Lake Champlain Basin Program

TECHNICAL REPORT NO. 105A

Implementation of Whole Farm Nutrient Management to Reduce Phosphorus and Improve Farm Viability in the Lake Champlain Basin: Appendices A - E

July 2023

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For:
The Lake Champlain Basin Program and
New England Interstate Water Pollution Control Commission

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https://www.lcbp.org/news-and-media/publications/technical-reports/

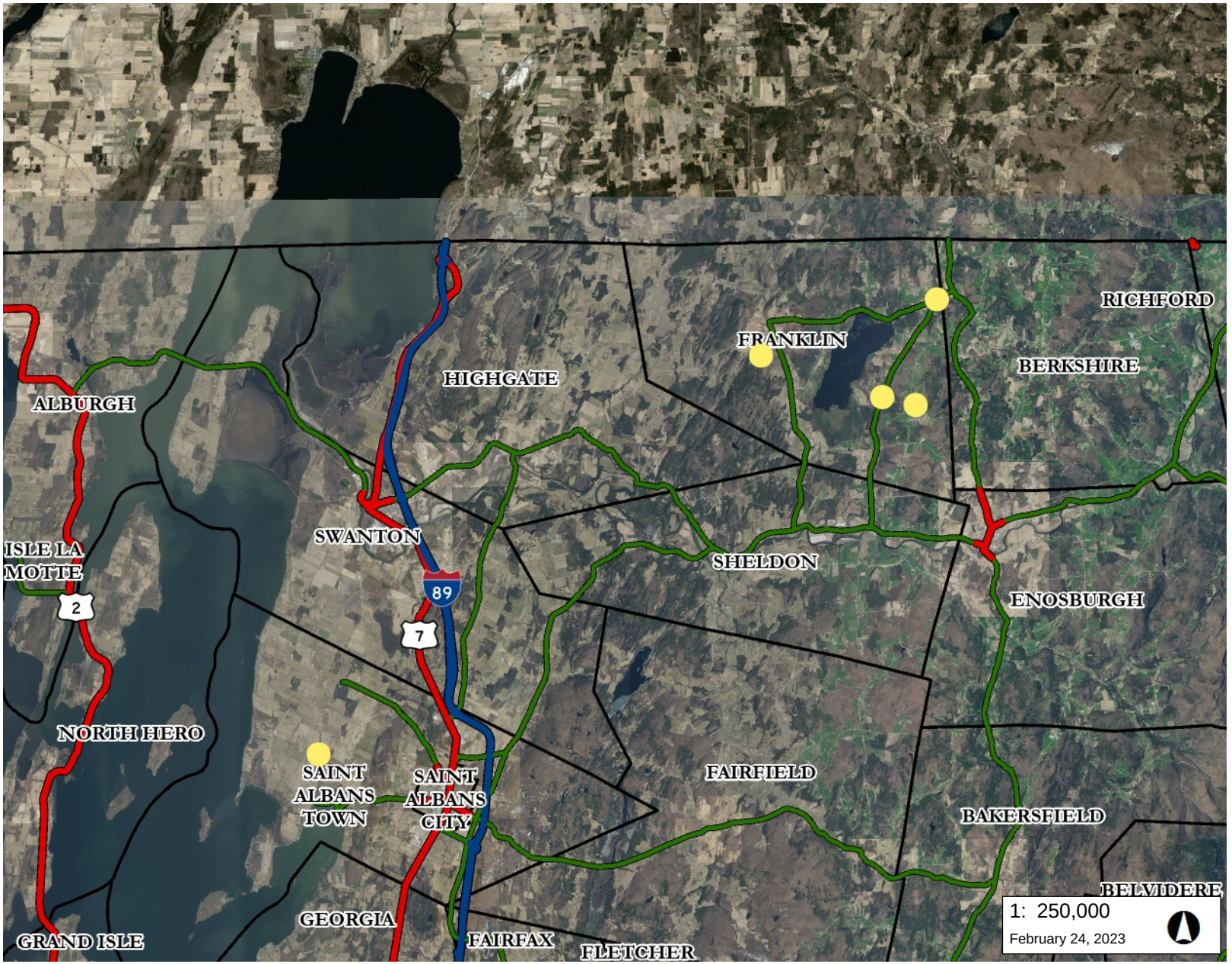
NEIWPCC Job Code: 995-002-001

VERMONT

LCBP Project Farm Locations

Vermont Agency of Natural Resources

vermont.gov



LEGEND

Roads

- Interstate
- US Highway; 1
- State Highway
- Town Highway (Class 1)
- Town Highway (Class 2,3)
- Town Highway (Class 4)
- State Forest Trail
- National Forest Trail
- Legal Trail
- Private Road/Driveway
- Proposed Roads

Town Boundary

NOTES

Map depicting location of participating farms in the LCBP project IMPLEMENTATION OF WHOLE FARM NUTRIENT MANAGEMENT TO REDUCE PHOSPHORUS AND IMPROVE FARM VIABILITY IN THE

12,700.0 0 6,350.00 12,700.0 Meters

WGS_1984_Web_Mercator_Auxiliary_Sphere 1" = 20833 Ft. 1cm = 2500 Meters

THIS MAP IS NOT TO BE USED FOR NAVIGATION

DISCLAIMER: This map is for general reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. ANR and the State of Vermont make no representations of any kind, including but not limited to, the warranties of merchantability, or fitness for a particular use, nor are any such warranties to be implied with respect to the data on this map.

Annual Nutrient Mass Balance

Farm Name **Farm 1**
Farm Manager
Balance Date **2020-05-01**
Preparer **Heather Darby**
Crop Year **2019**

Mass Nutrient Balance

Category	N	P	K	N	P	K	N	P	K
Imports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Feed	53.71	8.22	26.58	120.69	18.48	59.74	107.42	16.45	53.17
Fertilizer	30.53	1.56	7.15	68.60	3.50	16.07	61.06	3.12	14.30
Animals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Imports	84.24	9.78	33.73	189.30	21.99	75.81	168.48	19.57	67.47
Exports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Milk	36.70	6.36	11.32	82.47	14.30	25.43	73.40	12.73	22.63
Animals	3.77	0.91	0.26	8.47	2.04	0.58	7.54	1.82	0.52
Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports	40.47	7.27	11.58	90.95	16.35	26.01	80.94	14.55	23.15
Difference (Import - Export)	43.77	2.51	22.16	98.35	5.64	49.79	87.53	5.02	44.32

Dairy Diagnostics

Mature Cows	596
Animal Units	1180 AUs
Milk Production	23731.37 lbs/cow/year
Ratio of Cows to Heifers	1.99 to 1
Total Legume Acres	600 acres
Receiving Manure	89 % of tillable acres

Feed Purchased vs. Farm-Produced (as % of total feed dry matter)		
Feed Type	**Purchased**	**Farm-Produced**
Feed	20%	80%
Forage	0%	80%
Grain	20%	0%

Production Density In Context	per manure acre	per tillable acre
Animal Density	1.33 AUs / manure acre	1.18 AUs / tillable acre
Milk Production	15892.02 lbs / manure acre	14143.89 lbs / tillable acre

Remaining Nutrients In Context	N	P	K
Per Animal Unit	74.18 lbs/AU	4.25 lbs/AU	37.56 lbs/AU
Per Mature Cow	146.87 lbs/cow	8.42 lbs/cow	74.36 lbs/cow
% of Imported Remaining	52%	26%	66%

Production Efficiency In Context	N	P	K
Feed Use Efficiency (Milk/Feed)	14%	18%	6%
Imported per cwt milk sold	1.19 lbs/cwt	0.14 lbs/cwt	0.48 lbs/cwt
Remaining per cwt milk sold	0.62 lbs/cwt	0.04 lbs/cwt	0.31 lbs/cwt

Other Nitrogen Contributions

Source	tons/year	lbs/tillable acres
Legume N Fixation (Crops)	66.56	133.13
Atmospheric N Deposition	4.00	8.00
Total other N imports	70.56	141.13
Total N Remaining	114.33	228.66
Total N Remaining / AU	193.78 lbs/AU	
Total N Remaining / Cow	383.66 lbs/cow	
% Total N Remaining	74%	

Legume fixation is an important source of N on many farms, but there are many uncertainties associated with this estimate. The N fixation estimate is based on the farm total legume production. If the crop is >90% legume, the estimated N fixation is 60% of the crop N content. For crops with 90% or less legume, the estimated N fixation is 36% of the crop N constant.

Atmospheric nitrogen deposition is estimated at 8 lbs per total farm acre.

Annual Nutrient Mass Balance

Farm Name **Farm 1**
Farm Manager
Balance Date **2022-08-23**
Preparer **Heather Darby**
Crop Year **2022**

Mass Nutrient Balance

Category	N	P	K	N	P	K	N	P	K
Imports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Feed	69.81	7.66	21.25	156.88	17.20	47.76	139.62	15.31	42.51
Fertilizer	41.84	0.93	6.16	94.02	2.08	13.85	83.68	1.85	12.32
Animals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Imports	111.65	8.58	27.41	250.89	19.29	61.61	223.30	17.16	54.83
Exports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Milk	56.09	9.48	16.86	126.05	21.31	37.88	112.19	18.96	33.72
Animals	3.77	0.91	0.26	8.47	2.04	0.58	7.54	1.82	0.52
Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports	59.86	10.39	17.12	134.52	23.35	38.47	119.73	20.78	34.24
Difference (Import - Export)	51.78	-1.81	10.30	116.37	-4.07	23.14	103.57	-3.62	20.59

Dairy Diagnostics

Mature Cows	545	
Animal Units	1060.25	AUs
Milk Production	38664.12	lbs/cow/year
Ratio of Cows to Heifers	4.19	to 1
Total Legume Acres	600	acres
Receiving Manure	89	% of tillable acres

Feed Purchased vs. Farm-Produced (as % of total feed dry matter)		
Feed Type	**Purchased**	**Farm-Produced**
Feed	17%	83%
Forage	0%	83%
Grain	17%	0%

Production Density In Context	per manure acre	per tillable acre
Animal Density	1.19 AUs / manure acre	1.06 AUs / tillable acre
Milk Production	23676.34 lbs / manure acre	21071.95 lbs / tillable acre

Remaining Nutrients In Context	N	P	K
Per Animal Unit	97.68 lbs/AU	-3.42 lbs/AU	19.42 lbs/AU
Per Mature Cow	190.04 lbs/cow	-6.64 lbs/cow	37.79 lbs/cow
% of Imported Remaining	46%	-21%	38%

Production Efficiency In Context	N	P	K
Feed Use Efficiency (Milk/Feed)	22%	27%	8%
Imported per cwt milk sold	1.06 lbs/cwt	0.08 lbs/cwt	0.26 lbs/cwt
Remaining per cwt milk sold	0.49 lbs/cwt	-0.02 lbs/cwt	0.10 lbs/cwt

Other Nitrogen Contributions

Source	tons/year	lbs/tillable acres
Legume N Fixation (Crops)	52.81	105.62
Atmospheric N Deposition	4.00	8.00
Total other N imports	56.81	113.62
Total N Remaining	108.59	217.18
Total N Remaining / AU	204.84 lbs/AU	
Total N Remaining / Cow	398.50 lbs/cow	
% Total N Remaining	64%	

Legume fixation is an important source of N on many farms, but there are many uncertainties associated with this estimate. The N fixation estimate is based on the farm total legume production. If the crop is >90% legume, the estimated N fixation is 60% of the crop N content. For crops with 90% or less legume, the estimated N fixation is 36% of the crop N constant.

Atmospheric nitrogen deposition is estimated at 8 lbs per total farm acre.

