Data Needs

- For whole-farm manure-N balance sheet
- For Irrigation and Nitrogen Management Plan (INMP) and Implementation

Whole-farm manure-N balance sheet (values in lbs for demonstration purposes)

Farm input needed | Calculated quantity (no input needed)

Source	MNAA (Supply)	INMP Demand	Export Goal (Supply - Demand)	Export Actual	Export Balance (Goal - Actual)
Liquid Manure	420,000	200,000	220,000	0	220,000
Solid Manure	140,000	100,000	40,000	37,000	3,000
Total	**560,000**	**300,000**	**260,000**	**37,000**	**223,000**

SRMR: Table 11, modified

- MNAA = **M**anure **N**itrogen **A**vailable for **A**pplication
- INMP = **I**rrigation and **N**itrogen **M**anagement **P**lan

Manure-N Supply

N-excretion estimates (i.e., quantities that are calculated)

Quantity	Symbol
Herd's total excreted N (improved)	N_{E_total}
Herd's excreted N managed in liquid form (new)	N_{E_LM}
Herd's excreted N managed in solid form (new)	N_{E_SM}
Herd's total excreted N after volatilization losses (i.e., Manure Nitrogen Available for Application)	MNAA
Herd's excreted N managed in liquid form after volatilization losses (new)	$MNAA_{LM}$
Herd's excreted N managed in solid form after volatilization losses (new)	$MNAA_{SM}$

SRMR: Table 6

On subsequent slides, data needs are highlighted with a colored cloud

Data needs for N-excretion by animal

Dairy Order Animal Group	Total nitrogen excretion per animal per day (N_E)	
	Merced County Tool	Proposed Change
Lactating Cow	N_E = Milk x 4.204 + 283.300 ‡ Inter-study error = 57.7 Residual error = 110.8	No Change
Dry Cow	N_E = 0.5 (lbs/animal/day) § Assumes animal weight of 1,660 lbs ¶	No Change
Heifer (15-24 months)	N_E = 0.26 (lbs/animal/day) § Assumes animal weight of 970 lbs ¶#	Keep N_E = 0.26 (lbs/animal/day) as default Provide option: N_E = DMI x C_{CP} x 78.390 + 51.350 ▲ Inter-study error = 24.47 | Residual error = 10.76
Heifer (7-14 months)		
Calf (4-6 months)	N_E = 0.14 (lbs/animal/day) § Assumes animal weight of 330 lbs ¶#	Continue use of N_E = 0.14 (lbs/animal/day) Extend age group to 3-6 month
Calf (0-3 months)		Reduce age group to 0-2 months N_E = 0.017 (lbs/animal/day) §

SRMR: Table 2

† In g/animal/day unless stated otherwise; ‡ ASAE D384.2 MAR2005, Section 5.3.7, equation 16 (p.8); Milk=milk production (kg/animal/day)
§ ASAE D384.2 MAR2005, Table 1.b (p.2)
¶ Agricultural Waste Management Field Handbook, Chapter 4, Table 4-5 (p.4-13)
# Representative weight for this growth period, see Agricultural Waste Management Field Handbook, Chapter 4 (p.4-8)
▲ ASAE D384.2 MAR2005, Section 5.3.9, equation 19 (p.8); DMI=dry matter intake (kg dry feed/ animal/day); C_{CP} = concentration of crude protein of total ration (g crude protein/g dry feed)

Data needs for N-excretion by animal group

Animal Group	Dairy Order Variable	Proposed Change
Lactating Cow	MaxMilkCowCount (maximum)	MaxMilkCowCount (mean)
Dry Cow	MaxDryCowCount (maximum)	MaxDryCowCount (mean)
Heifer (15-24 months)	MaxHeifer15To24Count (maximum)	MaxHeifer15To24Count (mean)
Heifer (7-14 months)	MaxHeifer7To14Count (maximum)	MaxHeifer7To14Count (mean)
Calf (3-6 months)	MaxCalf4To6Count (maximum)	MaxCalf**3**To6Count (mean)
Calf (0-3 months)	MaxCalfTo3Count (maximum)	MaxCalfTo**2**Count (mean)

SRMR: Table 3, modified

N-excretion estimates (i.e., quantities that are calculated)

