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## Dynamic herd simulations

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# Dynamic Herd simulations



**REDNEX**

***CowNex, a tool to assess nitrogen excretion and efficiency of a dairy cattle herd according management***

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***RedNex Final conference Paris 30th August 2013***





REDNEX

# Context

- Competition on protein resources
  - Increase in cost
  - Interest to produce most of them (Farm self-sufficiency)
- **Nreactive** (Nitrogen cascade, Galloway 2004) has always many environmental impacts (climate change, eutrophication, acidification, health with small particles), and livestock is an important step in its transformation
  - 77% of ammonia emissions come from animal N excretion
- Farmers have an important responsibility in the use the protein



REDNEX

# Background and objective

- At cow level, on a daily basis:
  - N efficiency in dairy cows depends of the rumen balance of nitrogen and the efficiency of metabolizable protein (MP)
  - MP efficiency if a function of MP/NE of the diet, energy balance, essential AA content and milk yield.
- However, what are the main factors of N efficiency at herd scale according the type of dairy system and annual feeding management ?

→ **CowNex, a simple tool to estimate  
N efficiency of a dairy herd**

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# Plan

- Description of the modeling work
- Presentation of the CowNex Website
- Simulation of different model farms with different characteristics and feeding systems



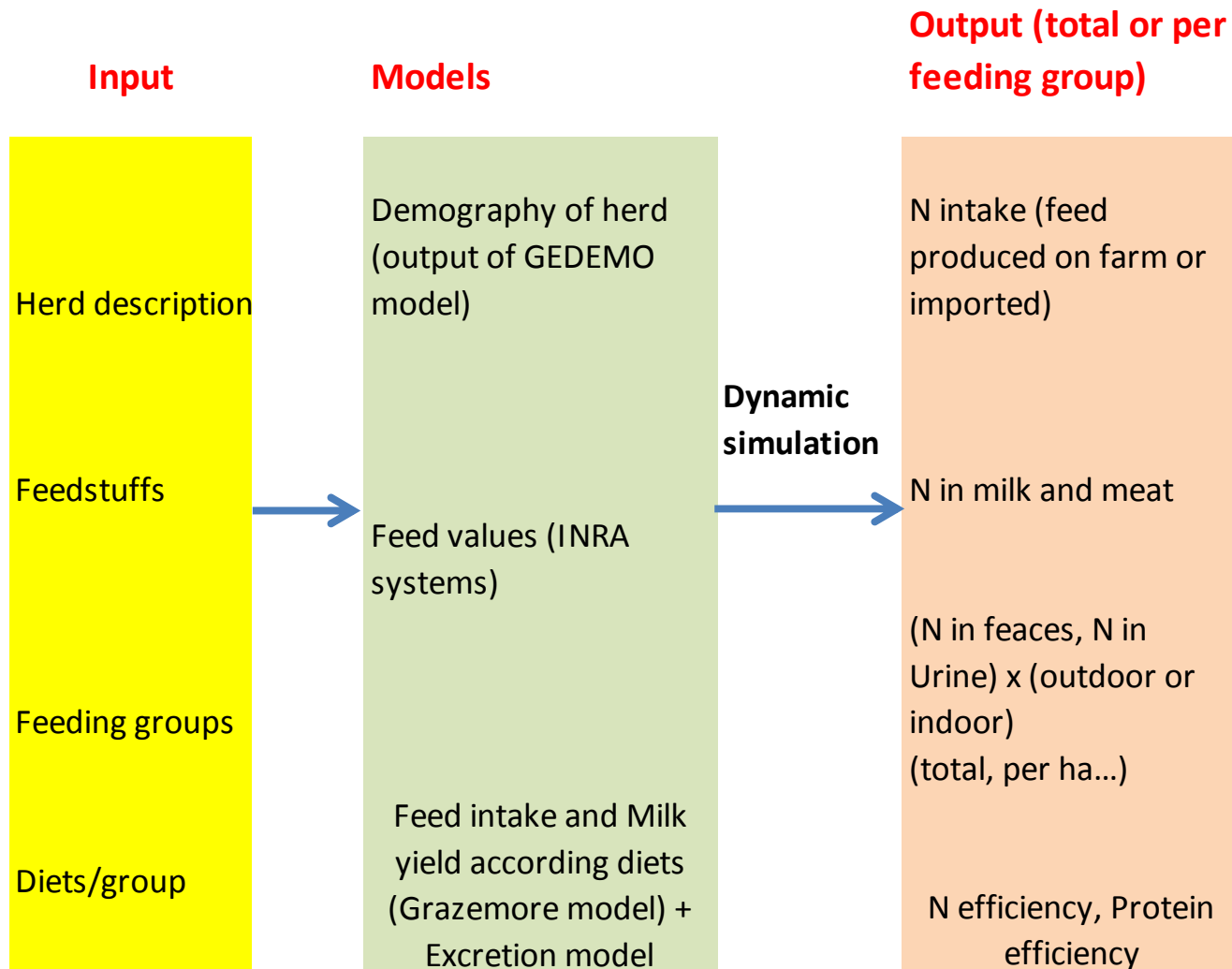
## Objective of CowNex: Building a model predicting N excretion for a dairy herd over the year

- **Calculating N excretion from a dairy herd** according to the number of animals and the diets on a daily basis.
- **Merging animal sub-model** and **a herd demography structure** (number of heifers, dry cows and productive cows across the year and the feeding strategies for each category of animals).
- **The animal sub-model predicts N intake and urinary and faecal N** output on a daily basis using on farm available data.
- **N intake and N partition is predicted daily using the intake model developed during the GRAZEMORE project and other results of the RedNex project.**



