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Nutrient Management of Livestock Manure

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of Manitoba**

1) Benefits of manure:

- supplies macro- & micro- nutrients for crops, increasing yield & quality
- increases SOM content, improving:
 - microbial activity
 - soil structure, aeration, water holding capacity, hydraulic conductivity, resistance to wind and water erosion
 - cation exchange capacity
 - soil pH buffering capacity



2) Challenges of manure:

- moisture and nutrient content vary with production system, weather, storage, handling
- inflexible balance of nutrients for crop needs

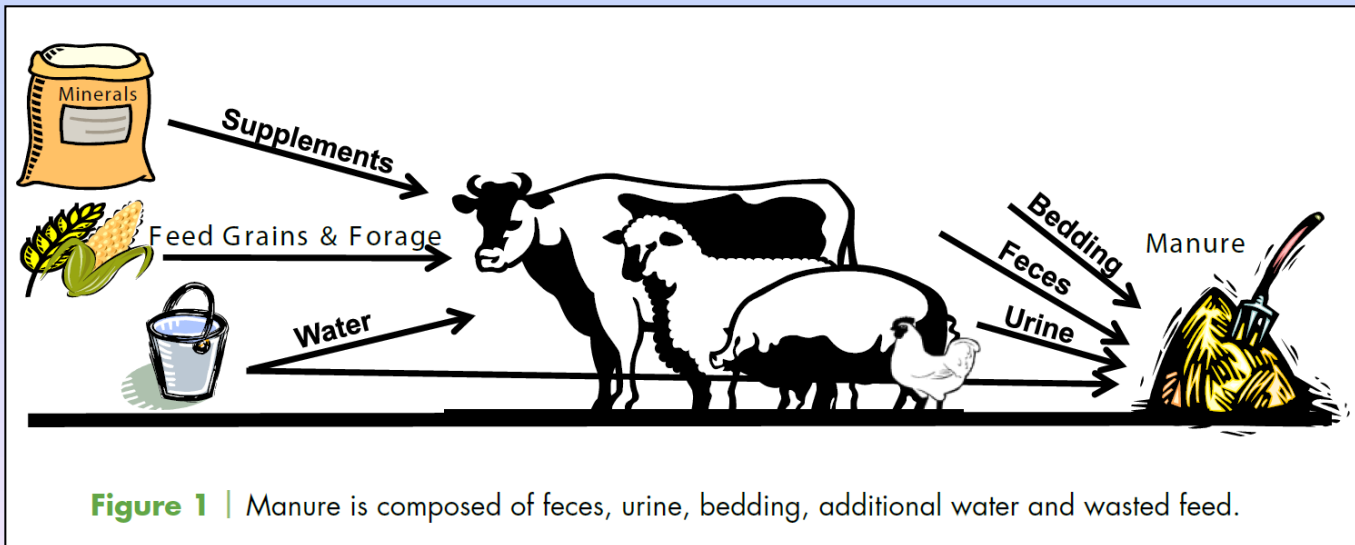


Figure 1 | Manure is composed of feces, urine, bedding, additional water and wasted feed.

Nutrient Content in Manure is Variable

Table 3d | Means, medians, maximums and minimums for total N, ammonium, organic N, P, K, S, DM and available N:P₂O₅ ratios for liquid pig manure from farrow to finish operations.

Farrow to Finish Operations		TKN	NH ₄ -N	Org N	P	K	S	DM	avail N:P ₂ O ₅
		lb/1000 gal							
All n=118	Mean	26.9	18.7	8.2	6.2	11.4	1.8	2.2	1.9
	Median	26.0	18.0	7.0	5.0	11.7	1.5	1.7	0.8
	Max	67.0	35.0	37.0	43.7	17.5	9.1	10.0	12.5
	Min	7.0	3.9	0.0	0.1	1.4	0.3	0.5	0.2

Table 5 | Means, medians, maximums and minimums for total N, ammonium, organic N, P, K, S and estimated¹ available N:P₂O₅ ratios for solid beef manures.