Quantity	Symbol
✓ Herd's total excreted N (improved)	N_{E_total}
Herd's excreted N managed in liquid form (new)	N_{E_LM}
Herd's excreted N managed in solid form (new)	N_{E_SM}
Herd's total excreted N after volatilization losses (i.e., Manure Nitrogen Available for Application)	MNAA
Herd's excreted N managed in liquid form after volatilization losses (new)	$MNAA_{LM}$
Herd's excreted N managed in solid form after volatilization losses (new)	$MNAA_{SM}$

Data needs for N-partitioning into liquid and solid

This table shows liquid manure collection as percentage of total manure collection based on residence time of lactating cows

Type of Dairy	Residence Time	Range
Corrals without flush lanes	8-19%	11%
Corrals with flush lanes	21-48%	27%
Freestalls without corrals	100%	0%
Freestalls with corrals	42-100%	58%

SRMR: Table 4, modified

- Farmer enters dairy type. DMS returns default upper and lower bounds for LM and SM
- Farmer can further refine based on farm-specific operational knowledge

This table modified from Chang et al. (2006)

N-excretion estimates (i.e., quantities that are calculated)

Quantity	Symbol
✓ Herd's total excreted N (improved)	N_{E_total}
✓ Herd's excreted N managed in liquid form (new)	N_{E_LM}
✓ Herd's excreted N managed in solid form (new)	N_{E_SM}
Herd's total excreted N after volatilization losses (i.e., Manure Nitrogen Available for Application)	MNAA
Herd's excreted N managed in liquid form after volatilization losses (new)	$MNAA_{LM}$
Herd's excreted N managed in solid form after volatilization losses (new)	$MNAA_{SM}$

No data needs for N-volatilization (at this time)

30% volatilization losses are applied to LM and SM alike (no change from current General Order).

Maybe refined (customized site-specifically) in the future based on manure-N partitioning, evaluation of whole-farm balance outliers, and improved SM sampling protocol.

N-excretion estimates (i.e., quantities that are calculated)

Quantity	Symbol
✓ Herd's total excreted N (improved)	N_{E_total}
✓ Herd's excreted N managed in liquid form (new)	N_{E_LM}
✓ Herd's excreted N managed in solid form (new)	N_{E_SM}
✓ Herd's total excreted N after volatilization losses (i.e., Manure Nitrogen Available for Application)	MNAA
✓ Herd's excreted N managed in liquid form after volatilization losses (new)	$MNAA_{LM}$
✓ Herd's excreted N managed in solid form after volatilization losses (new)	$MNAA_{SM}$

Supply side completed

Farm input needed

Calculated quantity (no input needed)

Source	MNAA (Supply)	INMP Demand	Export Goal (Supply - Demand)	Export Actual	Export Balance (Goal - Actual)
Liquid Manure	✓ 420,000	200,000	220,000	0	220,000
Solid Manure	✓ 140,000	100,000	40,000	37,000	3,000
Total	✓ 560,000	300,000	260,000	37,000	223,000