Annual Nutrient Mass Balance

Farm Name **Farm 2**
Farm Manager
Balance Date **2020-05-01**
Preparer **Heather Darby**
Crop Year **2019**

Mass Nutrient Balance

Category	N	P	K	N	P	K	N	P	K
Imports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Feed	101.20	14.97	26.15	110.00	16.27	28.43	110.00	16.27	28.43
Fertilizer	99.77	0.00	0.00	108.45	0.00	0.00	108.45	0.00	0.00
Animals	0.04	0.01	0.00	0.05	0.01	0.00	0.05	0.01	0.00
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Imports	201.01	14.98	26.15	218.49	16.28	28.43	218.49	16.28	28.43
Exports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Milk	53.61	9.45	16.80	58.27	10.27	18.26	58.27	10.27	18.26
Animals	6.29	1.52	0.43	6.84	1.65	0.47	6.84	1.65	0.47
Crops	6.96	1.12	6.14	7.57	1.21	6.67	7.57	1.21	6.67
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports	66.86	12.08	23.37	72.67	13.14	25.40	72.67	13.14	25.40
Difference (Import - Export)	134.15	2.90	2.78	145.82	3.15	3.02	145.82	3.15	3.02

Dairy Diagnostics

Mature Cows	847	
Animal Units	1651.9	AUs
Milk Production	24793.39	lbs/cow/year
Ratio of Cows to Heifers	1.64	to 1
Total Legume Acres	210	acres
Receiving Manure	100	% of tillable acres

Feed Purchased vs. Farm-Produced (as % of total feed dry matter)		
Feed Type	**Purchased**	**Farm-Produced**
Feed	28%	72%
Forage	0%	72%
Grain	28%	0%

Production Density In Context	per manure acre	per tillable acre
Animal Density	0.90 AUs / manure acre	0.90 AUs / tillable acre
Milk Production	11413.04 lbs / manure acre	11413.04 lbs / tillable acre

Remaining Nutrients In Context	N	P	K
Per Animal Unit	162.42 lbs/AU	3.51 lbs/AU	3.37 lbs/AU
Per Mature Cow	316.77 lbs/cow	6.84 lbs/cow	6.57 lbs/cow
% of Imported Remaining	67%	19%	11%

Production Efficiency In Context	N	P	K
Feed Use Efficiency (Milk/Feed)	23%	29%	12%
Imported per cwt milk sold	1.91 lbs/cwt	0.14 lbs/cwt	0.25 lbs/cwt
Remaining per cwt milk sold	1.28 lbs/cwt	0.03 lbs/cwt	0.03 lbs/cwt

Other Nitrogen Contributions

Source	tons/year	lbs/tillable acres
Legume N Fixation (Crops)	25.40	27.60
Atmospheric N Deposition	7.36	8.00
Total other N imports	32.76	35.60
Total N Remaining	166.91	181.42
Total N Remaining / AU	202.08 lbs/AU	
Total N Remaining / Cow	394.11 lbs/cow	
% Total N Remaining	71%	

Legume fixation is an important source of N on many farms, but there are many uncertainties associated with this estimate. The N fixation estimate is based on the farm total legume production. If the crop is >90% legume, the estimated N fixation is 60% of the crop N content. For crops with 90% or less legume, the estimated N fixation is 36% of the crop N constant.

Atmospheric nitrogen deposition is estimated at 8 lbs per total farm acre.

Annual Nutrient Mass Balance

Farm Name **Farm 2**
Farm Manager
Balance Date **2022-08-23**
Preparer **Heather Darby**
Crop Year **2022**

Mass Nutrient Balance

Category	N	P	K	N	P	K	N	P	K
Imports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Feed	129.31	21.73	28.17	150.41	25.28	32.77	143.95	24.19	31.36
Fertilizer	65.37	0.32	6.62	76.03	0.37	7.70	72.77	0.35	7.37
Animals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	11.08	4.83	10.45	12.89	5.62	12.16	12.33	5.38	11.64
Total Imports	205.75	26.87	45.25	239.33	31.26	52.64	229.05	29.92	50.37
Exports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Milk	61.01	10.51	18.69	70.97	12.23	21.74	67.92	11.70	20.80
Animals	6.35	1.53	0.44	7.39	1.78	0.51	7.07	1.71	0.49
Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports	67.36	12.04	19.13	78.35	14.01	22.25	74.99	13.41	21.29
Difference (Import - Export)	138.39	14.83	26.12	160.98	17.25	30.39	154.06	16.51	29.08

Dairy Diagnostics

Mature Cows	890	
Animal Units	1960	AUs
Milk Production	26247.19	lbs/cow/year
Ratio of Cows to Heifers	1.33	to 1
Total Legume Acres	547.36	acres
Receiving Manure	95.7	% of tillable acres

Feed Purchased vs. Farm-Produced (as % of total feed dry matter)		
Feed Type	**Purchased**	**Farm-Produced**
Feed	13%	87%
Forage	0%	84%
Grain	13%	3%

Production Density In Context	per manure acre	per tillable acre
Animal Density	1.14 AUs / manure acre	1.09 AUs / tillable acre
Milk Production	13586.29 lbs / manure acre	13002.48 lbs / tillable acre

Remaining Nutrients In Context	N	P	K
Per Animal Unit	141.22 lbs/AU	15.13 lbs/AU	26.66 lbs/AU
Per Mature Cow	310.99 lbs/cow	33.33 lbs/cow	58.71 lbs/cow
% of Imported Remaining	67%	55%	58%

Production Efficiency In Context	N	P	K
Feed Use Efficiency (Milk/Feed)	10%	12%	5%
Imported per cwt milk sold	1.76 lbs/cwt	0.23 lbs/cwt	0.39 lbs/cwt
Remaining per cwt milk sold	1.18 lbs/cwt	0.13 lbs/cwt	0.22 lbs/cwt

Other Nitrogen Contributions

Source	tons/year	lbs/tillable acres
Legume N Fixation (Crops)	67.96	75.66
Atmospheric N Deposition	7.19	8.00
Total other N imports	75.15	83.66
Total N Remaining	213.54	237.72
Total N Remaining / AU	217.90 lbs/AU	
Total N Remaining / Cow	479.87 lbs/cow	
% Total N Remaining	76%	

Legume fixation is an important source of N on many farms, but there are many uncertainties associated with this estimate. The N fixation estimate is based on the farm total legume production. If the crop is >90% legume, the estimated N fixation is 60% of the crop N content. For crops with 90% or less legume, the estimated N fixation is 36% of the crop N constant.

Atmospheric nitrogen deposition is estimated at 8 lbs per total farm acre.

Annual Nutrient Mass Balance

Farm Name **Farm 3**
Farm Manager
Balance Date **2020-03-11**
Preparer **Heather Darby**
Crop Year **2019**

Mass Nutrient Balance

Category	N	P	K	N	P	K	N	P	K
Imports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Feed	10.82	1.92	2.60	59.13	10.52	14.23	59.13	10.52	14.23
Fertilizer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Animals	0.12	0.03	0.01	0.67	0.16	0.05	0.67	0.16	0.05
Miscellaneous	0.01	0.00	0.00	0.05	0.00	0.00	0.05	0.00	0.00
Total Imports	10.95	1.95	2.61	59.85	10.68	14.27	59.85	10.68	14.27
Exports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Milk	6.39	1.03	1.84	34.93	5.65	10.05	34.93	5.65	10.05
Animals	1.06	0.26	0.07	5.81	1.40	0.40	5.81	1.40	0.40
Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports	7.46	1.29	1.91	40.74	7.06	10.46	40.74	7.06	10.46
Difference (Import - Export)	3.50	0.66	0.70	19.10	3.62	3.82	19.10	3.62	3.82

Dairy Diagnostics

Mature Cows	150	
Animal Units	234.6	AUs
Milk Production	15330	lbs/cow/year
Ratio of Cows to Heifers	21.43	to 1
Total Legume Acres	50	acres
Receiving Manure	100	% of tillable acres

Feed Purchased vs. Farm-Produced (as % of total feed dry matter)		
Feed Type	**Purchased**	**Farm-Produced**
Feed	25%	75%
Forage	0%	75%
Grain	25%	0%

Production Density In Context	per manure acre	per tillable acre
Animal Density	0.64 AUs / manure acre	0.64 AUs / tillable acre
Milk Production	6282.79 lbs / manure acre	6282.79 lbs / tillable acre

Remaining Nutrients In Context	N	P	K
Per Animal Unit	29.80 lbs/AU	5.65 lbs/AU	5.95 lbs/AU
Per Mature Cow	46.61 lbs/cow	8.83 lbs/cow	9.31 lbs/cow
% of Imported Remaining	32%	34%	27%

Production Efficiency In Context	N	P	K
Feed Use Efficiency (Milk/Feed)	24%	21%	7%
Imported per cwt milk sold	0.95 lbs/cwt	0.17 lbs/cwt	0.23 lbs/cwt
Remaining per cwt milk sold	0.30 lbs/cwt	0.06 lbs/cwt	0.06 lbs/cwt

Other Nitrogen Contributions

Source	tons/year	lbs/tillable acres
Legume N Fixation (Crops)	0.76	4.16
Atmospheric N Deposition	1.46	8.00
Total other N imports	2.23	12.16
Total N Remaining	5.72	31.26
Total N Remaining / AU	48.77 lbs/AU	
Total N Remaining / Cow	76.28 lbs/cow	
% Total N Remaining	43%	

Legume fixation is an important source of N on many farms, but there are many uncertainties associated with this estimate. The N fixation estimate is based on the farm total legume production. If the crop is >90% legume, the estimated N fixation is 60% of the crop N content. For crops with 90% or less legume, the estimated N fixation is 36% of the crop N constant.

Atmospheric nitrogen deposition is estimated at 8 lbs per total farm acre.

Annual Nutrient Mass Balance

Farm Name **Farm 3**
Farm Manager
Balance Date **2022-01-01**
Preparer **Heather Darby**
Crop Year **2022**

Mass Nutrient Balance

Category	N	P	K	N	P	K	N	P	K
Imports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Feed	10.69	1.81	2.56	58.42	9.89	14.00	58.42	9.89	14.00
Fertilizer	3.04	0.00	0.00	16.59	0.00	0.00	16.59	0.00	0.00
Animals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
Total Imports	13.73	1.81	2.56	75.02	9.89	14.00	75.02	9.89	14.00
Exports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Milk	7.04	1.17	2.09	38.45	6.42	11.41	38.45	6.42	11.41
Animals	0.90	0.22	0.06	4.92	1.19	0.34	4.92	1.19	0.34
Crops	1.52	0.16	1.16	8.31	0.89	6.32	8.31	0.89	6.32
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports	9.46	1.56	3.31	51.68	8.50	18.07	51.68	8.50	18.07
Difference (Import - Export)	4.27	0.25	-0.75	23.34	1.39	-4.07	23.34	1.39	-4.07

Dairy Diagnostics

Mature Cows	130	
Animal Units	196.2	AUs
Milk Production	20075	lbs/cow/year
Ratio of Cows to Heifers	N/A	to 1
Total Legume Acres	50	acres
Receiving Manure	100	% of tillable acres

Feed Purchased vs. Farm-Produced (as % of total feed dry matter)		
Feed Type	**Purchased**	**Farm-Produced**
Feed	12%	88%
Forage	0%	88%
Grain	12%	0%

Production Density In Context	per manure acre	per tillable acre
Animal Density	0.54 AUs / manure acre	0.54 AUs / tillable acre
Milk Production	7130.46 lbs / manure acre	7130.46 lbs / tillable acre

Remaining Nutrients In Context	N	P	K
Per Animal Unit	43.54 lbs/AU	2.59 lbs/AU	-7.60 lbs/AU
Per Mature Cow	65.72 lbs/cow	3.92 lbs/cow	-11.47 lbs/cow
% of Imported Remaining	31%	14%	-29%

Production Efficiency In Context	N	P	K
Feed Use Efficiency (Milk/Feed)	16%	16%	8%
Imported per cwt milk sold	1.05 lbs/cwt	0.14 lbs/cwt	0.20 lbs/cwt
Remaining per cwt milk sold	0.33 lbs/cwt	0.02 lbs/cwt	-0.06 lbs/cwt

Other Nitrogen Contributions

Source	tons/year	lbs/tillable acres
Legume N Fixation (Crops)	3.69	20.19
Atmospheric N Deposition	1.46	8.00
Total other N imports	5.16	28.19
Total N Remaining	9.43	51.53
Total N Remaining / AU	96.12 lbs/AU	
Total N Remaining / Cow	145.07 lbs/cow	
% Total N Remaining	50%	

Legume fixation is an important source of N on many farms, but there are many uncertainties associated with this estimate. The N fixation estimate is based on the farm total legume production. If the crop is >90% legume, the estimated N fixation is 60% of the crop N content. For crops with 90% or less legume, the estimated N fixation is 36% of the crop N constant.