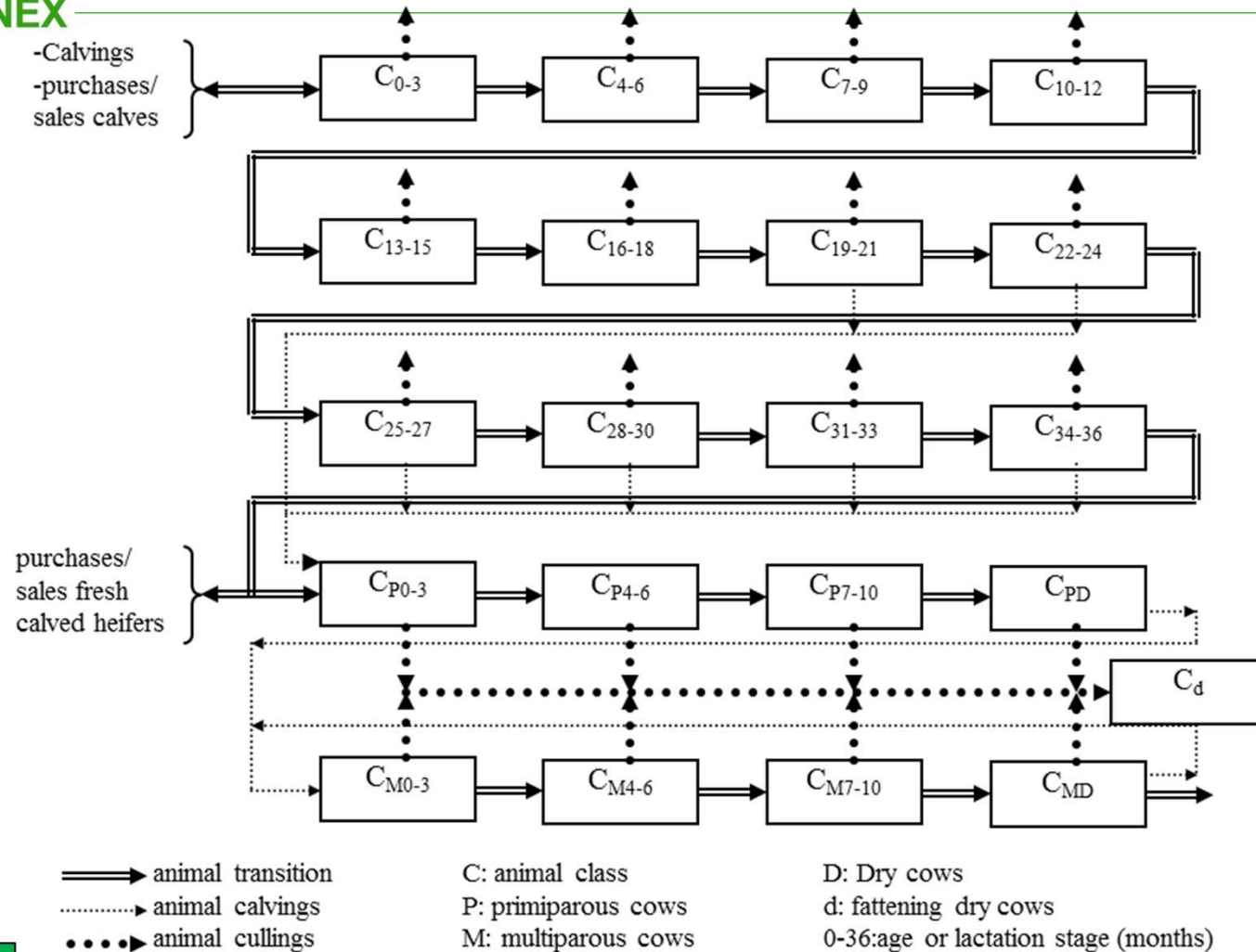
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# General overview of CowNex



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# A model to rebuild the dynamic structure of the herd



(Coquil et al)

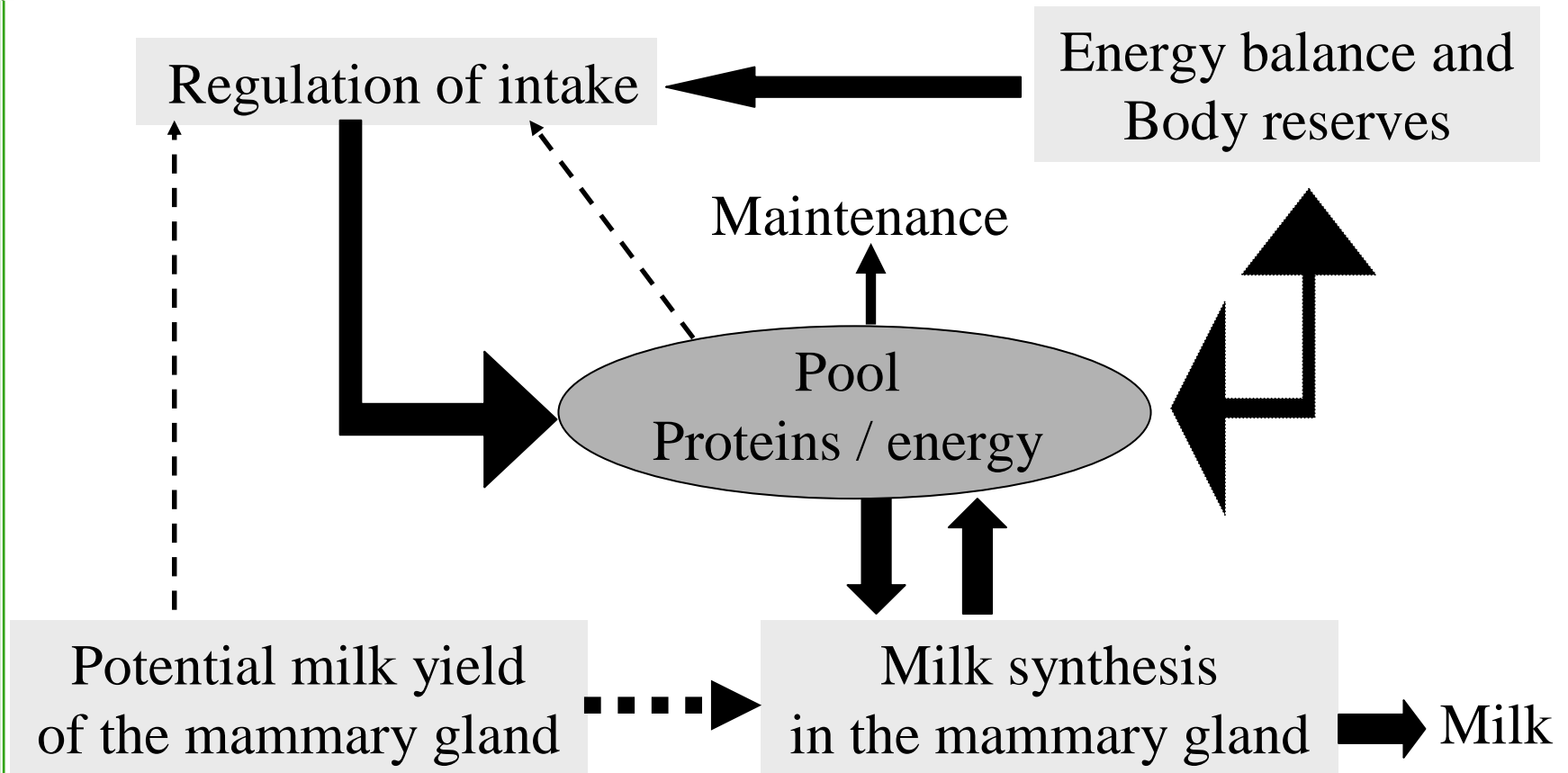
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# Intake Capacity and lactation of Grazin



(Faverdin et al, Grass and Forage Science, 2011)



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# The CowNex Website

Using the INRA modeling Record Platform



With the VLE modeling language




And the informatic skills of ULCO



REDNEX CowNex [Log out \(PF\)](#)

Home First Step Herd Feed Feeding Groups Diet Plan Simulation

### CowNex Simulator



The CowNex simulator is used to calculate protein synthesis and nitrogen excretion in dairy cattle herd, including heifers, depending on herd management.