Manure-N Demand

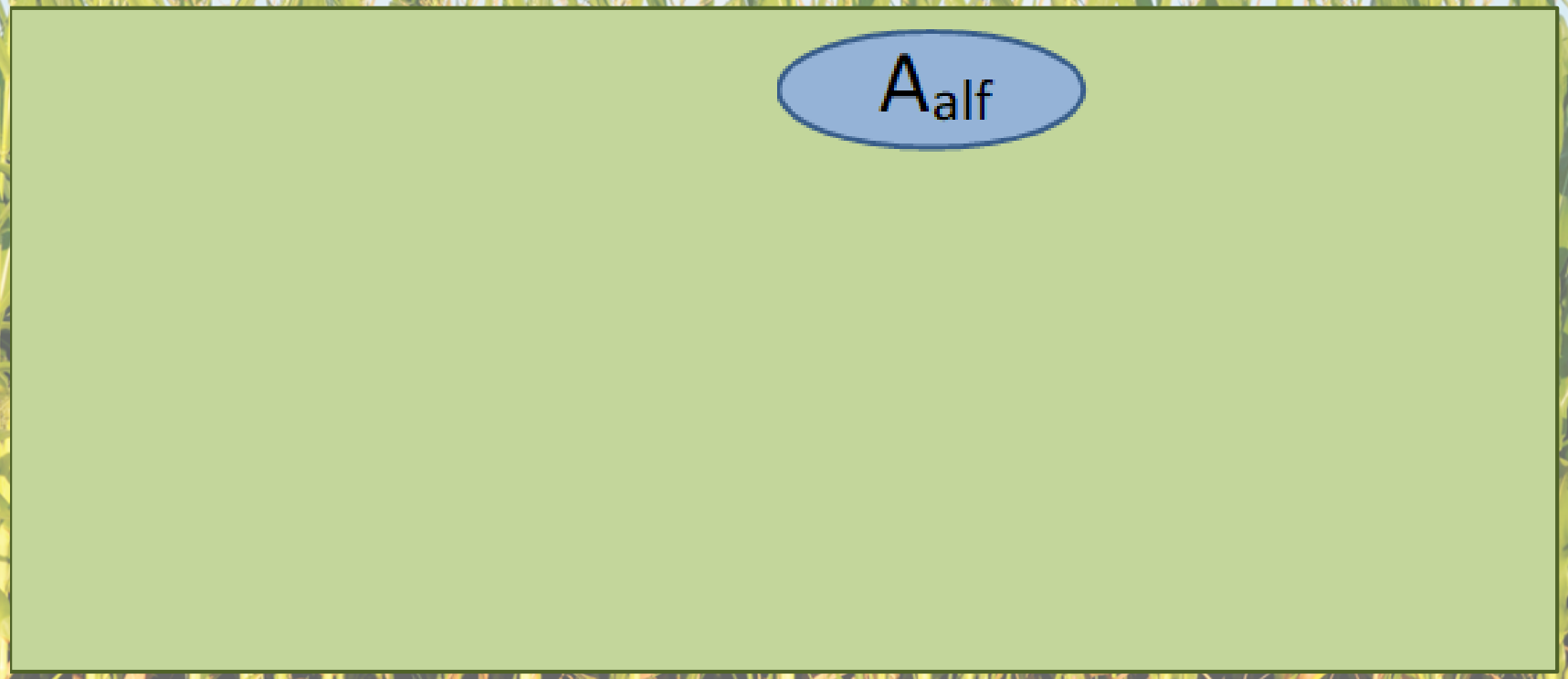
Data needs for physical acreage

Physical Acreage	Symbol & Relationships	Comment
Controlled acreage	A_c	This is the croppable acreage, not the actually cropped acreage regardless of the type of crop or the number of crops per year. It includes fallowed land, land planted in crops that do not receive manure, and land planted in alfalfa (regardless of whether manure is applied or not).
Manured acreage ‡	A_m $A_m = A_{LM} + A_{no\_LM}$ $A_m \leq A_c$	This is the portion of the controlled acreage where manure is applied (LM and/or SM).
LM manured acreage ‡	A_{LM} $A_{LM} \leq A_m \leq A_c$	This is the portion of the controlled acreage that is accessed by permanent/semi-permanent LM piping/conveyance infrastructure **and** receives LM.
Third-party acreage receiving LM ‡	A_{LM3}	This is not a portion of the controlled acreage. It is a neighbor's property that is accessed with permanent/semi-permanent LM piping/conveyance infrastructure; needs third-party agreement.
SM manured acreage ‡	A_{no_LM} $A_{no\_LM} \leq A_m \leq A_c$	This is the portion of the controlled acreage that is not accessed by permanent/semi-permanent LM piping/conveyance infrastructure **and** receives SM.
Acreage planted in leguminous crops	$A_{alf} \leq A_c$	This is the portion of A_c, that is planted in alfalfa or any other leguminous crop. It is not part of A_m, regardless of whether it receives LM and/or SM. Harvest removal from this acreage is not used in any of the diagnostics or N-accounting schemes recommended herein.

SRMR: Table 7

Physical acreage pictogram (previous slide visualized)

- other than A_m, these concepts are new -



Additional data needs for the demand side of the whole-farm manure N balance sheet

1. Crops and associated acreages (by type of physical acreage)
2. Yield goals by crop
3. N-concentrations in harvested crop*

*use readily available, established, crop-specific, representative values (new)

Demand side completed

Farm input needed

Calculated quantity (no input needed)

Source	MNAA (Supply)	INMP Demand	Export Goal (Supply - Demand)	Export Actual	Export Balance (Goal - Actual)
Liquid Manure	✓ 420,000	✓ 200,000	220,000	0	220,000
Solid Manure	✓ 140,000	✓ 100,000	40,000	37,000	3,000
Total	✓ 560,000	✓ 300,000	260,000	37,000	223,000