Atmospheric nitrogen deposition is estimated at 8 lbs per total farm acre.

Annual Nutrient Mass Balance

Farm Name **Farm 4**
Farm Manager
Balance Date **2020-07-01**
Preparer **Heather Darby**
Crop Year **2019**

Mass Nutrient Balance

Category	N	P	K	N	P	K	N	P	K
Imports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Feed	9.05	2.36	5.20	46.65	12.17	26.79	41.17	10.74	23.64
Fertilizer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Animals	82.64	19.95	5.70	425.97	102.82	29.38	375.89	90.73	25.92
Miscellaneous	19.68	2.45	3.60	101.44	12.62	18.56	89.52	11.13	16.37
Total Imports	111.37	24.76	14.50	574.07	127.61	74.72	506.57	112.61	65.94
Exports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Milk	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Animals	86.26	20.82	5.95	444.63	107.32	30.66	392.35	94.70	27.06
Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports	86.26	20.82	5.95	444.63	107.32	30.66	392.35	94.70	27.06
Difference (Import - Export)	25.11	3.94	8.55	129.44	20.29	44.06	114.22	17.90	38.88

Dairy Diagnostics

Mature Cows	360	
Animal Units	576	AUs
Milk Production	0	lbs/cow/year
Ratio of Cows to Heifers	4.5	to 1
Total Legume Acres	0	acres
Receiving Manure	88.24	% of tillable acres

Feed Purchased vs. Farm-Produced (as % of total feed dry matter)		
Feed Type	**Purchased**	**Farm-Produced**
Feed	< 1%	99%
Forage	< 1%	99%
Grain	< 1%	0%

Production Density In Context	per manure acre	per tillable acre
Animal Density	1.48 AUs / manure acre	1.31 AUs / tillable acre
Milk Production	0.00 lbs / manure acre	0.00 lbs / tillable acre

Remaining Nutrients In Context	N	P	K
Per Animal Unit	87.19 lbs/AU	13.67 lbs/AU	29.68 lbs/AU
Per Mature Cow	139.51 lbs/cow	21.86 lbs/cow	47.49 lbs/cow
% of Imported Remaining	23%	16%	59%

Production Efficiency In Context	N	P	K
Feed Use Efficiency (Milk/Feed)	N/A	N/A	N/A
Imported per cwt milk sold	N/A	N/A	N/A
Remaining per cwt milk sold	N/A	N/A	N/A

Other Nitrogen Contributions

Source	tons/year	lbs/tillable acres
Legume N Fixation (Crops)	0.00	0.00
Atmospheric N Deposition	1.76	8.00
Total other N imports	1.76	8.00
Total N Remaining	26.87	122.22
Total N Remaining / AU	93.30 lbs/AU	
Total N Remaining / Cow	149.28 lbs/cow	
% Total N Remaining	24%	

Legume fixation is an important source of N on many farms, but there are many uncertainties associated with this estimate. The N fixation estimate is based on the farm total legume production. If the crop is >90% legume, the estimated N fixation is 60% of the crop N content. For crops with 90% or less legume, the estimated N fixation is 36% of the crop N constant.

Atmospheric nitrogen deposition is estimated at 8 lbs per total farm acre.

Annual Nutrient Mass Balance

Farm Name **Farm 4**
Farm Manager
Balance Date **2021-12-09**
Preparer **Heather Darby**
Crop Year **2022**

Mass Nutrient Balance

Category	N	P	K	N	P	K	N	P	K
Imports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Feed	7.48	3.35	2.44	38.53	17.27	12.60	34.00	15.24	11.11
Fertilizer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Animals	21.69	5.26	1.50	111.80	27.11	7.73	98.66	23.92	6.82
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Imports	29.17	8.61	3.94	150.34	44.38	20.33	132.66	39.16	17.94
Exports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Milk	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Animals	25.22	6.15	1.77	129.99	31.72	9.13	114.71	27.99	8.06
Crops	7.18	0.87	5.80	36.98	4.48	29.88	32.64	3.95	26.37
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports	32.39	7.02	7.57	166.97	36.20	39.01	147.34	31.94	34.43
Difference (Import - Export)	-3.23	1.59	-3.63	-16.64	8.18	-18.69	-14.68	7.22	-16.49

Dairy Diagnostics

Mature Cows	80	
Animal Units	352.2	AUs
Milk Production	0	lbs/cow/year
Ratio of Cows to Heifers	3.64	to 1
Total Legume Acres	0	acres
Receiving Manure	88.24	% of tillable acres

Feed Purchased vs. Farm-Produced (as % of total feed dry matter)		
Feed Type	**Purchased**	**Farm-Produced**
Feed	< 1%	100%
Forage	0%	100%
Grain	< 1%	0%

Production Density In Context	per manure acre	per tillable acre
Animal Density	0.91 AUs / manure acre	0.80 AUs / tillable acre
Milk Production	0.00 lbs / manure acre	0.00 lbs / tillable acre

Remaining Nutrients In Context	N	P	K
Per Animal Unit	-18.33 lbs/AU	9.01 lbs/AU	-20.59 lbs/AU
Per Mature Cow	-80.69 lbs/cow	39.69 lbs/cow	-90.63 lbs/cow
% of Imported Remaining	-11%	18%	-92%

Production Efficiency In Context	N	P	K
Feed Use Efficiency (Milk/Feed)	N/A	N/A	N/A
Imported per cwt milk sold	N/A	N/A	N/A
Remaining per cwt milk sold	N/A	N/A	N/A

Other Nitrogen Contributions

Source	tons/year	lbs/tillable acres
Legume N Fixation (Crops)	8.98	40.83
Atmospheric N Deposition	1.76	8.00
Total other N imports	10.73	48.83
Total N Remaining	7.51	34.15
Total N Remaining / AU	42.63 lbs/AU	
Total N Remaining / Cow	187.68 lbs/cow	
% Total N Remaining	19%	

Legume fixation is an important source of N on many farms, but there are many uncertainties associated with this estimate. The N fixation estimate is based on the farm total legume production. If the crop is >90% legume, the estimated N fixation is 60% of the crop N content. For crops with 90% or less legume, the estimated N fixation is 36% of the crop N constant.

Atmospheric nitrogen deposition is estimated at 8 lbs per total farm acre.

Annual Nutrient Mass Balance

Farm Name **Farm 5**
Farm Manager
Balance Date **2020-02-27**
Preparer **Heather Darby**
Crop Year **2019**

Mass Nutrient Balance

Category	N	P	K	N	P	K	N	P	K
Imports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Feed	3.31	1.09	1.85	22.68	7.48	12.67	15.81	5.21	8.83
Fertilizer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Animals	0.17	0.04	0.01	1.19	0.29	0.08	0.83	0.20	0.06
Miscellaneous	0.02	0.00	0.00	0.15	0.01	0.00	0.11	0.01	0.00
Total Imports	3.51	1.14	1.86	24.03	7.78	12.75	16.74	5.42	8.89
Exports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Milk	1.03	0.16	0.29	7.06	1.11	1.97	4.92	0.77	1.37
Animals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crops	2.76	0.30	2.13	18.94	2.08	14.58	13.20	1.45	10.16
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports	3.80	0.47	2.42	26.00	3.19	16.55	18.12	2.22	11.53
Difference (Import - Export)	-0.29	0.67	-0.55	-1.97	4.59	-3.79	-1.37	3.20	-2.64

Dairy Diagnostics

Mature Cows	50	
Animal Units	88	AUs
Milk Production	7200	lbs/cow/year
Ratio of Cows to Heifers	0.83	to 1
Total Legume Acres	419	acres
Receiving Manure	69.69	% of tillable acres

Feed Purchased vs. Farm-Produced (as % of total feed dry matter)		
Feed Type	**Purchased**	**Farm-Produced**
Feed	8%	92%
Forage	7%	92%
Grain	< 1%	0%

Production Density In Context	per manure acre	per tillable acre
Animal Density	0.30 AUs / manure acre	0.21 AUs / tillable acre
Milk Production	1232.88 lbs / manure acre	859.19 lbs / tillable acre

Remaining Nutrients In Context	N	P	K
Per Animal Unit	-6.55 lbs/AU	15.23 lbs/AU	-12.59 lbs/AU
Per Mature Cow	-11.52 lbs/cow	26.80 lbs/cow	-22.16 lbs/cow
% of Imported Remaining	-8%	59%	-30%

Production Efficiency In Context	N	P	K
Feed Use Efficiency (Milk/Feed)	4%	4%	1%
Imported per cwt milk sold	1.95 lbs/cwt	0.63 lbs/cwt	1.03 lbs/cwt
Remaining per cwt milk sold	-0.16 lbs/cwt	0.37 lbs/cwt	-0.31 lbs/cwt

Other Nitrogen Contributions

Source	tons/year	lbs/tillable acres
Legume N Fixation (Crops)	10.08	48.12
Atmospheric N Deposition	1.68	8.00
Total other N imports	11.76	56.12
Total N Remaining	11.47	54.74
Total N Remaining / AU	260.64 lbs/AU	
Total N Remaining / Cow	458.73 lbs/cow	
% Total N Remaining	75%	

Legume fixation is an important source of N on many farms, but there are many uncertainties associated with this estimate. The N fixation estimate is based on the farm total legume production. If the crop is >90% legume, the estimated N fixation is 60% of the crop N content. For crops with 90% or less legume, the estimated N fixation is 36% of the crop N constant.

Atmospheric nitrogen deposition is estimated at 8 lbs per total farm acre.