It performs these calculations throughout the year and measures the impact of management changes, particularly nutrition, on the efficiency of nitrogen use by the herd and the release of fecal or urine nitrogen.

The amount of nitrogen to manage as manure is considered separately from the quantities directly returned to pasture.

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Release 157

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# Use of CowNex: different steps

- Describe the main characteristics of the herd : Herd
- Select the feedstuffs used to feed the herd during the year :  
Feed
- Define the main groups of cattle gathering several classes of animal fed with the same diet during the year :  
Feeding Groups
- Indicate for each feeding group the different diets offered during the year : Diet Plan
- Run the simulation to get results : Simulation

# Simulation of feeding management of different model farms using survey data



Exemple of one model farm description (Institut de l'Elevage, 2011)

Type of farm

General description

Characteristics of forage used

Heifers: Example of feeding calendar

**Elevages spécialisés lait de Plaine**  
avec plus de 30% de maïs dans la surface fourragère hors Grand-Ouest

*Ce système concerne 4,4 % des exploitations laitières françaises. Données 2007, issues de 41 exploitations des Réseaux d'élevage. Ces exploitations sont présentes en Picardie et Nord Pas-de-Calais (4), Haute-Normandie (2), Champagne-Ardenne et Alsace (8), Poitou-Charentes et Centre (15), Aquitaine et Midi-Pyrénées (14).*

**► CARACTÉRISTIQUES GÉNÉRALES DES EXPLOITATIONS**

Surface Agricole Utile (SAU)	91,0 ha (± 45,5 ha) dont grandes cultures : 35,0 (± 24,5 ha)
Surface Fourragère Principale (SFP)	55,5 ha (± 25,5 ha) dont surface en herbe : 30,0 ha (± 15,5 ha)
Taille du troupeau	65,0 vaches laitières (± 26,5) représentant 71 % des UGB totales de l'élevage
Races	Prim Holstein (68 %) et 4 autres races pour les autres troupeaux
Quota de production	495 100 L (± 199 700 L) référence MG : 39,5 g/L (± 6,5 g/L)
Quantité de lait produit	7 710 Lvache (± 860 L) à TB de 41,3 g/L et TP de 33,3 g/L

**► LES FOURRAGES**

**Les fourrages conservés :**  
Les stocks fourrages sont importants : **4,7 t MS/UGB/an (± 0,8 t MS)**. Ils sont constitués aux 3/4 d'ensilage de maïs. Des résiduels (chêne, fenilages et foin) sont peu représentés. Ces fourrages conservés sont utilisés pendant l'hiver et durant la période estivale durant laquelle le pâturage n'est pas exploité dans plusieurs des régions concernées.

**La pâturage :**  
Les données proviennent de 6 exploitations de plusieurs régions parmi les 41 élevages des Réseaux. Une mise à l'herbe précoce, pour déprimage, à parfois lieu à mi-mars selon les régions. Au printemps les vaches pâturent de début-avril à début juin avec un complément de maïs ensilage de 2,5 kg MS/jour dans une exploitation sur deux (Aquitaine, Poitou-Charentes). Utile les vaches pâturent de juillet à fin août-début septembre et reçoivent régulièrement du fourrage complémentaire en zones sèches (1,5 kg MS/jour) ; ceci n'est pas indispensable dans les régions mieux arrosées. À l'automne les troupeaux de régions à climat doux et humide (Haute-Normandie) peuvent pâturer de début septembre à fin-octobre ; le pâturage est alors accompagné d'ensilage de maïs (en moyenne 3,5 kg MS/jour).

**Repartition des fourrages conservés :**

- Ensilage maïs : 72%
- Ensilage herbe et ensilage : 7%
- Foin : 17%
- Autres fourrages : 4%

**Part de pâturage dans la ration fourragère (%) :**

Arrêt fréquent du pâturage en été pour les troupeaux des régions au sud de la Loire

.../... Elevages spécialisés lait de Plaine avec plus de 30% de maïs dans la surface fourragère hors Grand-Ouest

**► LES ALIMENTS CONCENTRÉS**

Quantité totale de concentrés : 1 670 kg/vache (± 480 kg) soit 240 g de concentré/L de lait (± 60 g/L). Les aliments concentrés se répartissent en :  
 > 12 % de matières premières prélevées sur l'exploitation et 88 % d'aliments achetés,  
 > 82 % de matières premières distribuées (prélevées ou achetées) et 18 % d'aliments composés.

Les aliments composés représentent presque autant que les tourteaux parmi les aliments achetés : parmi les aliments composés ceux de type VL se répartissent à 50 % entre ceux de production à 16-22 % de protéines et 50 % de correcteurs protéiques à 40 % MAT.

Les coproduits sont présents à plus de 10 % dans ces élevages. Un quart des élevages utilisent de la pulpe de betterave (Picardie - Nord Pas-de-Calais) ou de la drêche de brasserie (Alsace).

**Les aliments concentrés achetés :**

- Tourteaux : 40%
- Autres mat. prim. : 1%
- Coproduits concentrés : 13%
- Type VL : 36%
- AMV : 6%
- Autres all. composés : 4%
- Céréales : 4%

**► UN EXEMPLE DE CALENDRIER ANNUEL D'ALIMENTATION**  
« SYSTÈME EN CÔTEAUX SECS ARGILO-CALCAIRES - VALLÉES ET TERRASSES DU SUD-OUEST »

Concentrés : 1 205 kg VL/an (170 g/L lait)

1<sup>er</sup> avril : Foin 570 kg MS

20 juin : Pâturin 1280 kg MS

1<sup>er</sup> novembre : Ensilage de maïs 3 550 kg MS

Ensilage d'herbe : 1 040 kg MS

Source : "Systèmes bovins laitiers du Sud-Ouest, Référentiels issus du collectif Optilait et des Réseaux d'élevage, 2007".