Solid Beef Manure		TKN	NH ₄ -N	Org N	P	K	S	DM	avail N:P ₂ O ₅
		lb/ton							
n=93	Mean	10.6	1.5	9.0	2.0	10.5	1.8	26.1	1.0
	Median	10.3	1.2	8.8	1.9	9.10	1.5	24.7	0.8
	Max	16.9	8.5	15.3	7.0	37.2	8.9	50.2	3.5
	Min	5.4	0.0	2.9	0.6	3.3	0.1	14.3	0.2

¹ Available N is estimated to be all of the ammonium-N plus 25 per cent of the organic N. Recent research has shown that the available N in solid pig, dairy and beef manures with straw bedding is often much less and may be zero in the first years following manure application.

Source: MB Agriculture. Properties of Manure. <https://www.gov.mb.ca/agriculture/environment/nutrient-management/pubs/properties-of-manure.pdf>

2) Challenges of manure:

- moisture and nutrient content vary with production system, weather, storage, handling
- inflexible balance of nutrients for crop needs
- short economic hauling distance (low nut. content)
- odour and pathogens
- excessive rates, in particular, pose environmental risks and legal risks, due to regulations

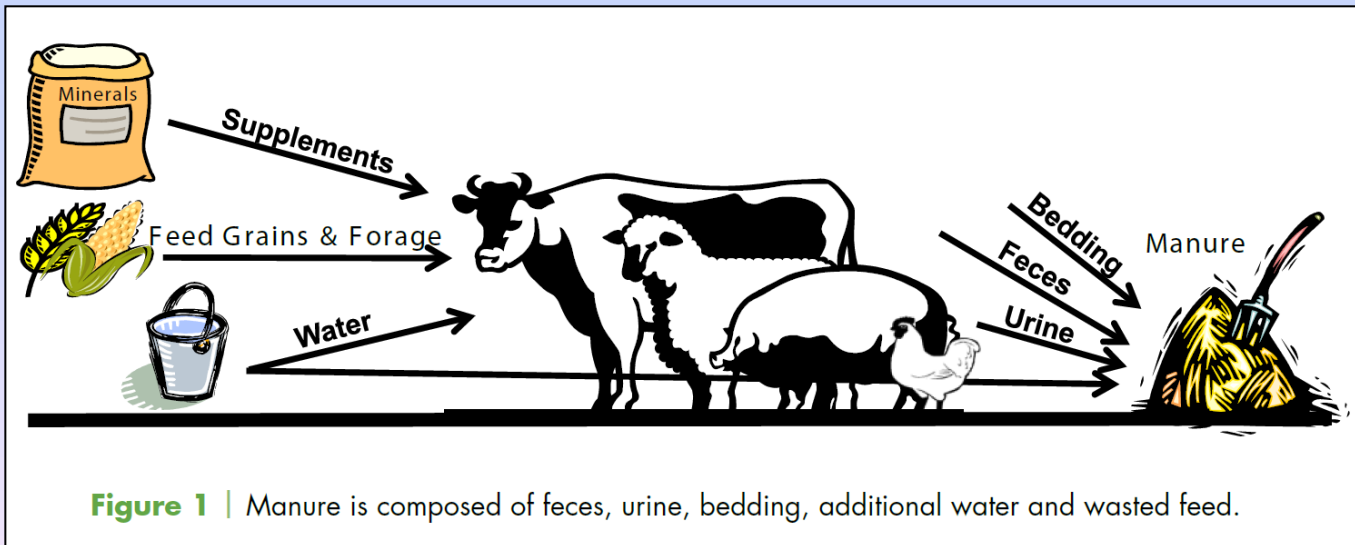


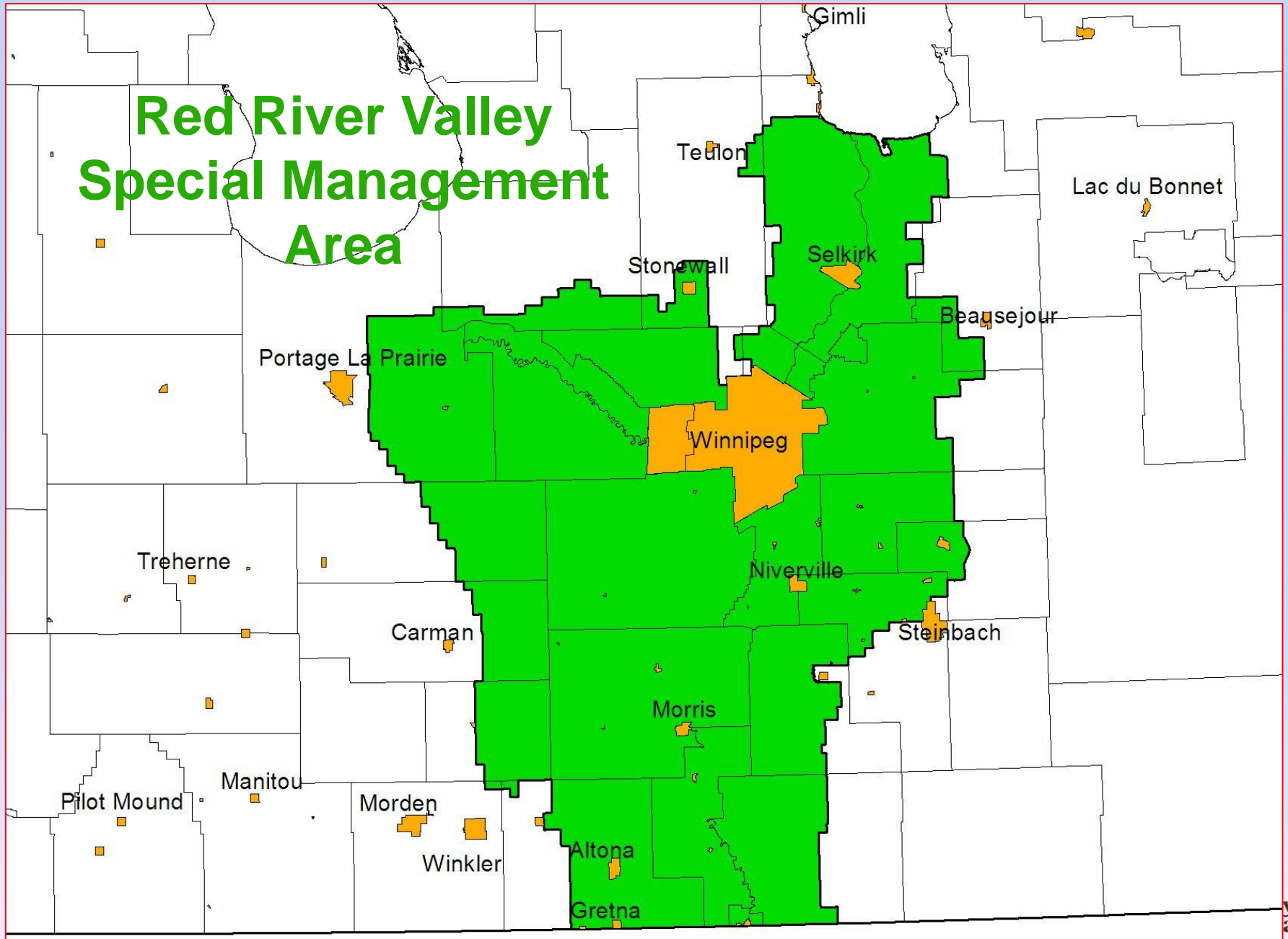
Figure 1 | Manure is composed of feces, urine, bedding, additional water and wasted feed.

3) Manure management regulations in Manitoba

Livestock Manure & Mortalities Mgmt. Reg'n (LMMMR):

- manure management plans are required for large operations**
- winter application of manure is prohibited**
- fall application of manure is restricted ... injection or incorporation required in areas with risk of flooding**
- N limits ... Water Quality Management Zones and Residual Nitrate-N Limits (lb NO₃-N/ac in fall) are defined by Canada Land Inventory Ag Capability Classes (same as for synthetic fertilizer mgmt.)**
- P Limits ... Manitoba's P reg'ns restrict maximum amount of P that can be applied as manure, based on concentrations of Olsen soil test P (same as for synthetic fertilizer mgmt.)**