Annual Nutrient Mass Balance

Farm Name **Farm 5**
Farm Manager
Balance Date **2022-12-19**
Preparer **Heather Darby**
Crop Year **2022**

Mass Nutrient Balance

Category	N	P	K	N	P	K	N	P	K
Imports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Feed	0.00	0.53	0.04	0.00	3.60	0.24	0.00	2.51	0.17
Fertilizer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Animals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.02	0.00	0.00	0.11	0.01	0.00	0.08	0.01	0.00
Total Imports	0.02	0.53	0.04	0.11	3.61	0.24	0.08	2.51	0.17
Exports	tons per year			lbs per acre receiving manure per year			lbs per total tillable acres per year		
Milk	0.77	0.12	0.22	5.30	0.83	1.48	3.69	0.58	1.03
Animals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exports	0.77	0.12	0.22	5.30	0.83	1.48	3.69	0.58	1.03
Difference (Import - Export)	-0.76	0.40	-0.18	-5.18	2.77	-1.24	-3.61	1.93	-0.86

Dairy Diagnostics

Mature Cows	60	
Animal Units	88.5	AUs
Milk Production	4500	lbs/cow/year
Ratio of Cows to Heifers	1.33	to 1
Total Legume Acres	419	acres
Receiving Manure	69.69	% of tillable acres

Feed Purchased vs. Farm-Produced (as % of total feed dry matter)		
Feed Type	**Purchased**	**Farm-Produced**
Feed	< 1%	100%
Forage	0%	100%
Grain	< 1%	0%

Production Density In Context	per manure acre	per tillable acre
Animal Density	0.30 AUs / manure acre	0.21 AUs / tillable acre
Milk Production	924.66 lbs / manure acre	644.39 lbs / tillable acre

Remaining Nutrients In Context	N	P	K
Per Animal Unit	-17.10 lbs/AU	9.15 lbs/AU	-4.09 lbs/AU
Per Mature Cow	-25.23 lbs/cow	13.50 lbs/cow	-6.03 lbs/cow
% of Imported Remaining	-4587%	77%	-517%

Production Efficiency In Context	N	P	K
Feed Use Efficiency (Milk/Feed)	4%	3%	1%
Imported per cwt milk sold	0.01 lbs/cwt	0.39 lbs/cwt	0.03 lbs/cwt
Remaining per cwt milk sold	-0.56 lbs/cwt	0.30 lbs/cwt	-0.13 lbs/cwt

Other Nitrogen Contributions

Source	tons/year	lbs/tillable acres
Legume N Fixation (Crops)	6.51	31.10
Atmospheric N Deposition	1.68	8.00
Total other N imports	8.19	39.10
Total N Remaining	7.43	35.48
Total N Remaining / AU	168.00 lbs/AU	
Total N Remaining / Cow	247.79 lbs/cow	
% Total N Remaining	91%	

Legume fixation is an important source of N on many farms, but there are many uncertainties associated with this estimate. The N fixation estimate is based on the farm total legume production. If the crop is >90% legume, the estimated N fixation is 60% of the crop N content. For crops with 90% or less legume, the estimated N fixation is 36% of the crop N constant.

Atmospheric nitrogen deposition is estimated at 8 lbs per total farm acre.

Farm Recommendation Report for LCBP Project

Farm #1

Project Goals: This project will demonstrate how whole farm nutrient management can reduce a farm's impact on phosphorus loading and water quality while enhancing overall farm viability.

EXECUTIVE SUMMARY

- Farm #1 is a 450-cow dairy operation located in East Franklin, VT with over 31% of the farm operation in the Lake Carmi Watershed.

- The farm has the opportunity to decrease purchased grain feeding by 2-4lbs/cow, approximately 5% across the lactating herd. Current ration P levels as provided by the current nutritionist are at 0.41% of DM, exceeding NRC recommendations. Modest reductions in ration P levels to 0.38% has the potential of reducing P imports by 1200 lbs/yr, or about 7%. This could be achieved by feeding higher forage rations. Currently the high cow group is fed a 53% forage ration. By increasing forages, purchased grain can be reduced while maintaining over all milk production. Potential reduction of 2-4lbs grain/cow across the lactating herd providing a financial savings of $0.30 per cow per day ($49,275.00 per year).

- To achieve these results critical improvements must be made to feed storage to minimize feed degradation and losses of nutrients through leachate.

- The farm has adequate land base to supply the herd with 85% of its diet from homegrown forage further reducing the need to purchase grain but forage species must be modified to maximize quality and fertilizer programs must be implemented to maintain at least average yields.

- Additional changes required to achieve these results will be phased into the farm plan once infrastructure is in place.

FARM INTRODUCTION

Farm #1 operates a 450 Holstein dairy operation in East Franklin, Vermont. This family farm has approximately 1000 acres of crop land and raises all its own replacement animals. This herd averages 80 pounds of milk per cow per day. This farm grows all of its own forages and some of its grain requirements in the form of snaplage. It grows about 450 acres of corn and crops about 600 acres of perennial forages. It purchases the balance of the grain requirements and its minerals.

WHOLE FARM NUTRIENT BALANCE

The farm feeds a high forage diet when possible. Part of this project has been to help them improve forages to reduce purchased nutrients in the form of grain. For the crop year 2020, the farm imported 44 tons of nitrogen, 2.51 tons of phosphorus, and 22 tons of potassium onto their farm. Most of the nitrogen importation (63%) is through feed purchases. 84% of the

phosphorus imports were due to purchased feeds. Purchased feeds also accounted for 75% of the potassium imports. The use of the Cornell Whole Farm nutrient balance model strongly suggests that improvements in utilization of home-grown forages and a reduction of purchased feeds will lower net imports of nutrients onto Farm #1. Nutrients left the farm in the form of milk and animal sales.

CROP AND NUTRIENT MANAGEMENT PLAN

Farm #1 has a nutrient management plan that meets the NRCS 590 standard and meets other state water quality requirements. The farm has participated in various state and federal conservation programs. In 2020, the farm produced forage from 24 corn silage fields (approximately 400 acres) and 19 hay fields (approximately 600 acres). The fertility on most of the Benjamin fields is adequate and the pH levels are sufficient to average yields if proper fertilization is applied during the growing season. The soil test P levels ranged from 1.05 to 11.25 ppm with a farm average of 5.64 ppm. This is in the optimum range for crop fields in Vermont. The P-Index ranged from a score of 7 to 57 with a farm average score of 33 (medium risk). This indicates that the farm is managing both P loading and transport to minimize risk to the surrounding water.

The farm implements no-till practices, manure injection on both perennial and annual crop fields, and utilizes reduced tillage when field conditions require it. All corn fields are cover cropped in the fall. This farm does conservation crop rotation practices on many of their fields. Much of the farm is very stony which limits corn rotations on some fields. Hay fields in rotation are a mix of improved grass and legume species. Levels of legumes are above 30% in the rotation fields helping to minimize the crop nitrogen requirements. However, permanent hay fields are primarily a blend of Kentucky bluegrass and white clover. These species are common in Vermont fields and generally reduce forage productivity and quality per acre.

Manure is the primary source of nutrients for all crops. A starter fertilizer is purchased for the corn crop. Additional fertilizer is purchased to grow the corn crop when PSNT testing recommends it.

To achieve the required amount of forage to feed an 85% forage diet, fertility in fields will need to be maintained to acquire forage yield and quality to support this high forage diet.

Forage species should be evaluated and modified where necessary to produce forage that has 65 to 70% digestible fiber. This may involve reseeding, frost seeding, and/or adding new forage species (small grains, summer annuals) to the cropping system.

PRECISION FEED MANAGEMENT

The goal of this project is to ultimately work towards feeding 1.2% of the cow's bodyweight as NDF. The neutral detergent fiber (NDF) is the portion of forage that includes hemicellulose, cellulose, and lignin. The more digestible the NDF the more forage a cow can eat. Hence to feed a cow 1.2% of its bodyweight as NDF the farm needs plentiful high-quality forage. To meet this goal, the Benjamin's farm will need to produce 4,611 tons of dry matter forages per year. This farm has the land base and the management skills to accomplish this goal. This can be grown as both corn silage or hay forages depending on the management style of the operator and how the fields can best be utilized. To produce not only the volume of forage but the quality

many additional factors must be considered/analyzed. First the species of forages in the field must be able to generate fiber digestibility of 70%. Second the feed must be harvested timely and stored properly to maintain the quality. Lastly, the ration must be balanced to maximize the inclusion of homegrown feed and supplement with additional feedstuffs where needed. This is a challenge on this farm primarily due to dated feed storage infrastructure that is resulting in significant feed quality losses. Before any of the outcomes can be achieved from this project, the infrastructure must be improved and updated.

FARM INFRASTRUCTURE ASSESSMENT

Much of the facilities and equipment on the farm are used but well maintained. This farm utilizes its own equipment and hires custom operators to help with the field work. This farm does an adequate job of managing the crop work to ensure timely harvests and pays attention to putting up the feed at the proper moisture levels to insure proper fermentation. Assessment of feed over the past year has indicated that most of the degradation of feed quality is due to feed storage limitations at the farm. While the purchased feeds are stored in upright bins, minimizing loss, the home-grown forages are stored in a less than adequate storage facility.

This farm has grown significantly over the last 20 years and the feed storage facilities have not been updated to provide adequate storage for the increased volume of feed. The bunks (where the forage is stored) are far too small for feed that needs to be stored. This farm utilized one storage bunker for most of the feed. The reliance on this one main storage bunker has resulted in the mixing and over piling of the feed. This results in the mixing of both feeds and contamination of the haylage with the silage leachate. Improvements in this area of the farm would reduce spoilage and leachate runoff while improving feed fermentation and allow for optimization of feed utilization by properly being able to properly separate feeds by quality. This would result in less spoilage losses of the total forage, retention of nutrients and forage quality, allowed for improved feed efficiency, higher forage intakes, less purchased grain.

Based on annual feed consumption requirements it is recommended that the farm build/implement improved feed storage. To achieve this goal, much earth work would need to be done. We are looking to what those costs may be for future recommendations.

The farm recently built a new heifer facility which is very efficient way to raise youngstock. The cow barns are well maintained and provide a comfortable environment for the cows to live in.

RECOMMENDATIONS FOR THE WHOLE FARM NUTRIENT PLAN

To achieve the required amount of forage to feed an 85% forage diet, fertility in fields will need to be maintained for optimum forage yield and quality to support the high forage diet.

Forage species should be evaluated on a field-by-field basis and modified where necessary to produce forage that has 65 to 70% digestible fiber. This may involve reseeding, frost seeding, and/or adding new forage species (small grains, summer annuals) to the cropping system. It also recommended that additional bunker storage be built to facilitate the utilization of BMR silage which will increase the digestibility of the diet and reduce grain inputs.

The balance of farm nutrients is good and no further modifications need to be made; however, P imports will be reduced when less grain is fed.

OUTCOMES OF THE WHOLE FARM NUTRIENT PLAN

Farm #1 is located in East Franklin, VT with over 31% of the farm operation in the Lake Carmi Watershed.

The farm has the opportunity to decrease grain feeding by increasing forage feeding approximately 5% units to that lactating cows, thereby reducing P imports by 5% and providing a financial savings of $0.30 per cow per day ($49,275.00 per year). Increasing use of forages from current 53% to >60% of rations and beyond will require 20-30% more forage storage capacity.

CHALLENGES TO ACCOMPLISHING THE PLAN

The farm can make improvements that can improve feed efficiency, reduce nutrient losses and loading, and enhance farm viability. Although the plan is practical there are still significant barriers to adoption of these improvements.

Due to the farm's financial situation, additional funding will need to be secured to implement the plan.

Most of the practices that need to be implemented are not funded through external grant or government programs.

Although financial gains will be gained through purchasing less grain, at least some of these savings would need to be reinvested in crop and soil management.

Finally, many of these practices, with proper funding, could be implemented immediately, the farm will likely need several years to fully implement the recommendations and realize the benefits.

Farm Recommendation Report for LCBP Project

Farm #2

Project Goals: This project will demonstrate how whole farm nutrient management can reduce a farm's impact on phosphorus loading and water quality while enhancing overall farm viability.

EXECUTIVE SUMMARY

- Farm #2 is a 840 cow dairy operation located in St. Albans Bay, VT with over 75% of the farm operation in the St. Albans Bay Watershed.

- Farm #2 in year 2020 fed rations of 0.46% P, exceeding nutritional requirements of 0.40% and averaged just under 30% efficiency of N utilization, feeding over 18% CP rations. Cow death losses/culls of animals <60 DIM averaged a reasonable 5% for the year, however, were nearly 10% for 6 months of the year. These cumulative data points indicate the potential for significant nutritional improvements. The farm has recently changed nutritionists and feed companies and many of the above benchmarks have been improved upon in the last 2 months. Though more documentation of current trends is needed for tracking. The basic approach of the current nutritionists has been to increase forage usage in lactating diets for healthier cows and production that meets farm economic needs under the milk basis limits recently imposed through their milk marketer. Estimations of economic savings and nutrient reductions need to be reviewed. Forage quality is excellent at Farm #2 and suitable for higher forage feeding >60% forage rations.

- To achieve these results critical improvements must be made to haylage storage to minimize improve feed out strategies and improved and more resilient forage crop program.