Cows: Types and amount of concentrates used

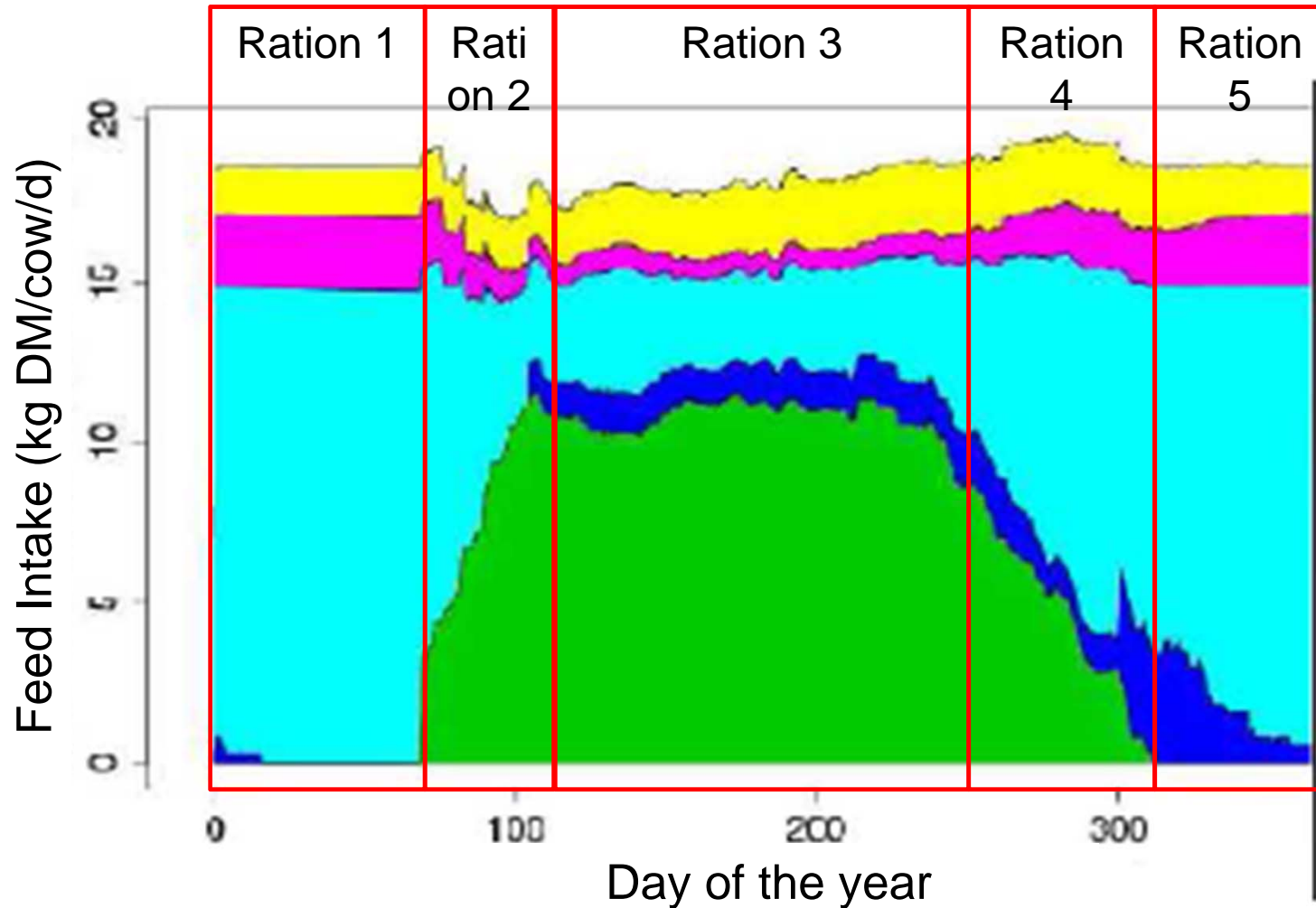
Cows : example of feeding calendar

15 diets of different model farms in different parts of France

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# A complex description of the intake: simplification with a sequence of diet





# Simulation using model farms to study N efficiency Protein selfsufficiency and emissions in different farming systems



1/ Translation of the feeding system description in CowNex to be consistent with global feed use data



2/ Simulation of the model farms and adaptation with CowNex

- Effect of age at first calving
- Comparison of model dairy farms
- Effect of protein supplementation on several model farms

Cows-Vaches

	Diet 1 (75 Day)		Diet 2 (60 Day) ✗		Diet 3 (88 Day) ✗		Diet 4 (76 Day) ✗		Diet 5 (62 Day) ✗	
	DM (kg/day)	%	DM (kg/day)	%	DM (kg/day)	%	DM (kg/day)	%	DM (kg/day)	%
FreshGrass		100						100		100
MilkP-LaitP										
MaizeS-EMais			7			65				
Straw-Paille										
SMB-Tt_Soja			1			10				
Barley-Orge	4					20	4		4	
Grass Silage										
BRE										
Foin				100		5				
Total	4	100	8	100	0	100	4	100	4	100
Time outdoors (h)		20		0		0		20		20



# Whole herd analysis : effect of age at first calving



- Virtual Farm with 100 cows high maize use, high producing cows (9700 kg milk) and group calving
- All heifers are reared with high replacement rate
- Replacement rate has little effect on N meat or milk efficiency

Variable	2 years	3 years
Cows	100	100
Heifers	84	133
Calves	13	13
Feed use (t/y)	998	1199
Conc use (t/y)	195	203
N intake (kg/y)	24380	29399
N Meat (kg/y)	622	745
N Milk (kg/y)	5109	5119
N Efficiency %	23.7	20.0
N milk efficiency %	27.3	27.3
N meat efficiency %	9.9	6.3
N Self sufficiency	70.2	73.3



# Example of 6 specialize dairy farms

- Farms of plain regions

Forage system	West	Other regions
>30% ha maize	Maize W	Maize E
10%< ha maize<30%	Maize Grass W	Maize Grass E
>10% ha maize	Grass W	Grass E





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# Comparison of dairy systems

		OTHER REGIONS			WEST	
Annual results	Maize E	Maize Grass E	Grass E	Maize W	Maize Grass W	Grass W
Total Diet DM (kg)	7047	6756	6108	6791	6327	5732
Total Diet N(kg)	187	181	152	165	163	142
CP annual diet	166	168	156	152	161	155
Milk (kg) /cow	8169	7500	6334	7827	6786	5608
Self sufficiency(DM)	76%	82%	89%	87%	88%	94%
Self sufficiency(N)	49%	57%	78%	67%	73%	79%



# Comparison of dairy systems

		OTHER REGIONS			WEST	
Annual results	Maize E	Maize Grass E	Grass E	Maize W	Maize Grass W	Grass W
N Milk (kg)	44.2	40.6	32.5	42.3	37.8	30.4
N Faeces (kg)	61.8	62.0	54.2	59.5	56.3	52.0
N Urine (kg)	80.2	78.7	64.9	62.5	68.7	57.8
N excreted (kg)	142	141	119	122	125	110
N Efficiency	23.6%	22.4%	21.4%	25.7%	23.1%	21.4%
Kg NH <sub>3</sub> /T milk	4.9	4.0	1.8	2.2	3.4	1.7
% Controllable	69%	63%	48%	58%	56%	47%