LMMMR: Restrictions on Fall Application of Manure



Maximum Residual Soil Test N for Manitoba's Water Quality Management Zones

Zone	CLI Ag Cap Class	Residual NO ₃ -N
N1	1, 2, 3 (except 3m)	140 lb/ac
N2	3m, 4, irrigated 5m	90 lb/ac
N3	5 (except irr. 5m)	30 lb/ac
N4, Nutrient Buffer Zones	6, 7, areas in or near waterways	No Application
N5	Urban and built-up areas	Under Development

***Regulated for manure & synthetic fertilizer as of 2011**

**Province of Manitoba Water Quality
Management Zones for Nutrients**

140

Zone 1

30

Zone 3

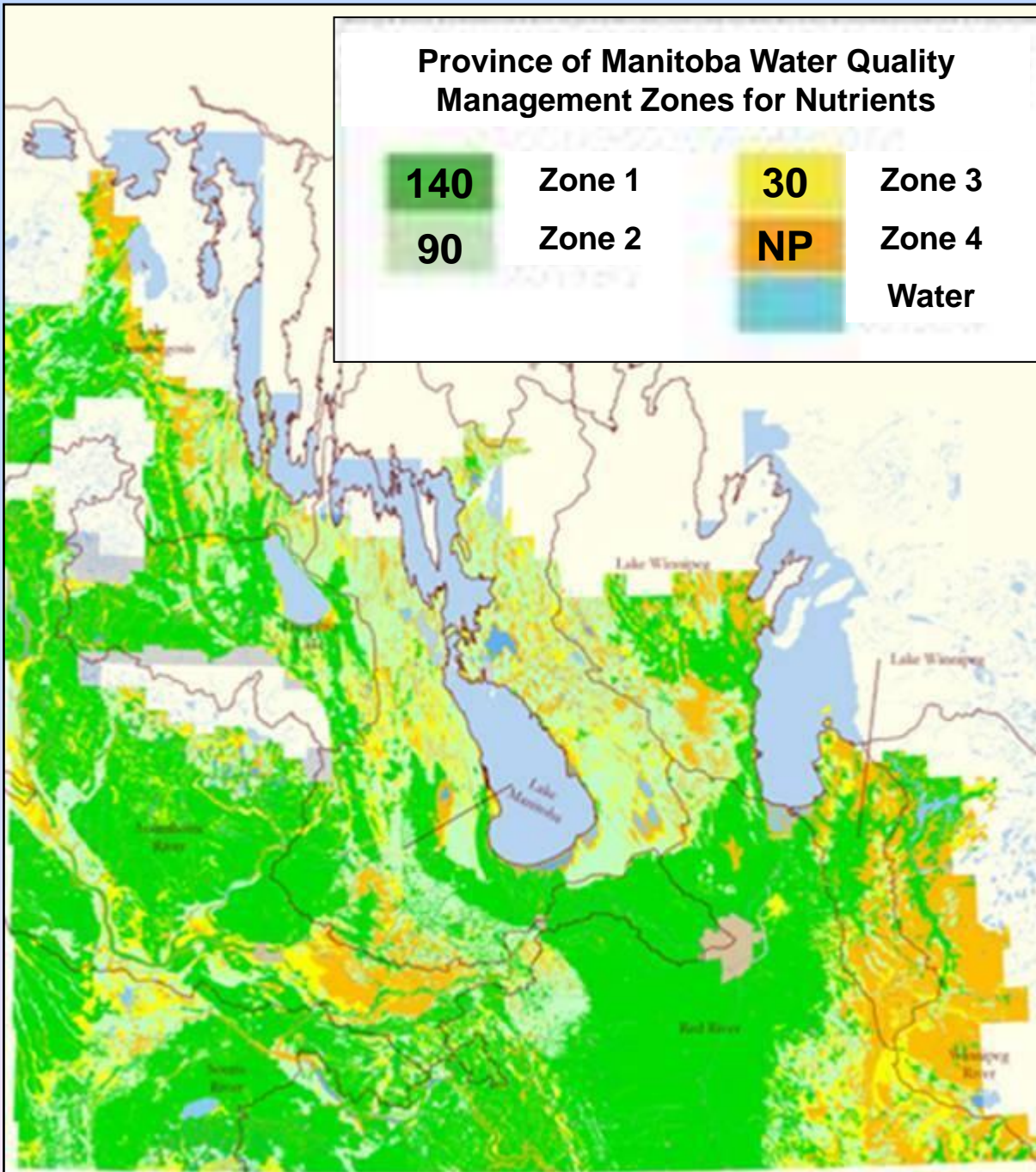
90

Zone 2

NP

Zone 4

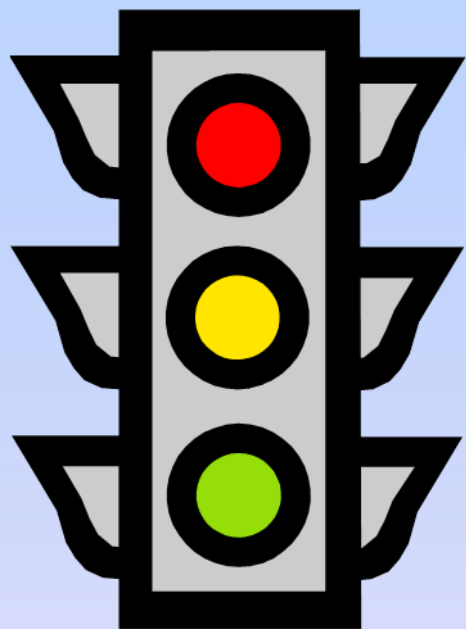
Water



**Water Quality
Management
Zones and
Residual Nitrate-N
Limits (lb NO₃-
N/ac)
at the Provincial
Scale**

Manitoba's Phosphorus Regulations

(For Manure and Synthetic Fertilizer)



Soil Test P*	Maximum Rate of Manure P Application
>180 ppm	No P application
120-180 ppm	Apply P up to <u>1x</u> crop removal rate
60-120 ppm	Apply P up to <u>2x</u> crop removal rate
<60 ppm P	Apply manure for crop <u>N requirements</u>

* sodium bicarbonate (Olsen) extraction method

4) Manure Nutrient Availability to Crops

Nitrogen in manure

- available org. N - MB guidelines estimate available Org. N in Year 1 as ~ 0.25 (Org. N)
- available ammonium-N ($\text{NH}_4\text{-N}$):
= $\text{NH}_4\text{-N} \times \frac{(100 - \% \text{ Volatilization Loss})}{100}$