- The farm has adequate land base to supply the herd with 85% of its diet from homegrown forage further reducing the need to purchase grain but forage species must be modified to maximize quality and fertilizer programs must be implemented to maintain at least average yields.

- Additional changes required to achieve these results will be phased into the farm plan once infrastructure is in place.

FARM INTRODUCTION

Farm #2 operates an 840 Holstein dairy operation in St. Albans Bay, Vermont. This family farm has 1792 acres of crop land and raises all its own replacement animals. This herd averages 89 pounds of milk per cow per day. This farm grows all of its own forages and some of its grain requirements in the form of snaplage (due to drought conditions no snaplage was harvested in 2021). It grows 1100 acres of corn and hays about 700 acres of perennial forages. It purchases the balance of the grain requirements and its minerals.

WHOLE FARM NUTRIENT BALANCE

Farm #2 feeds a high forage diet when possible. Part of this project has been to help them improve forages to reduce purchased nutrients in the form of grain. For the crop year 2020, the farm grew 72% of the feed they utilized on the farm. 28% was purchased as grain. This analysis done in May of 2020 detailed that the farm imported 134.15 tons of nitrogen, 2.90 tons of phosphorus, and 2.78 tons of potassium onto their farm. Much of the nitrogen importation (75%) is through feed purchases. 100% of the phosphorus imports were due to purchased feeds. Purchased feeds also accounted for 100% of the potassium imports. The use of the Cornell Whole Farm nutrient balance model strongly suggests that improvements in utilization of home-grown forages and a reduction of purchased feeds will lower net imports of nutrients onto Farm #2. Nutrients left the farm in the form of milk, sold feed, and animal sales.

CROP AND NUTRIENT MANAGEMENT PLAN

Farm #2 has a nutrient management plan that meets the NRCS 590 standard and meets other state water quality requirements. The farm has participated in various state and federal conservation programs. In 2020, the farm produced forage from 45 corn silage fields (approximately 1100 acres) and 26 hay fields (approximately 660 acres). The fertility on most of Bess-view's fields is adequate and the pH levels are sufficient to average yields if proper fertilization is applied during the growing season. The soil test P levels ranged from 1.95 to 54.4 ppm with a farm average of 9.04 ppm. This is in the high range for crop fields in Vermont. The P-Index has an average score of 69 (high risk). This number is high and reflects typical value for farmland on heavy clay soils which are more prone to rill erosion due to the fine soil particle size.

The farm has ramped up its use of no-till practices, and cover cropping since the beginning of this project. It now cover crops approximately 700 acres of corn ground and implements no-till and reduced tillage practices on 80 percent of the annual crop land. Farm #2 has a typical crop rotation for the area which is 5 years grass and 5 years corn. They typically seed down 100-150 acres of cropland per year. The new seedings are primarily alfalfa and orchard grass mixes. Alfalfa typically is productive for three years then dies out to other grasses. Improvements in this part of their cropping system would benefit this farm as most the older hayfields are primarily Kentucky blue grass, orchard grass and red canary grass and crop production is a struggle without adequate rainfall.

Manure is the primary source of nutrients for all crops. A starter nitrogen fertilizer is purchased for the corn crop. Additional nitrogen fertilizer is purchased to grow the corn crop when PSNT testing recommends it.

To achieve the required amount of forage to feed an 85% forage diet, fertility in fields will need to be maintained to acquire forage yield and quality to support this high forage diet.

Forage species should be evaluated and modified where necessary to produce forage that has 65 to 70% digestible fiber. This may involve reseeding, frost seeding, and/or adding new forage species (small grains, summer annuals) to the cropping system (the farm did experiment with growing sorghum in 2019). This farm produces a significant amount of summer feed from double cropping rye in the spring. Although the results are highly variable this practice shows promise as a stable source of highly digestible summer feed for the milking herd.

PRECISION FEED MANAGEMENT

The goal of this project is to ultimately work towards feeding 1.2% of the cow's bodyweight as NDF. The neutral detergent fiber (NDF) is the portion of forage that includes hemicellulose, cellulose, and lignin. The more digestible the NDF the more forage a cow can eat. Hence to feed a cow 1.2% of its bodyweight as NDF the farm needs plentiful high-quality forage. To meet this goal, Farm #2 will need to produce 9007 metric tons of dry matter forages per year. This farm has the land base and the management skills to accomplish this goal. This can be grown as both corn silage or hay forages depending on the management style of the operator and how the fields can best be utilized. To produce not only the volume of forage but the quality many additional factors must be considered/analyzed. First the species of forages in the field must be able to generate fiber digestibility of 70%. Second the feed must be harvested timely and stored properly to maintain the quality. Lastly, the ration must be balanced to maximize the inclusion of homegrown feed and supplement with additional feedstuffs where needed. This is a challenge on this farm primarily due to lack of adequate storage facilities for the haylage portion of the diet and the management changes that have recently occurred. This farm is in the middle of a generational shift and achieving these goals will have to be balanced with other ideas on the farm.

FARM INFRASTRUCTURE ASSESSMENT

The facilities and equipment on this farm are mostly adequate to reach the goals of this project. They have recently shifted from purchasing grain mixes to simply purchasing ingredients and mixing their own recipes depending on the needs of the cow. This will provide them with greater flexibility moving forward. The management of the crop harvesting, and the ensiling of the feed is very good. Repeated testing of forages indicate support this. The issue is that it is very difficult to separate the haylage forages in the current storage facility and as a result different quality haylages get mixed resulting in less than optimum feed out of the haylage products which results in inefficient utilization of the feed by certain groups of cows.

This farm should invest in addition flat storage for its haylage crop. This would along with other changes provide adequate space to manage the storage and feedout the haylage. Corn silage storage is adequate in that they have two large bunker silos which consistently store all the corn silage produced.

RECOMMENDATIONS FOR THE WHOLE FARM NUTRIENT PLAN

To achieve the required amount of forage to feed an 85% forage diet, fertility in fields will need to be maintained for optimum forage yield and quality to support the high forage diet.

Forage species should be evaluated on a field-by-field basis and modified where necessary to produce forage that has 65 to 70% digestible fiber. This may involve reseeding, frost seeding, and/or adding new forage species (small grains, summer annuals) to the cropping system

The balance of farm nutrients is good and no further modifications need to be made; however, P imports will be reduced when less grain is fed. It will be important for this farm and the watershed to reduce P importations by the use of more homegrown forages. The soils are high (not excessive) in P and through reduced P importation they could focus on better managing P loading on their fields. We would recommend starting with the fields with heavy clay soils.

OUTCOMES OF THE WHOLE FARM NUTRIENT PLAN

Farm #2 is a 840 cow dairy operation located in St. Albans Bay, VT with over 75% of the farm operation in the St. Albans Bay Watershed.

Reducing ration P from 0.46% to 0.40% will result in a 5 T reduction in excess P for the year.

Increasing %forage by only 2% units with a commensurate 2% reduction in grain purchases of a conservative cost of only $300/T has the potential to reduce grain purchase b 168T/yr with a possible reduction of $50,590/yr. in grain purchases.

Considering milk production limits imposed by the milk marketer, it is highly recommended that Farm #2 consider reducing cow numbers. Quality and inventory of forages have the potential to result in similar volume of milk production with fewer cows, more forage intake, and there by requiring fewer purchased feed inputs.

CHALLENGES TO ACCOMPLISHING THE PLAN

Farm #2 can make improvements that can improve feed efficiency, reduce nutrient losses and loading, and enhance farm viability. Although the plan is practical there are still significant barriers to adoption of these improvements.

With the transitions the farm is undergoing the project team will need to work closely with Farm #2 management to get the needed changes implemented on the feed management side of the business.

Due to the farm's financial situation, additional funding will need to be secured to implement the plan.

Most of the practices that need to be implemented are not funded through external grant or government programs.

Although financial gains will be gained through purchasing less grain, at least some of these savings would need to be reinvested in crop and soil management.

Finally, many of these practices, with proper funding, could be implemented immediately, the farm will likely need several years to fully implement the recommendations and realize the benefits.

Farm Recommendation Reports for LCBP Project

Farm #3

Project Goals: This project will demonstrate how, through whole farm nutrient management, major improvements can be made to water quality through reduced Phosphorus loading and improved farm viability.

Executive Summary:

- Farm #3 has the land base to implement a high forage diet which will reduce nutrient imports to the watershed.
- If all recommendations were implemented this farm would cut purchased feeds (imported nutrients) from 28% of the ration to 13% of the ration.
- With the proper infrastructure this farm could reduce its phosphorus loading by 22% per year in feed efficiencies. It could also export 10% of the phosphorus associated with growing hay through exportation of feed out of the watershed.
- With proper infrastructure this farm could cut leachate subject to risk of runoff by 90% per year.
- If recommendations are implemented the Income Over Purchased Feed Costs (IOpurFC) on this farm would go from $8.87 to $9.95. This is a savings of $1.08 per cow per day. Theoretically, this could amount to a savings of $47,304.00 per year.
- This operation lacks the necessary infrastructure to be able to accomplish these goals.
- If all the infrastructure changes are implemented on the farm it would cost approximately $200,000.00 dollars.

Farm Introduction:

Farm #3 dairy has a 120 Holstein cow operation in Franklin Vermont. The main milking facility is located inside the Lake Carmi Watershed. The heifer facility is the also known as the home farm is located just outside the Lake Carmi watershed and currently houses 70 heifers. The farm grows all its own feed less grain inputs. The dairy herd averages about 60 lbs./cow/day. The farm currently grows approximately 110 acres of corn and 300 acres of mix grass forages. The farm often sells haylage in a normal cropping season. The farm is very good about rotating fields to maintain high feed quality. The farm's approach to farming is one of utilizing what they have first and only purchase outside fertilizer and feedstocks when needed. Much of the equipment on the farm used to conduct field operations is very much depreciated and will be a source of compromised quality soon. They operate the farm as a self-sufficient operation with very little outside influence. The operation has no outside labor and family performs all operations. They do utilize government programs where and when it is feasible to do so. They currently utilize no-till and reduced tillage practices. They did utilize the grassland manure injector but are hesitant to use it because of the cost of hiring trucks to supply the injectors frac tank. The soil test data on this farm indicate that there are not any excessively high phosphorus fields on this farm.

Current Situation:

Land base and its ability to produce optimum amount of feed

The goal of this project is to ultimately work towards feeding 1.2% of the cow's bodyweight as NDF. To do this the farm will need to produce 1370 tons of dry matter forages per year. This farm has the land base and the management skills to accomplish this goal. This can be grown as corn silage or hay forages depending on the management style of the operator and how the fields can best be utilized. To accomplish this high-quality forage must be grown, stored, and feed to the herd. This is a challenge on this farm.

Farms Infrastructure Assessment:

The feed storage and feed out bunks on this farm are very outdated. The bunks are far too small for feed that needs to be stored in them. At the main facility they have one bunk that they must store both the haylage and corn silage in. This results in the mixing of both feeds and contamination of the haylage with the silage leachate. The bunker floor is in very rough shape which makes it difficult for proper bunk management during feed out. Improvements in this area of the farm would reduce spoilage and leachate runoff while improving feed fermentation and allow for optimization of feed utilization by properly being able to properly separate feeds by quality. This would result in improved feed efficiency and higher forage intakes reducing the need for purchased grain.

Based on annual feed consumption requitements it is recommended that the farm build a 60X165 paved pad on which to build drive over feed piles. It is also recommended that the farm construct an updated leachate collection system as part of this project.

The feed bunks in the barn need renovating as well. The bunks are designed in such a way that they are very difficult to clean out. This results in heated feed in the bunks and reduced intakes. If this was corrected the cows would likely eat more feed resulting in higher levels of production.

The cow comfort levels in the barn are quite good. The stalls are properly sized for the cows and they are bedded with sand. The cows are generally lying down when not being milked or up at the bunk.