# Impact of indoor protein supplementation on emissions



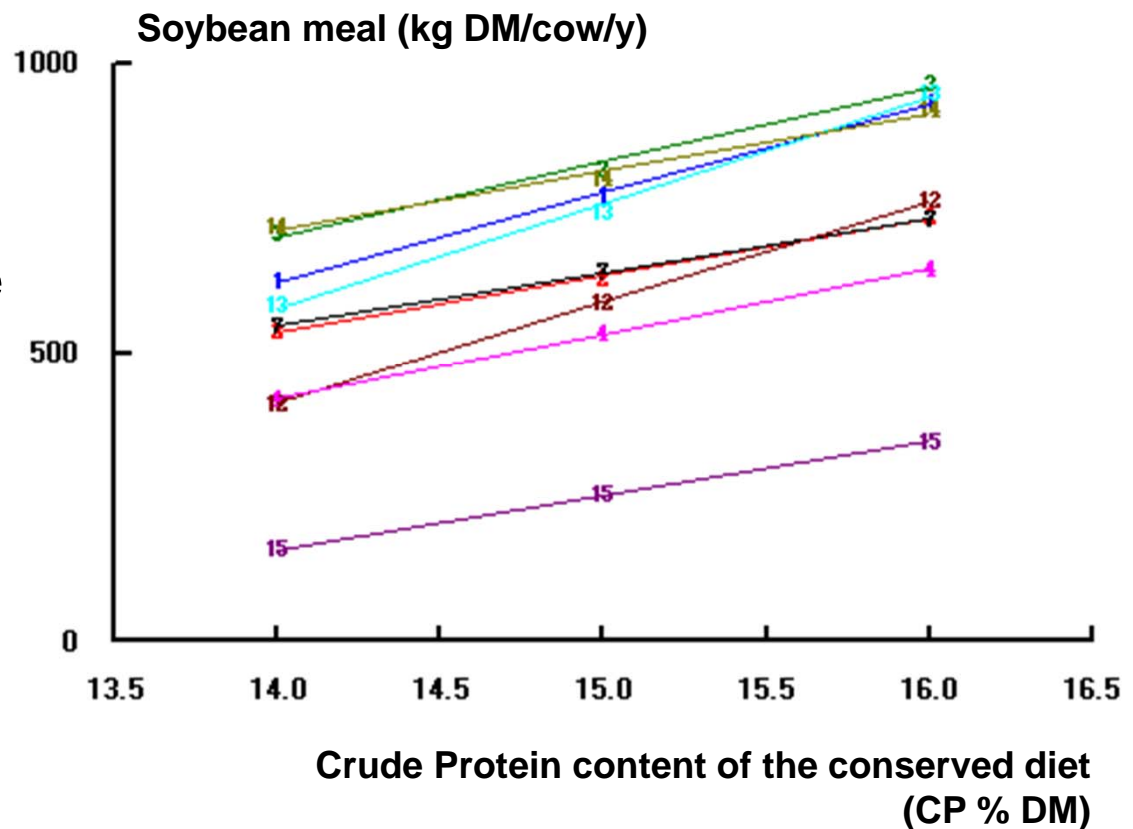
- Comparaison of different protein supplementations in dairy systems using large amount of soyabean meal (dairy specialized and crop-dairy systems). Calcul on dairy cows only.
  - 14% CP
  - 15% CP
  - 16% CP
- Collection of CowNex output to calculate  $\text{NH}_3$  and  $\text{N}_2\text{O}$  emission using the EMEP/EEA european reference method and national database to describe housing and manure management systems

	A	B	C	D	
1	equations/lots	Cows-Vaches	Heifers-GÃ©nisses	Calves-Veaux	Her
14	MaizeS-EMais N	17.9361614	0	1.208880048	
15	Straw-Paille N	0	1.884728099	0	
16	SMB-Tt_Soja N	20.29854541	6.946569279	0	
17	Barley-Orge N	23.6938453	0	4.064640162	
18	Grass Silage N	0	7.538912283	0	
19	BRE N	0	0	0	
20	Foin N	10.00888089	0	0	
21	Total Diet MS(input)	7510.849093	3339.256725	547.5000218	
22	Total Diet N(input)	181.8897581	91.28261772	13.78824055	
23	CP	151.3558553	170.8513025	157.4	
24					
25	N intake(dm)	757036.8075	446261.8916	6956.097832	
26	N intake(n)	18333.11255	12199.10807	175.1823678	
27	N produced(dm)	732255.5584	435017.3779	4173.658699	
28	N produced(n)	16287.17263	11270.76101	67.00113432	
29	N imported(dm)	24781.24906	11244.51375	2782.439133	
30	N imported(n)	24781.24906	11244.51375	2782.439133	
31	Self efficiency(dm)	96.72654634	97.48028815	60	
32	Self efficiency(n)	88.8401933	92.39004155	38.24650572	
33					
34	N Milk	45.29550802	0	0	
35	N Meat	5.51291129	3.936631399	0.629798532	
36	N Feaces	67.68911106	25.50556371	3.854400153	
37	N Urine	67.34937134	61.42919758	2.921911558	
38	Total Diet N (output)	181.8897581	91.28261772	13.78824055	
39	N Efficiency	27.93363399	4.312575052	4.567649725	
40					
41	totalExcretion	13610.85815	11618.05582	86.09440244	
42	Collectable feaces	2572.289909	866.2873052	48.97092874	
43	Collectable urine	1597.906984	1249.659492	37.1234737	
44	Collectable total	4170.196893	2115.946797	86.09440244	
45	Uncollectable feaces	4250.260765	2542.303901	0	
46	Uncollectable urine	5190.400494	6959.80512	0	
47	Uncollectable total	9440.66126	9502.109021	0	
48	% Controlable	30.63875067	18.21257214	100	
49					

# Relationship between the use of simulated soybean meal use per year and the protein content of the winter diet



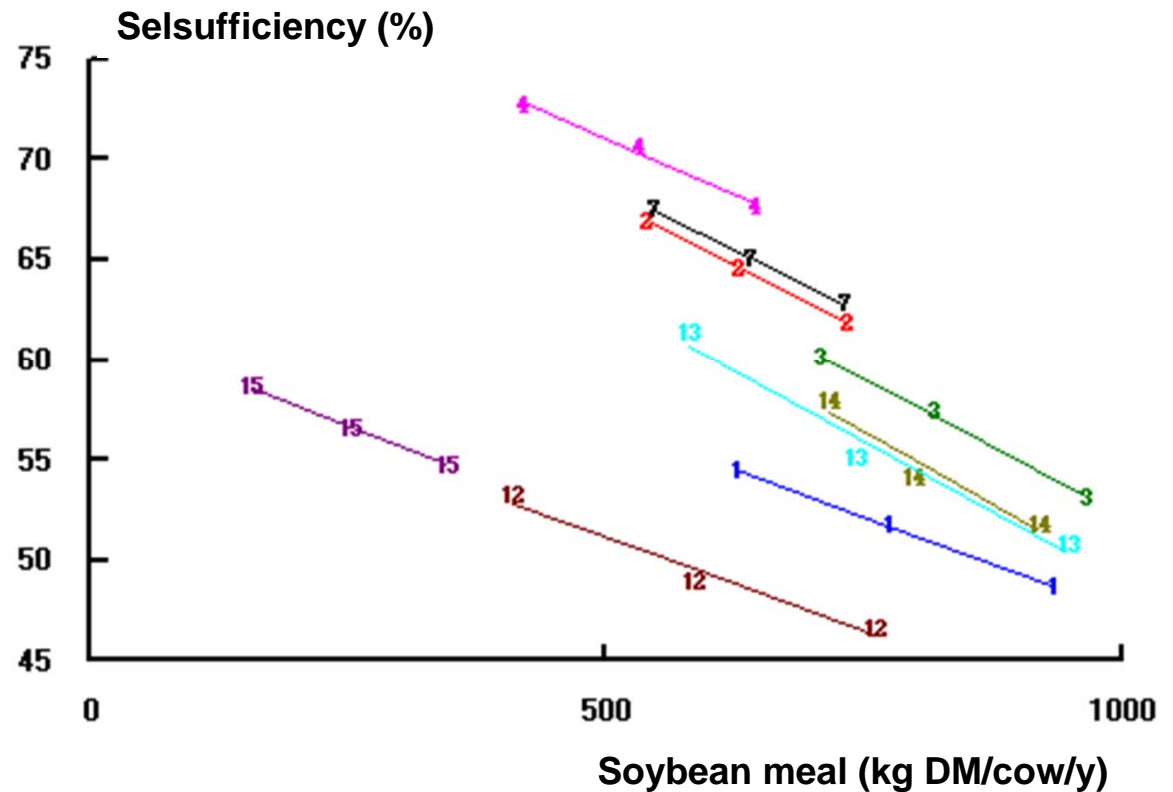
The soybean meal use increases of about 130 kg DM per 1 point more of crude protein in the conserved diets