- volatilization loss varies with weather & appl'n method; less loss with cool T & injection or incorporation

Volatilization Losses from Manure Application

TABLE 2: VOLATILIZATION LOSSES (%)¹

Method of Application	Weather Conditions				
	Average	Cool Wet	Cool Dry	Warm Wet	Warm Dry
Injected	0	0	0	0	0
Incorporated 1 day	25	10	15	25	50
Incorporated 2 day	30	13	19	31	57
Incorporated 3 day	35	15	22	38	65
Incorporated 4 day	40	17	26	44	72
Incorporated 5 day	45	20	30	50	80
Not Incorporated	66	40	50	75	100
Irrigated	Above +10%	Above +10%	Above +10%	Above +10%	Above +10%
Standing/Cover Crop/Stubble	35	25	25	40	50

¹ MARC 2008. Manure Application Rate Calculator software for Manitoba, Manitoba Agriculture, Food and Rural Initiatives.

Nitrogen in manure, cont'd.

- in reality, these "standard" calculations ignore:
 - some stockpiled solid manures contain significant nitrate-N
 - availability of organic N is highly influenced by C:N ratio of manure ... solid manure with bedding releases N much more slowly than liquid manure

Table 7 | C:N Ratios for Solid and Liquid Layer Manures and Solid Beef Manure in Manitoba.

	Layer		Solid Beef n=93
	Solid n=10	Liquid n=39	
Average	4.36	3.57	14.59
Min	2.75	2.38	7.08
Max	6.41	4.44	27.62

Source: MB Agriculture. Properties of Manure. <https://www.gov.mb.ca/agriculture/environment/nutrient-management/pubs/properties-of-manure.pdf>