The farm does all its own field work and some of the equipment is getting quite old, putting the farm at risk for reduced feed quality due to poor timing of harvests and improper ensilage for the feed. At times the length of cut of the silage is longer than the recommended length likely resulting in increased fermentation time and slower utilization of feed in the rumen. The farm needs to be profitable to have the capital to make investments needed to keep field equipment in proper condition. In 2020 they had problems with their mowing equipment which extended their harvest windows by several days resulting lower quality haylage than they would have had otherwise.

Feed Quality Assessment

The UVM Extension team with the assistance of two nutritionists reviewed the data collected over the first year of the project and made the following recommendations based on results from feed analysis and feeding records.

1) Farm #3 needs to make significant improvements to its feed storage and feed out area if they are to optimize the amount of home-grown forages to feed their animals.
2) Fermentation issues surrounding the ensiling of the feed is a leading cause of nutrient loss and feed quality degradation on this dairy.
3) With proper storage and feed out facilities this farm could reduce purchased feed to 6.5 pounds per cow per day from 14 pounds per cow per day.
4) With implementation of these recommendations the reductions in feed loss due to storage problems will result in an extra 115 tons of DM forage that will be available for sale with the opportunity to export it out of the watershed taking nutrients out of the watershed.
5) If the farm can implement the recommendations the resulting feed will be of significantly higher quality resulting in cows eating a higher forage diet. This will result in a significant drop in purchased grain. Our feed model suggests that the farm could increase forage amounts to 86% of the diet from 71% of the diet. This is a significant increase in Vermont grown forage.

Field Assessments

Farm #3 takes pride in how they manage the land they own. They do many of the recommended conservation practices and participate in many of the programs the UVM Extension supports. The farm has a current nutrient management plan and utilize the information in the plan to help make fertility decisions on the farm. The fertility on most of the fields is adequate and the ph levels are sufficient to get adequate yields if proper fertilization is applied during the growing season. The farm utilizes manure for much of their fertilization on the hay fields during the summer. They typically adhere to a 3-year corn 5-year grass/legume mix rotation where it is feasible to rotate fields into corn. Much of the farm is very stony which limits corn rotations on some fields. The fields were assessed at the beginning of the 2020 crop season and they had a good blend of legumes and grasses for the most part. Kentucky blue grass is a native grass on many of the fields in is typically a lower yielding grass and many of his fields did have a significant amount of these grasses. It doesn't take many years for it to reseed itself into the meadows.

The corn fields on the farm may be an area for improvement with respect to weed control and fertility. They utilize a very simple weed control program which probably could be modified to address some weed pressure that comes in later in the season. Some tweaks in this area of their field management could help produce more home-grown feed, reducing the need for purchased feed.

Outcomes if Goals are Achieved

If the recommendations are followed which are provided in this report, several important outcomes are possible:

- Increased high quality forage intakes will result in improved feed efficiencies and reduced need for purchased grain

- Increased forage intakes will result in increased milk production or at least producing milk at a lower cost.
- Improvements in feed storage situation (very expensive and could not be done without outside assistance) would allow for better utilization of feed and reduced risk of leachate runoff
- Improvements in the fields will result in increased yields and improved quality of feed.
- Implementation of this plan would improve the cycling of nutrients within the Lake Carmi Watershed and reduce the amount of imported nutrients which should have a positive impact on water quality and farm viability.

Summary of Challenges

Farm #3 has the opportunity to make significant improvements to how it utilizes feed on its farm. UVM Extension's work on this project has demonstrated that water quality and farm viability can be improved significantly if the farm can follow the recommendations in this report. There are several limitations that will be barriers to these improvements.

1) The farm's financial situation will not allow them a way to implement these changes without outside assistance.
2) Most outside assistance programs do not list the needed improvements on this farm as an allowable practice under current programming.
3) The farm will need several years to fully implement the recommendations made and it will take the work of many different partners to get

Farm Recommendation Reports for LCBP Project

Farm #4

Project Goals: This project will demonstrate how, through whole farm nutrient management, improvements can be made to water quality through reduced Phosphorus loading and improved farm viability.

Executive Summary:

- Farm #4 has the land base to implement a high forage diet which will reduce nutrient imports to the watershed.
- This farm feeds a high forage diet by the nature of the animals being fed (beef cows and dairy dry cows). Improvements in forage quality could further reduce nutrient imports into the watershed.
- This farm is in constant transition with respect to animals being housed on the farm. This means that nutrient requirements change frequently needs are hard to forecast.
- Higher quality forages could eliminate most of the need to import feed and concentrates onto the farm to meet the nutritional requirements of the animals that are housed there now.

Farm Introduction:

Farm #4 is a dairy farm that has recently converted to boarding dairy/beef animals to remain solvent. The volatility of the dairy markets led the ownership of the farm to transition away from milking cows. The farm currently houses approximately 300 animals from several farms in the area. The farm has 390 tillable acres which has recently been certified organic and is all in perennial forage production. The farm is in the Lake Carmi watershed. The hay fields are composed of Kentucky blue grass, alsike clover, and timothy. While the farm grows the haylage utilized by the cows boarded on the farm it imports the concentrates and corn silage if those products are requested by the owner of the animals. This farm has no outside labor and utilizes custom operators to perform all cropping practices. They typically harvest three cuts of haylage and does a significant amount of round baling as well. This farm also utilized a manure separator which produces compost quality separated manure that is sold off the farm. Given the organic status of his farm and the need for nutrients to grow his crops it is uncertain if this will continue into the future. To be clear the animals on the farm are not organic only his crop fields. Conventional feed stocks like ear corn and corn silage are imported to meet the energy needs of the cows that are boarded here.

Current Situation:

Land base and its ability to produce optimum amount of feed

Farm #4 has adequate land base to grow the required dry matter intakes for the animals housed there. There are challenges to getting the proper nutritional requirements out of the feed harvested. The farm struggles to put-up high-quality forages and this will not get better until several changes are made. This farm has converted to an organic certified land and getting adequate nitrogen on the fields without the introduction of more legumes will be very difficult. The manure generated by the animals is not

adequate to supply the crops with enough nutrients to achieve optimum yields. The labor situation of the farm needs to improve to make changes to the composition of the fields. This farm gets its crops harvested at less-than-optimal times and because of that quantity increases but quality decreases and leads to the need to import more purchased feed.

Farms Infrastructure Assessment:

This farm has adequate storage for most of the feed. It has large narrow bunks that adequately hold the feed that is placed in them. The farm has a large commodity shed and a silo that can be utilized when needed. The bunker floor in one of the bunks is sloped the wrong way and traps water in against the feed which is resulting in some feed degradation. The mixer wagon scales are not functioning as well as they should, and the operator is not able to properly record the usage of ingredients when feeding the different animals on the farm. This has resulted in inaccurate feeding and poor tracking of inputs. Improvements in this area will be beneficial to the farmer and the environment.

The barns are adequate for livestock and features a slotted floor for manure collection. The farm has had to make some modifications to the barns when housing beef cows due to their wild tendencies and smaller overall size. The main barn has a drive through alley which is in good shape and the other main barn utilizes H bunks with a conveyor which distributes the feed in the manger.

As mentioned earlier this farm hires all the crop work done. This saves the farm equipment costs and labor. The drawback is that his crops do not get harvested at the optimum harvest dates and the manure doesn't get applied as quickly after harvest that they might like. This has a detrimental effect on his profitability and increased the amount of supplemental feeds that must be purchased to meet the nutritional requirements of the animals. One issue noted while doing assessments is that the feed was extremely dry and cut excessively long like there was an issue with the harvesting equipment. This compounds the issues surrounding feed quality because the feed will not pack or ferment properly leading to a lower quality feed.

Feed Quality Assessment

The UVM Extension team with the assistance of two nutritionists reviewed the data collected over the first year of the project and made the following recommendations based on results from feed analysis and feeding records.

6) This farm while having adequate land base to meet the needs of the animals boarding at the farm now, may need to source or adjust species in the fields to maximize nitrogen production as the soils convert to organic (no commercial fertilizer).
7) This farm is losing forage quality potential based on timing of the harvest. Feed is over mature, and some cuttings are not ensiled at the proper moisture for optimum fermentation/quality.
8) Some of the fields would benefit from additional lime applications which could help more desirable species of perennial forage to grow.
9) This farm is feeding its lower quality feed to the animals it boards there. If higher quality forages were achieved this farm could substitute the higher quality feed for the

concentrates (grain) being brought in to achieve the desired body condition on the animals housed there.

Field Assessments

This farm is all perennial forage. It has participated in several programs over the last 5 years to seed its 25 acres of corn down to grass/legume. At this time the fields are made up of mostly Kentucky blue grass, orchard grass and some clover. The farms wet upland soils are most suitable to grass, and many have poor internal drainage which limits what can be grown. The farm is currently injecting the available manure on the fields after the 2nd cut of feed is taken. The farm would benefit from increasing the legumes on these fields. This would benefit quality and the legumes would help fix nitrogen in the soil for the other grasses to benefit from. Soil tests indicate that many of the fields have phosphorus levels in the optimum to high range. The farm should work to introduce legumes into the fields after a cutting or by frost seeding over several years Historically because the farm is run by only the owner there is very limited time to make any additional changes, and this is factor in moving forward.

Outcomes if Goals are Achieved

If the recommendations are followed which are provided in this report, several important outcomes are possible:

- Increased high quality forage intakes will result in improved feed efficiencies and reduced need for purchased grain
- Improvements in the fields will result in increased yields and improved quality of feed.
- Implementation of this plan would improve the cycling of nutrients within the Lake Carmi Watershed and reduce the amount of imported nutrients which should have a positive impact on water quality and farm viability.
- Improvements in the quality of the forages will add to the viability of the business by making it more attractive to farms that may want to have cattle boarded there and make feed more salable as an export off the farm. This is especially true in the production of organic feed.

Summary of Challenges

Farm #4 has the opportunity to make significant improvements to how it utilizes feed on its farm. UVM Extension's work on this project has demonstrated that water quality and farm viability can be improved significantly if the farm can follow the recommendations in this report. There are several limitations that will be barriers to these improvements.

4) This farm has only one employee and thus it is likely that funds will need to be found to pay to get field improvements implemented.
5) The farm's financial situation will not allow them a way to implement these changes without outside assistance.
6) It is important to find markets for the organic feed. Currently he is selling the organic feed to conventional farms that will not pay the premium it should produce. The farm is

incurring additional cost of growing organic crops. This will be threat to their fiscal viability.

7) The farm will need ongoing support to make the changes suggested in this report due to time constraints on the owner.
8) Th farm is constantly changing people who board animals on his farm. This is a lack of stability so incurring any additional costs to make improvements are seen as additional risk by the farm.

Farm Recommendation Report for LCBP Project

Farm #5

Project Goals: This project will demonstrate how whole farm nutrient management can reduce a farm's impact on phosphorus loading and water quality while enhancing overall farm viability.

EXECUTIVE SUMMARY

- Farm #5 is a small 60 cow grass fed only dairy in Franklin, VT. They have approximately 300 acres in total which they can graze or harvest crops from.
- Their farm is constantly changing in terms of long-range planning and how they operate the dairies day to day operations. Since the beginning of this project, they have gone from 2x milking to 1x milking and back again to 2x milking, purchased a farm they are now trying to sell. Harvest 2 cuttings per field to harvesting 1 cutting per field. These constant changes make attributing outcomes from changes suggested by this project difficult to measure.
- They produce sufficient feed to feed their herd, but the quality is lacking resulting in reduced milk production. The farm averages between 15 and 30 pounds of milk production per day.
- The farms MNB indicates that the are mining nutrients out of the soil except for phosphorus which they produce a .67-ton surplus annually. This should be corrected through improvements in cropping system and better utilization of available nutrients.
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FARM INTRODUCTION

Farm #5 is in Franklin Vermont. It is a small mixed breed dairy which produces grass fed only milk. This farm operated approximately 137 acres of hay land and 52 acres of pasture. They also recently acquired another farm and are deciding how to integrate that into their existing operation. The combined land available to the farm is 317 tillable acres. They grow all of their own replacement stock and leases all the land on the original farmstead. The farm's approach to the dairy business is low inputs and low outputs. This farm has a severe labor shortage and seems always be undergoing management changes.