# Protein Dairy Farm selfsufficiency

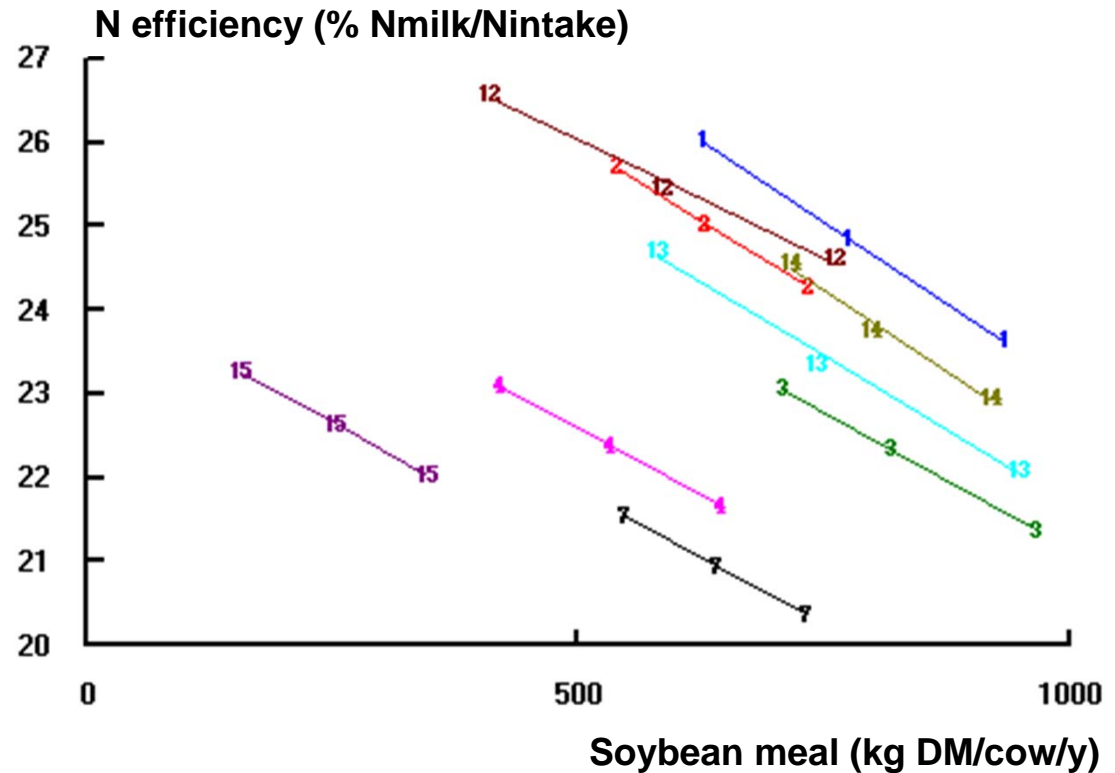
Protein Selfsufficiency of dairy herds decreases of 2.4 per 100 kg DM additional soybean meal.



# Nitrogen efficiency decreases with nitrogen supplementation



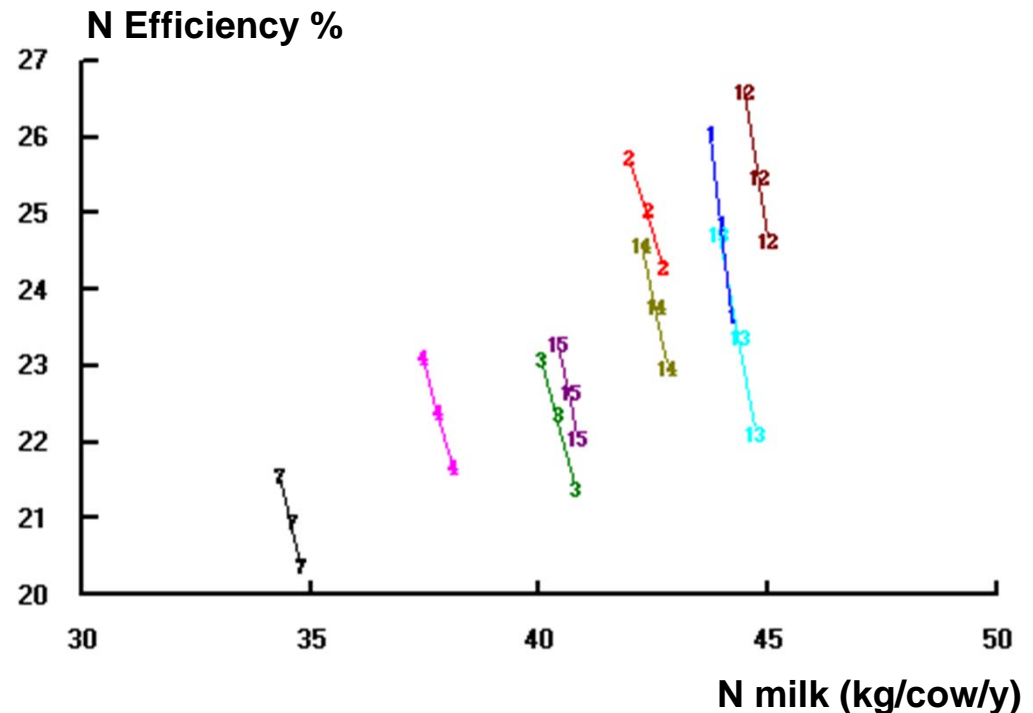
Efficiency of nitrogen utilization by the dairy cows decreases by 0.68 for 100 kg DM additional soybean meal, but varies largely with the farming system