Different types of manure are ... different



**Beef manure @ 64 t/ac
89 lbs “available” N/acre**



**Hog manure @ 3560 gal/ac
89 lbs “available” N/acre**

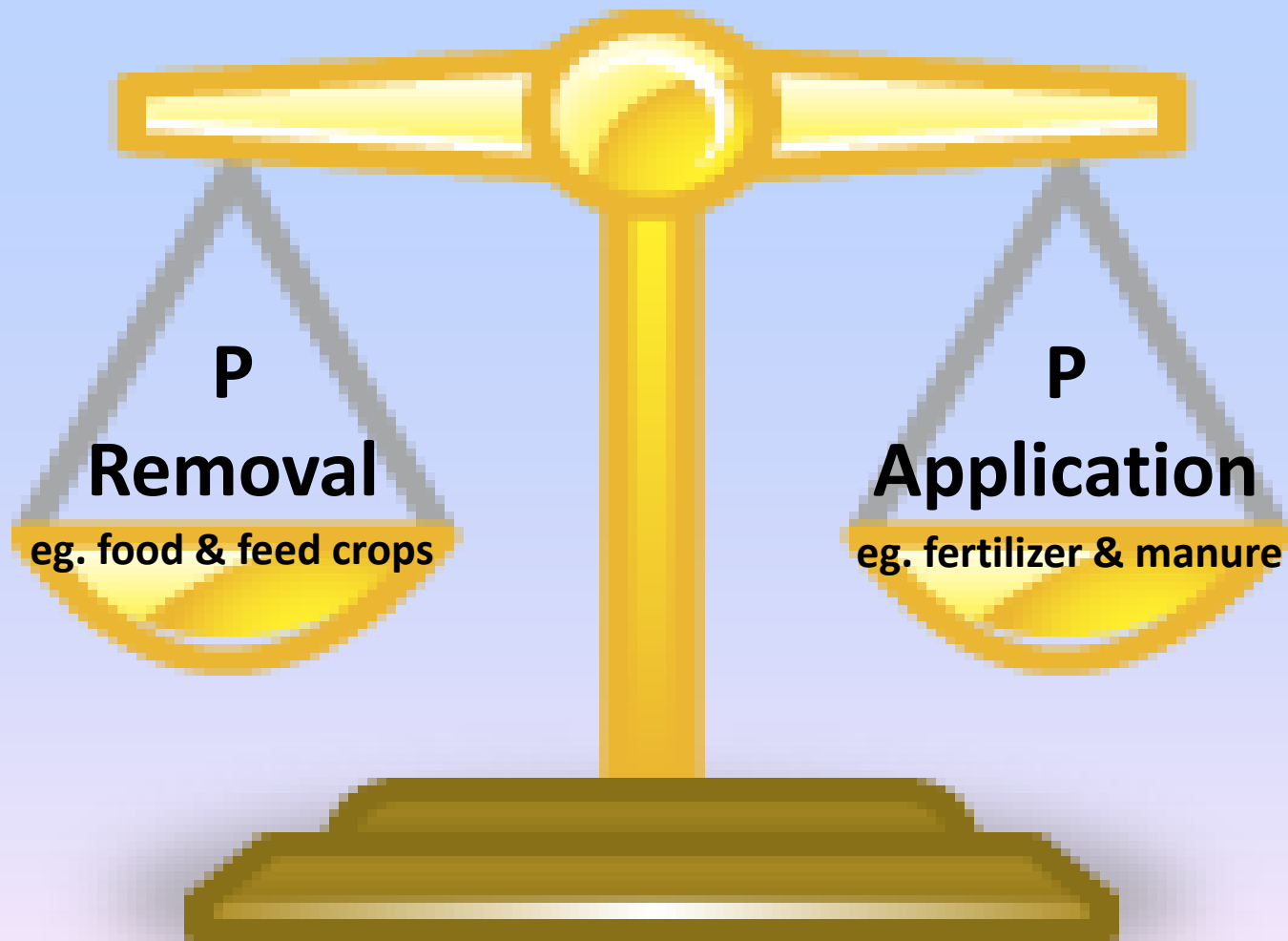
Nitrogen in manure, cont'd.