WHOLE FARM NUTRIENT BALANCE

Farm #5 feeds a forage-based diet. They are 100% grass fed. They also feed supplemental minerals to the herd. The whole farm nutrient balance for the farm indicates that the farm has a surplus of phosphorus and is slightly deficient in nitrogen and potassium. The Cornell model indicates that the phosphorus surplus (.67 tons) is primarily related to the purchase of some hay and the supplemental minerals that the farm fed the cows in 2019. The farm doesn't always purchase additional feed, so the phosphorus calculations are likely to be negative most years. The nitrogen (-.29 tons) and potassium (-.55 tons) indicate that the farm is mining some of the nutrients out of the soil. Having a nutrient deficient is not good for the long-term viability of the farm as nutrients get depleted from the soil the land will become less productive leading to reduced income potential and the need for larger inputs put into the soil in the future to return to adequate fertility levels. Another interesting observation worth noting is that this farm's amount

of phosphorus per hundred weight of milk is higher than an average conventional farm. The Cornell MNB model indicates that for dairy farms a positive phosphorus balance less than .11 lbs./CWT is sustainable. The farm is at .31 lbs. of phosphorus per CWT. This is probably due to each animal needing a certain amount of phosphorus for maintenance purposes.

CROP AND NUTRIENT MANAGEMENT PLAN

The farm has an up-to-date NMP and an active cropping strategy. They utilize their NMP to properly apply nutrients to their fields. They generally run short of the required nutrients to maximize crop yields. This is typical of a herd that grazes during the summer. To attempt to make improvements in feed quantities they have attempted to grown Sunn Hemp with varied success. They also delay harvest in the spring to harvest build feed inventories. This does result in significantly reduced quality. Milk production is secondary to keeping costs low on this farm and they have limited labor so harvesting less often is a strategy they like to use. They also have utilized the practice of harvesting their haylage very wet. The round bales they produce are very heavy and present an issue when feeding in the barn during the winter months. His hay fields are typical of upland meadows in Vermont. They primarily consist of Kentucky Blue grass with some clover and timothy. Where they have some need for improvement is on their summer pastures. They get grazed aggressively and often run out of feed mid-summer depending on heat and moisture.

PRECISION FEED MANAGEMENT

This farm does not practice any sort of precision feed management. They typically roll out round bales in the manager except when they are feeding with their mixer wagon. In this case the bales are ground up in a stationary mixer then a feed cart distributes the feed in the manager. Some of the early work we did on this farm indicated that the feed was getting over processed by the mixer wagon. They went to just rolling out round bales in the manager which did improve milk production. They have subsequently reverted to using the mixer again because of the difficulties associated with moving the round bales around inside the barn. They do mark their bales by cutting for the most part, so they have a good understanding of where their good and poor feed is located for feeding purposes.

FARM INFRASTRUCTURE ASSESSMENT

The farm has a rapidly changing infrastructure. Since the beginning of this project the farm has purchased another farm and is now trying to sell it while keeping several pieces of equipment from it in the process. The equipment used to put hay up on this farm is in decent condition. The bales are made with a John Deere round baler. The only issue with the baler is that doesn't have a processor in it so the late cut feed is extremely long. This reduces dry matter intakes because it takes longer for the cow to break down the feed in her system. The bales are stored in the fields and at the farm itself. The mixer wagon used to mix the feed is in rough condition. It tends to over grind the hay if left unattended for too long. This has resulted in the cows passing the feed to fast through the rumen and a reduction in milk production and component scores. This farm has low input requirements which also lowers the amount of required infrastructure to keep the farm viable. The manure pit is adequate at the original farm but defunct at the new farm. One area for improvement may be their manure spreading equipment. They have limited labor and the equipment is quite old which translates into additional repair time and less manure being applied when it is best for the crops.

RECOMMENDATIONS FOR THE WHOLE FARM NUTRIENT PLAN

Farm #5 has a unique management style which seems to work for them. Areas for improvement include the utilization of summer annuals on the pastures to reduce the use of winter feed stocks during the summer months. The farm often run an aerator on their fields, and it would be beneficial if they could put some additional legumes into the cropping system to generate additional nitrogen for the hay crops. The development of a good grazing plan would help procure adequate summer feed sources for the herd. The farm needs to pay close attention to how they feed out the bales in the barn and should acquire equipment that would help them do this in an efficient manner. Another recommendation is to try to improve the quality of the feed. They sometimes sell hay for additional income. They might consider growing higher quality feed to boost milk production rather than selling feed. This would provide them with more consistent income and allow them to produce closer to their allotted quota. From a MNB standpoint the farm needs to figure out how to generate additional nutrients to better balance what is going on the fields and what is coming off. Running a long term deficient will impact future ability meet crop production needs.

OUTCOMES OF THE WHOLE FARM NUTRIENT PLAN

The outcomes of implementing the whole farm nutrient plan would benefit the farm's viability and profitability. Improved feed will result in higher milk production and better components in their milk product. The improvements to pastures will improve summer milk production and reduce the use of supplemental feed during the summer months. A properly developed grazing plan would help extend the feed they put up in the summer and allow for higher quality feed production on the pastures.

CHALLENGES TO ACCOMPLISHING THE PLAN

After working with Farm #5 for many moths there are several challenges for them to achieve these goals. First, because they operate on a very small budget the purchase of additional seed or equipment to make improvements is cost prohibitive. A major drawback of the way they farm is that they don't lose money often, but it is difficult to make changes that would result in making additional money. Second, the idea of putting up feed earlier is difficult for the farm. Many of their fields are wetter fields and they are severely limited by available labor. They have no hired help and takes them a long time to get hay put up and manure applied. Lastly, the farm would need significant technical support and financial support to make the changes proposed and they are not the type of farmers that are comfortable asking for help. This would be barrier that would need to be overcome to move forward.

Whole Farm Management to Reduce Phosphorus and Improve Farm Viability: Research Recommendations

Background

Vermont's most recent (2016) Total Maximum Daily Load (TMDL) states that 41% of the phosphorus load into Lake Champlain from 2001-2010 is from the agricultural sector (EPA, 2016). However, farm management has changed in the subsequent decade to reduce loading though implementation of nutrient management plans, cover crops, crop rotations, and alternative manure management e.g., injection. This has accounted for 13% of the 54% TMDL required phosphorus reduction (VAAFM, 2021).

Key Findings

1. Phosphorus loading onto farms can be reduced with production of higher quality feed and better feed storage infrastructure.
2. Current environmental support programs do not address feed management as a method of phosphorus reduction.
3. Improved support via technical support and funding will help farmers decrease phosphorus loading onto farms and into waterways.

One area often overlooked as a contributor to phosphorus loading into the Lake Champlain watershed is through grain/feed imports for livestock production. Phosphorus is imported onto farms as feed, excreted from the cow in manure and urine, and then applied to fields as a fertility source where it is subject to loss into the waterways through erosion. In general, farms often import more nutrients (i.e., grain, fertilizer, etc.) onto their farm than what is exported off from the farm, i.e., milk, meat, crops, or manure (Soberon, et al., 2015).

Through case studies of five farms, additional infrastructure and field-based practices that fall out of the scope of typical environmental cost share programs (i.e. EQIP, CSP, and FAP) were identified as high priority for reducing phosphorus loading on agricultural operations. Although the number of participating farms is not extensive, they represent various types of management operations (organic grass-fed operation, recent transition from dairy production to boarding bovine, certified small, medium, and large operations) and findings are widely applicable to farmers in Vermont.

Through intensive interviews and monitoring over three years, common themes for phosphorus reduction were identified. Phosphorus loading onto farms and therefore potential loading into Vermont's waterways can be reduced through better management of forage produced on the farm. Through producing higher quality forage and improving feed storage infrastructure, feed imports can be drastically reduced which decreases phosphorus loading onto farms and could provide additional cost savings for the farm.

Improve On-Farm Feed Production

High quality forage and well-balanced rations contribute to herd health, high production, and farm viability. Purchased concentrates and grain widely vary in phosphorus concentration and price. Most farms work with representatives from the grain industry to develop rations to feed their herd. Some farms use a "least cost approach" which often results in higher phosphorus levels in the final ration due to phosphorus levels in the ingredients. Lower cost feeds typically contain higher levels of phosphorus. Protein supplements such as canola meal and distillers grains are often used to replace higher costing soybean meal, but contain 10-40% more phosphorus. Energy and fiber feeds such as beet pulp and wheat midds are commonly used as forage extenders when forage inventory and or quality is limiting. These feeds contain 5-6x the amount of phosphorus compared with soy hulls and citrus pulp.

When forage quality and inventory is sufficient, import of these feeds on farm can be minimized or eliminated. Not all farms design rations with a tight tolerance on phosphorus because feeding excess phosphorus to the cow is not damaging to the cow (the cow simply excretes the excess) and it allows for more flexibility in developing the ration. Review of many lactating rations in the past few years of higher grain costs shows levels of phosphorus increasing and at times >0.40% of dry matter. Dietary phosphorus levels of 0.35-0.38% are sufficient to meet the phosphorus requirements of high producing dairy cows.

The UVM Extension and other institutions have found that rations typically contain >0.43% phosphorus, more than 17% above the needs of the cow. Our case studies indicate that on a large dairy farm, by reducing phosphorus ration levels that exceed that recommended rate by as little as 0.06% or 2% of the total feed imports can reduce phosphorus imports up to 5 tons/year and save the farmer $50,500 annually.

In addition to higher quality feed, producing more forage on-farm to meet the dietary requirements of livestock can reduce grain or other feed imports. Through high yielding quality feed produced on farm with higher quality crop species selection and better fertility management, excessive phosphorus imports can be reduced, the risk of phosphorus loss from field to water will be reduced, and dietary needs of livestock can be met.

Improve Feed Storage Infrastructure

Once feed is harvested, the quality of its preservation depends on the quality of the feed storage infrastructure. Feed quality is impacted by moisture, temperature, storage period, storage infrastructure design, and physical integrity of the storage structure. Our case studies show that on a medium sized dairy, with improved storage structures, feed importation can decrease by as much as 15%, reduce phosphorus importation by 22%, and annually save the farmer $47,000.

Bunkers, typically made of three concrete walls and floor, are common feed storage structures for hay and corn silage in Vermont. Poor design or outdated bunkers can lead to excessive production of leachate, nutritionally concentrated feed run-off, which can pose environmental risks. The presence of leachate also indicates reduced feed quality. The sugars and carbohydrates are degraded in the inefficient fermentation process that results in leachate production. What is left is less digestible fiber, and higher risk of anti-nutritional factors such as, yeast, mold, and clostridia contamination of the forage which needs to be balanced with grain to meet livestock dietary requirements. Current methods to mitigate leachate are expensive and include retention ponds or pumping the run-off into manure storage infrastructure. Capturing the leachate certainly helps to reduce the risk of environmental contamination, but what it does not do is save or protect the overall quality of feed.

Degraded walls or floors can change the environmental conditions of the stored feed which can lead to decline in its quality. Lack of bunker space to accommodate harvests also decreases the ability of the farmer to separate feed by quality. Ideally, feed would be separated by quality with higher quality feed fed to lactating cows which have higher nutritional demand and lower quality feed fed to dry cows which have lower nutrition demand. When lower quality feed is fed to lactating cows, the ration needs to be balanced with grain, an importation of phosphorus. Higher quality bunkers that meet the storage demands of the farm can reduce phosphorous loading onto farms and into waterways through decreased environmental risk with better storage infrastructure and reduced grain importation with higher quality feed through better storage.

