not adjusted because of the limited effect on the N and P_2O_5 excretion of cattle. Substitution of these feed materials by fresh grass leads to the intake of comparable quantities of N and P. For silage maize, the effect of substitution by fresh grass is larger because of large differences in mineral content between these feed materials. The effect on excretion of adjusting the mineral content of feed materials is also examined.
The fixation in animal product is altered by adjusting the P content of the milk and the mineral content of meat. The uncertainty in the mineral content of meat is not doubled but raised and reduced respectively by five percentage points. It does not seem realistic that the uncertainty in the mineral content of meat is around 20 percent.
For indoor livestock the effect on mineral excretion is calculated if all uncertainties were twice as high. An exception is made for the mineral content of meat that, in the same way as for grazing livestock, is increased by five percentage points.

If the abovementioned adjustments to the parameter uncertainties are applied separately, the uncertainty in total N and P_2O_5 excretion increases to a maximum of 5 percent. If all parameter uncertainties are increased simultaneously, the uncertainty in total N excretion increases to 6 percent and in total P_2O_5 excretion to 7 percent.

The uncertainty of 5 percent in the trend is calculated with 2000 as a more or less arbitrarily chosen base year. If the base year is set at 1990, the uncertainty in the trend decreases by one percentage point. Now the question is whether the uncertainties in excretion factors and livestock numbers in the base year and the current year (2010) are still in the same order of magnitude, as the base year is located further away from the current year.

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