Manure exports are manifested (no change to GO)

	Farm input needed		Calculated quantity (no input needed)		
Source	MNAA (Supply)	INMP Demand	Export Goal (Supply - Demand)	Export Actual	Export Balance (Goal - Actual)
Liquid Manure	✓ 420,000	✓ 200,000	220,000	✓ 0	220,000
Solid Manure	✓ 140,000	✓ 100,000	40,000	✓ 37,000	3,000
Total	✓ 560,000	✓ 300,000	260,000	✓ 37,000	223,000

- SRMR proposes improved sampling protocol to estimate N content in SM (based on Miller, Heguy et al. 2019)

Additional Data Needs for INMP

- Used for the computation of robust diagnostics

Data needs for harvest removal rates from manured acreages

Symbol (lbs/ac)	Comment
$N_R(A_m) = N_R(A_{LM}) + N_R(A_{no\_LM})$	Harvest N removal from manured acreage
$N_R(A_{LM})$	N harvest removal from A_{LM} (New)
$N_R(A_{no\_LM})$	N harvest removal from A_{no_LM} (New)

SRMR: Table 9

- SRMR proposes improved sampling protocol to estimate harvest N removal (based on Miller, Fadel et al. 2018)
- Actual yield and associated harvest-N removal will be used to refine next year's yield goals/planning

Calculated robust diagnostics (New)

Maximum average farm-scale loading rate

Symbol	Comment
$MaxLR_{LM} = MNAA_{LM} \div A_{LM}$	Relationship between the dairy's MNAA managed in liquid form and the LM manured acreage.
$MaxLR_{LM\_adj} = MNAA_{LM} \div (A_{LM} + A_{LM3})$	Relationship between the dairy's MNAA managed in liquid form and the sum of LM manured acreage and LM3 manured acreage.
$MaxLR_{SM} = MNAA_{SM} \div A_{m}$	Relationship between dairy's MNAA managed in solid form and the manured acreage.
$MaxLR_{LM+} = MaxLR_{LM\_adj} + MaxLR_{SM}$	Relationship between total maximum average manure applications (both LM and SM) and the LM manured acreage (A_{LM}). This is not the same as MNAA ÷ A_{LM} or MNAA ÷ A_{m}

SRMR: Table 8

Calculated robust diagnostics (New)

Maximum average farm-scale application/removal ratio (difference if subtracted)

Symbol	Comment
$MaxMAR_{LM} = MaxLR_{LM} \div N_R(A_{LM})$	Relationship between the dairy's MNAA managed in liquid form and the harvest removal from A_{LM}.
$MaxMAR_{LM\_adj} = MaxLR_{LM\_adj} \div N_R(A_{LM})$	Relationship between the adjusted liquid manure loading rate and the harvest removal from A_{LM}.
$MaxMAR_{SM} = MaxLR_{SM} \div N_R(A_m)$	Relationship between the dairy's MNAA managed in solid form and the harvest removal from the manured acreage (A_m).
$MaxMAR_{LM+} = MaxLR_{LM+} \div N_R(A_{LM})$	Relationship between the dairy's total maximum average manure applications (both LM and SM) and the harvest removal from A_{LM}. This is not the same as MNAA $\div N_R(A_{LM})$ or MNAA $\div N_R(A_m)$.

SRMR: Table 10

Additional Data Needs for INMP

From SRMR, Section 2.6

Basic topics to be included in INMPs…

…in addition to those described on previous slides:

1. Identify actions to improve performance based on the analysis of data collected as part of the previous year's or cropping cycle's plan, as appropriate (New)
2. N application schedule (mode of application, material, rate) (New)
3. Irrigation systems (New)
4. Irrigation water sources and estimates of N content (New)
5. Irrigation schedule (based on estimates of expected ET, rainfall, and infiltration) (New)
6. Irrigation system maintenance procedures (New)
7. Wellhead protection procedures (New)
8. Procedures for maintaining fertigation equipment (New)
9. Description of data collection efforts (New)

Cited References

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Miller, C. M. F., J. G. Fadel, J. M. Heguy, B. M. Karle, P. L. Price and D. Meyer, 2018: Optimizing accuracy of protocols for measuring dry matter and nutrient yield of forage crops. Science of the Total Environment **624**, 180-188.

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