- For spring applied manure:
 - Total Avail. N = Avail. $\text{NH}_4\text{-N}$ + Avail. Org. N
- For fall applied manure:
 - Total Avail. N = **0.83** x (Avail. $\text{NH}_4\text{-N}$ + Avail. Org. N)
 - accounts for 17% efficiency loss if applied in fall vs. spring due to:
 - Immobilization
 - Leaching
 - Denitrification

Phosphorus in manure

- livestock manure is a rich source of P for crops:
 - ratio of available N:total P₂O₅ in most manures is < 1:1
 - ratio of N required:P₂O₅ removed by most crops > 2:1
 - application of manure to meet the crop's N requirements results in application of enough P for several years of crop production

Balancing P application with crop removal is essential for sustainable crop production and environmental protection



Application of liquid hog manure or solid cattle manure to supply crop N requirements supplies several years of P for annual crops¹

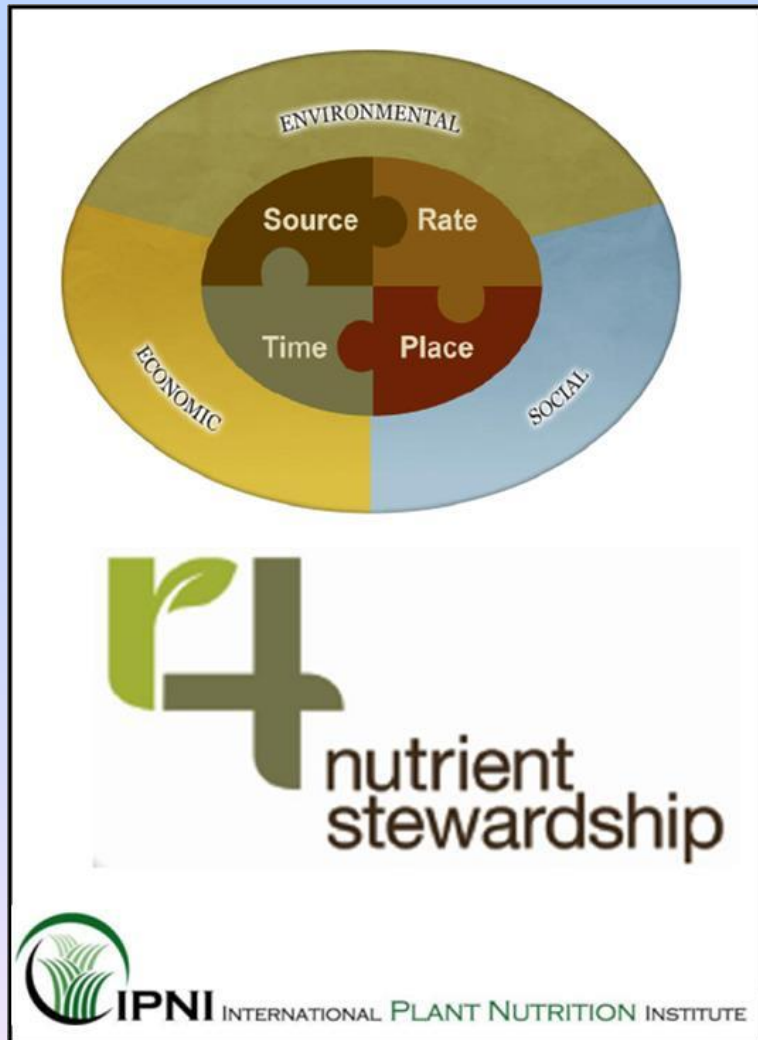
Barley with 80 bu/ac yield goal	Hog Manure	Cattle Manure
Target N Rate (net basis, lb N/ac) ²	80	80
Manure Appl'n Rate (gal or t/ac)	3,390	21
P Application Rate (lb P ₂ O ₅ /ac)	72	134
P Removal Rate (lb P ₂ O ₅ /ac) ³	35	35
P Surplus (lb P ₂ O ₅ /ac)	37	99

¹ Manure analyses are from the Tri-Provincial Manure Application and Use Guidelines

² Assumes all manure is spring applied, by subsurface injection, with no significant volatilization loss of NH₄-N

³ Assumes that P is removed as grain only

4R Principles of Nutrient Stewardship for Manure Management



- Right rate – aim for nutrient balance over the long term; avoid consecutive annual applications at N-based rates, which accumulate excessive P
- Right source & placement - inject (liquid manure) or incorporate (solid manure) to minimize losses & maximize benefits
- Right time – do not apply on frozen or snow-covered soils

Acknowledgements

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