# N efficiency at herd level

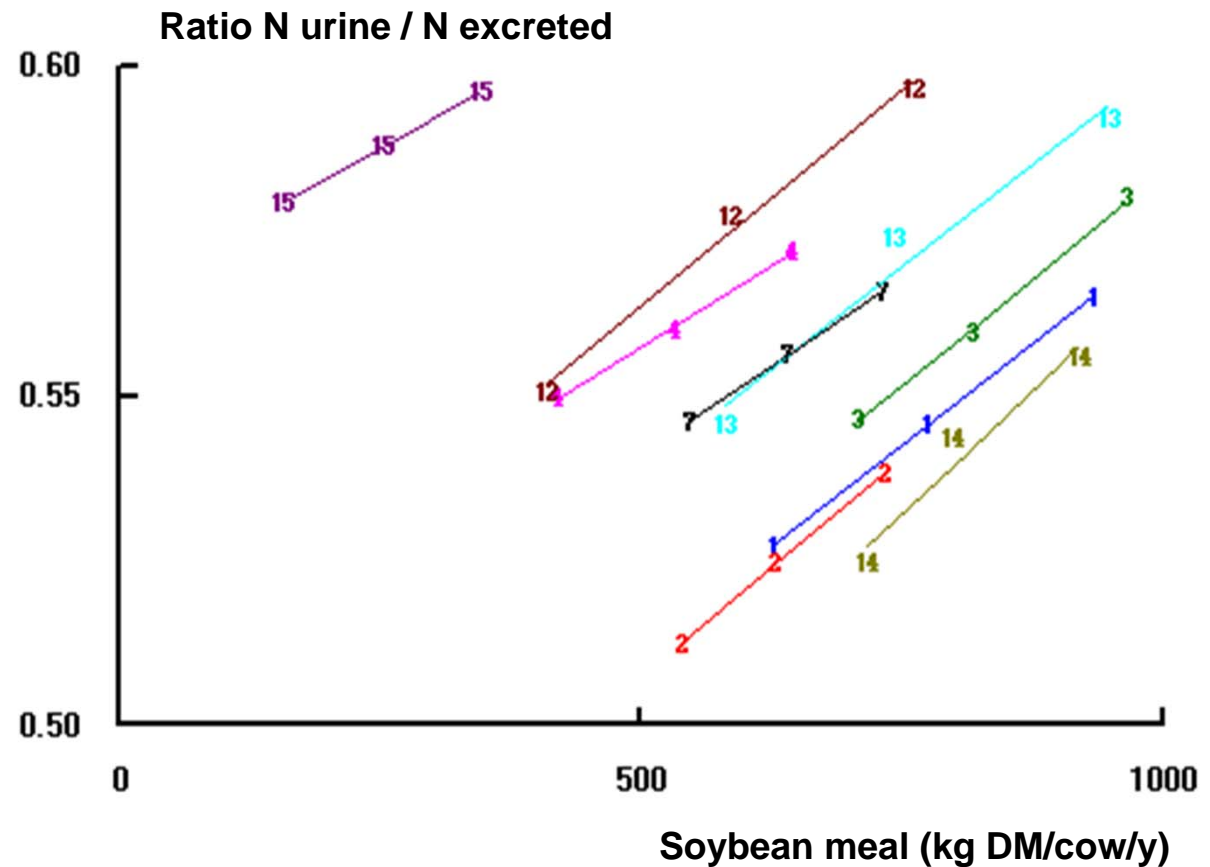
N efficiency (N milk or meat/ N intake) of dairy herds increases with milk production, but decreases with protein supplementation, which often offsets the benefit of the dairy performance



# The urine part of nitrogen excretion increases with protein supplementation



Urine N fraction increases of about 1.2 % with 100 kg DM additional soybean meal

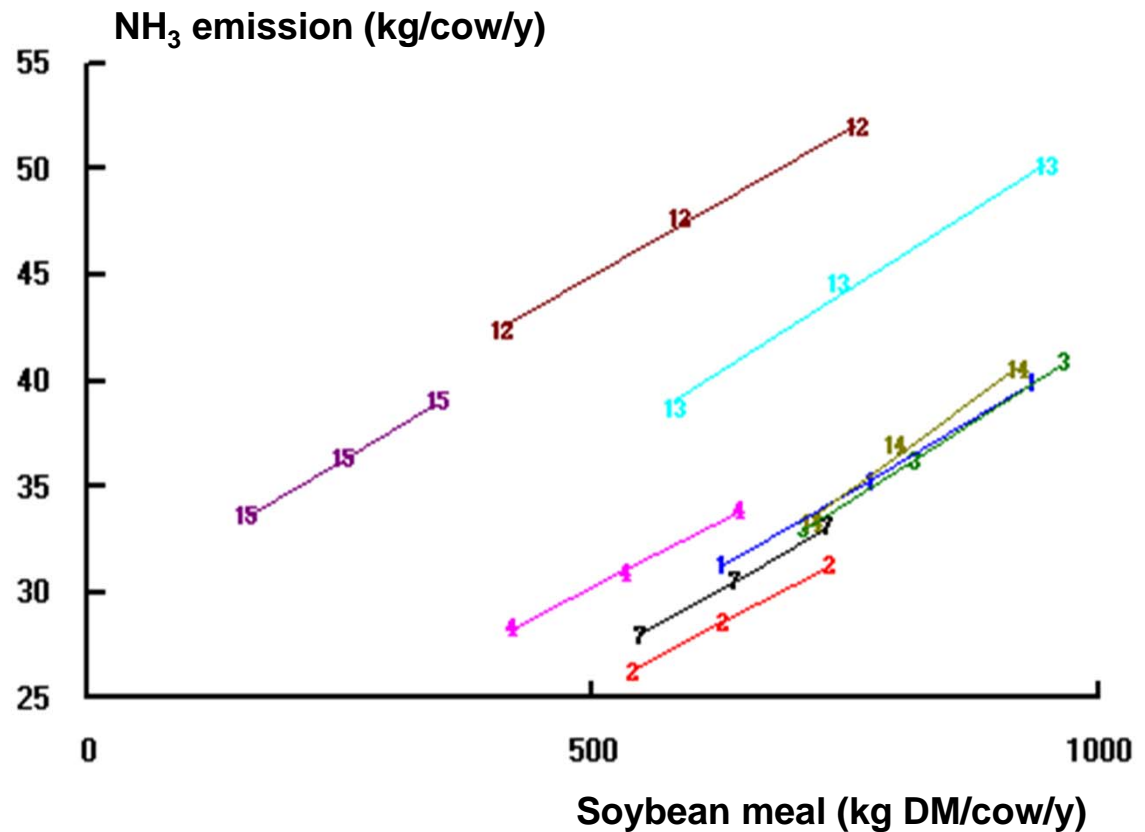




# Protein supplementation and ammonia losses



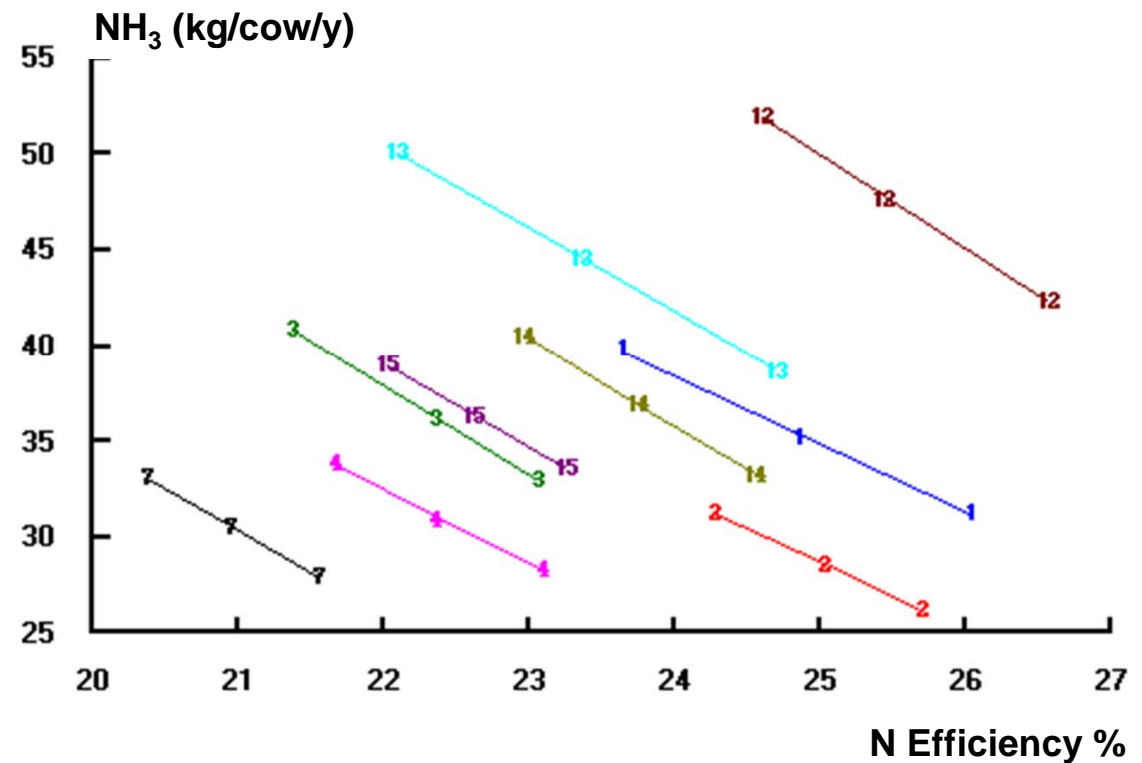
N ammonia increases of 2.9 kg per 100 kg DM Soybean Meal per cow per year, or 3.5 kg ammonia. (NH<sub>3</sub> emissions including manure spreading, inventory methods)





# N efficiency and ammonia emission

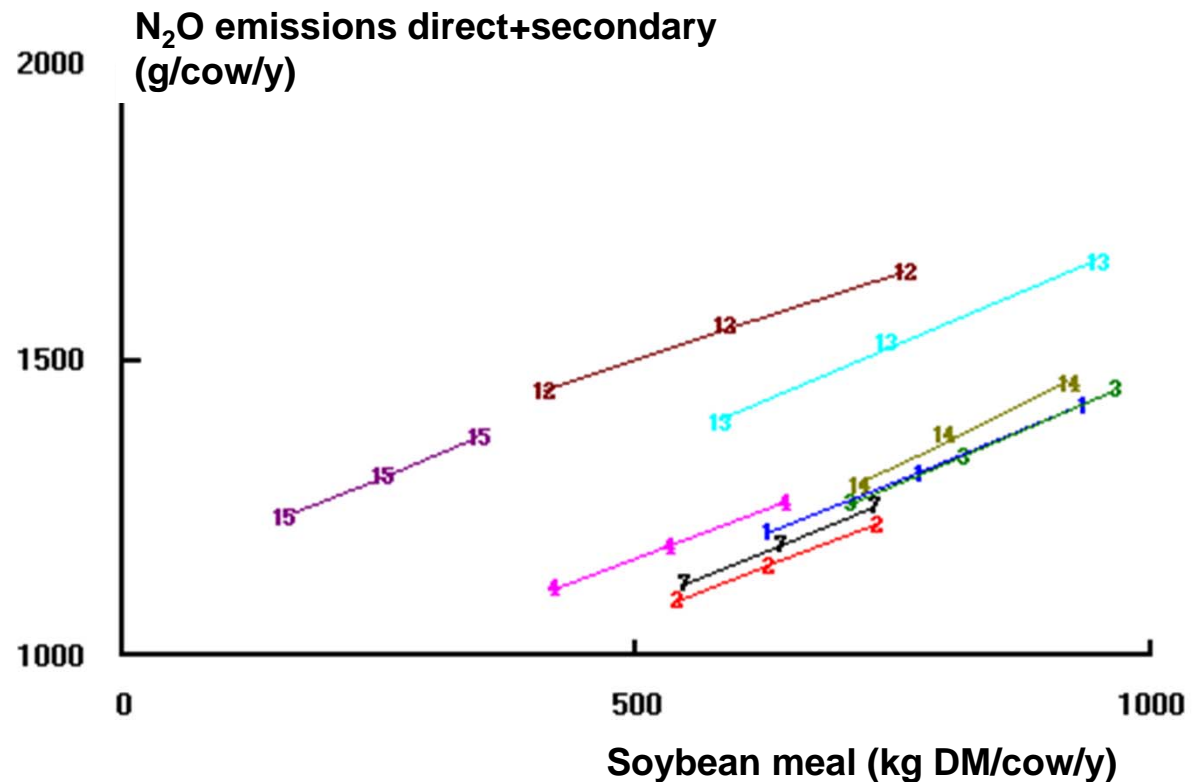
Ammonia emissions increases when N efficiency decreases within a system, but the relationship between farming systems is less clear, the time spent indoor being an important factor



# Greenhouse gas emissions increases with protein supplementation



The GHG emissions increases of 70.5 kg CO<sub>2</sub> equivalent for 100 DM additional soybean meal due to an increase in N<sub>2</sub>O emissions





# Conclusions

- CowNex is a simple tool to assess quickly the efficiency of N use at herd level
- Increase age at first calving decrease N efficiency of meat
- If maize systems could theoretically better balance protein supplementation, it is not always observed in practice and they are less protein selfsufficient
- Protein supplementation is an important lever to control protein selfsufficiency, nitrogen excretion and environmental impacts of dairy farming system
- Time spent indoor increases the risks of ammonia emissions
- In many systems, there is economic and environmental benefit to pay attention to the protein supplementation



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Thank you for your  
attention

It does not necessarily reflect its view and in no way anticipates the Commission's future policy in this area.