Importance of Segregation and Storage

Highly digestible forage fiber can reduce the need for purchased energy and protein feedstuffs; thereby reducing the import of phosphorus on farm. Animal nutrient requirements of energy, protein, and minerals differ by age (growth) and stage of lactation (high vs. low vs. dry cows).

The ability to segregate forages by type, quality and mineral content is imperative for optimal nutrition and nutrient management. Most dairy farms comingle forages because they lack storage capacity to segregate feeds by type, quality, or even variety. So often highly digestible forage is piled on top of less digestible feed making it difficult to optimize livestock production. Crop production is expensive and the investment of planting, fertilizer, labor, etc. can easily be lost once the feed makes its way into storage. Minimizing spoilage losses require diligence in harvest and preservations techniques for both fermented and dry feeds. The ability to size storage structures for proper feed-out rates in order to minimize aerobic deterioration is critical in maintaining forage quality and minimizing need of purchased feeds. Aerobic deterioration results in wild yeast and mold growth that are detrimental to rumen function and animal health.

In general, a purchase and import of a basic complete feed of energy and protein contains 0.40-0.50% phosphorus. For 100 cows a reduction of 1 lb. of grain/cow/day, replaced with high quality homegrown forage could result in 164 lbs. less phosphorus imported per year. In that scenario, phosphorus is fed just at nutrient requirements and milk production would be held constant as long as forage quality is excellent with no spoilage. Considering a situation where phosphorus is fed in excess, possibly at >0.40% of dry matter this could result in as little as 5g. phosphorus/cow/day above requirement, or 400 lbs. of phosphorus for 100 cows/year. However, we need to keep in mind the distinction between purchased phosphorus import compared to high phosphorus levels from home grown forages that may be simply cycling on-farm phosphorus. Clearly each farm's feeding and agronomic situation require individual assessment.

Current Soil Phosphorus Levels

Many farm fields' soil tests are at or above adequate available phosphorus levels to support crop needs. Improving forage yields and quality will allow for increased utilization of phosphorus already in farm soils which further decreases the need for purchased feed supplements and consequentially reducing phosphorus loading onto farms. Technical assistance and programs that help farmers invest in high quality forage production will help farmers reduce their reliance on grain imports.

Improve Support

The ability of farmers to make these improvements depends on support from technical assistance and funding. Technical assistance can aid farmers in producing higher quality feed through better crop management including species selection and nutrient management planning implementation. Precision feed technical assistance or nutritionist assistance can increase the likelihood that farmers will balance rations to meet livestock needs with feed produced on farms. Our case study experience indicates that without technical assistance to help balance rations with feed produced on farm, farmers will default to the recommendation of higher grain imports from their grain industry representative. Financial support through grants or cost-share will enable farmers to invest in better feed storage infrastructure.

Conclusions and Recommendations

Feed management strategies offer a solution toward meeting phosphorus TMDL reduction goals from the agricultural sector while at the same time improving farm viability. Many programs like EQIP, CSP, FAP, Vermont Pay for Phosphorus program, are designed to help farmers meet environmental standards, but

none of them address feed management or storage. The case study of five farms provides a window into post-harvest crop management and shortfalls of current storage facilities that may be applicable to many types of different farms across Vermont. Reducing phosphorus imports by minimizing our reliance on purchased feedstuffs, concentrates, and grain requires high yields of digestible forage fiber produced, stored, and fed on our farms. Providing technical assistance and financial support will increase farmer ability to decrease phosphorus loading in Vermont's waterways through reduced grain importation with higher quality feed and reduced environmental risk with higher quality feed storage infrastructure.

EPA. 2016. Phosphorus TMDLs for Vermont Segments of Lake Champlain. https://www.epa.gov/sites/default/files/2016-06/documents/phosphorus-tmdls-vermont-segments-lake-champlain-jun-17-2016.pdf Accessed 20 Dec. 2022.

Soberon, M., Sebastian, C., Kettering, Q., Rasmussen, C., and K. Czymmek. (2015). Changes in nutrient mass balances over time and related drivers for 54 New York State dairy farms. *Journal of Dairy Science*, 98(8), 5313-5329. Doi: https://doi.org/10.3168/jds.2014-9236

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Summer Dairy Series: Focus on Forage

We invite you to participate in our Summer Dairy Series hosted by UVM Extension, NOFA-VT, and VT Grass Farmers Association (VGFA). Following is information on our first on-farm field day with more events posted soon!

DATE: Friday, June 17, 2022

TIME: 11:00 a.m. to 1:00 p.m.

WHERE: Bridgeman View Farm, 4826 Hanna Road, Franklin, VT 05457

Enjoy a hamburger with us at 1:00 p.m. or bring your own lunch. Water provided.

Please register here by 6/14 for a head count for lunch.

Join us on June 17th at Tim and Martha Magnant's farm in Franklin to discuss and explore options and opportunities for feeding a high forage diet.

We'll discuss harvest management and storage, soil fertility management, and species selection to achieve high forage quality. We'll look at equipment options for forage seeding and will walk through calibrating a grain drill. We'll be joined by dairy nutritionists Patrice Vincent and Kurt Cotanch who will share tips and considerations for successfully feeding more homegrown forage.

Free Event. Please pre-register by 6/14. Call Susan at 802-524-6501 x432, email Susan.brouillette@uvm.edu, or visit https://2022summerdairyBridgemanViewFarm.eventbrite.com to register online.

To request a disability related accommodation to participate in this program, please contact Susan Brouillette at (802) 524-6501 or 1-800-639-2130 (toll-free in Vt. only) by June 3 so we may assist you.

Water Quality and CCA credit hours available.

Northeast SARE Partnership Grant award #ONE21-386

Northwest Crops and Soils Program | 278 So. Main Street, Suite 2 | St. Albans, VT 05478-1866

802-524-6501 or 1-800-639-2130 (toll-free in Vt.) | susan.brouillette@uvm.edu

www.uvm.edu/nwcrops

CULTIVATING HEALTHY COMMUNITIES

COLLEGE OF AGRICULTURE AND LIFE SCIENCES

2022 Annual Field Day

Borderview Farm, 487 Line Road, Alburgh, VT 05440

The University of Vermont Extension Northwest Crops & Soils Program will once again offer our on-farm Annual Field Day. You can view the details at http://go.uvm.edu/conferences.

DATE: Thursday, July 28, 2022

TIME: 10:00 a.m. to 3:30 p.m. Check-in starts at 9:30 a.m.

WHERE: Borderview Farm, 487 Line Road, Alburgh, VT 05440

Cost is $25 per non-farmer and free for farmers. Includes lunch. Event is rain or shine, dress appropriately. **Advanced registration is required.**

Register here by noon 7/27. VAAFM WQ, Custom Applicator and CCA CEUs credits available.

The field day will get underway at 10:00 a.m. sharp with a tour of the farm and many of its research plots and experiments involving perennial forages, corn, soybeans, small grains, hemp, dry beans, and more.

Growers will get an update on ongoing and innovative crop and soil research trials, and UVM researches will share highlights from their research at the farm.

An Exhibitor Tent will be on-site. If interested email susan.brouillette@uvm.edu.

Cost is $25 per non-farmer and free for farmers. Advanced registration required by 7/27 online at https://go.uvm.edu/annualfieldday, or call UVM Non-Credit Registration Office at 802-656-8407.

Questions about the event? Call Susan at 802-524-6501 ext. 432 or email susan.brouillette@uvm.edu.

If you require an accommodation related to a disability, please contact UVM Student Accessibility Services at access@uvm.edu or 802-656-7753.

This is material is based upon work supported by USDA/NIFA under Award Number 2018-70027-28588.

NORTHEAST EXTENSION RISK MANAGEMENT EDUCATION

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SARE Sustainable Agriculture Research & Education

USDA United States Department of Agriculture Natural Resources Conservation Service

NORTHEAST DAIRY BUSINESS INNOVATION CENTER

Northwest Crops and Soils Program | 278 So. Main Street, Suite 2 | St. Albans, VT 05478-1866

802-524-6501 or 1-800-639-2130 (toll-free in Vt.) | susan.brouillette@uvm.edu

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NORTHWEST CROPS & SOILS PROGRAM

CULTIVATING HEALTHY COMMUNITIES

THE UNIVERSITY OF VERMONT EXTENSION

COLLEGE OF AGRICULTURE AND LIFE SCIENCES

2022 Annual Field Day

Borderview Farm, 487 Line Road, Alburgh, VT 05440

After lunch, from 1:30 p.m. to 3:30 p.m., we will have several afternoon sessions that you can choose from to attend (will need to pick one).

- **Grains**—hear about rye end-uses, partake in a rye sensory tasting session with our sensory expert Roy Desrochers, and join Harmonie Bettenhausen, director of the Hartwick College Center for Craft Food & Beverage, who will speak on grain quality for spirits.
- **Hemp**—Michael DiTomasso from VAAFM will speak about the transition from the State Hemp Program to the USDA Hemp Program. Learn about what changes will be implemented under the new federal management. Stop by our fiber and grain trials to learn about best practices for end use when growing industrial hemp and see prototypes of hemp products made by artist Laura Sullivan from our 2021 trial fiber. Stick around for a hempcrete demo with Alex Escher.
- **Forages**—Join us to discuss managing forage crops for optimal yield and quality to feed more forage. We'll be joined by dairy nutritionists Patrice Vincent and Kurt Cotanch and grazing expert Sarah Flack who will share tips and considerations for successfully feeding more homegrown forage. We'll discuss harvest and soil fertility management, and look at equipment options for seeding and calculating seeding rates. We'll share research results on species, varieties, fertility management, and much more!
- **Soil Health and Climate Resiliency**—Dig in with us! In this breakout session we will demo tools that measure characteristics of healthy living soils and discuss connections between soil health and climate resilience. Come learn about how these tools are used to measure soil health and greenhouse gas emissions in Vermont. Discuss with us the ways field management can influence soil health and contribute to climate resiliency.

PLANNED TIME SCHEDULE

9:30-10am - register, view exhibits

10-12:30pm - farm tour, stops at trials

12:30-1:30pm - lunch, ice cream, exhibits, networking

1:30-3:30pm - afternoon session choices (above)

4 VAAFM Water Quality, 1 Custom Applicator, and up to 4 CCA CEU credit hours available.

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SARE Sustainable Agriculture Research & Education

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NORTHEAST DAIRY BUSINESS INNOVATION CENTER

THE UNIVERSITY OF VERMONT EXTENSION

CULTIVATING HEALTHY COMMUNITIES

COLLEGE OF AGRICULTURE AND LIFE SCIENCES

2022 Fall Farm Meeting

Thursday, October 20, 2022, 11:00 a.m. to 1:00 p.m.

Roll Land Farm, 1880 N. Sheldon Road, Franklin, VT 05457

Join UVM Extension Northwest Crops and Soils Program (NWCS), Farmer's Watershed Alliance (FWA), and Friends of Northern Lake Champlain (FNLC) at Rolland Rainville's farm, Roll Land Farm for a Fall Farm Meeting. Topic highlights include:

Corn harvest, planting cover crops, updates on grassland manure injection, precision sustainable agriculture, and the state of soil health in Vermont. We will also receive an update on Lake Carmi and hear program updates from State Agencies.

Free event and lunch, but must pre-register at **https://2022fallfarmmeeting.eventbrite.com**

FIELD DAY DETAILS

10:45 a.m. Arrive at Roll Land Farm in Franklin, VT

11:00 a.m. Welcome

11:15 a.m. FWA and FNLC project updates

11:50 a.m. UVM research and project updates

12:30 p.m. Updates from Vermont Agencies

1:00 p.m. Free lunch, followed by Tour of Due North Vineyards (in Rolland's back yard)

Water Quality and Custom Applicator credit hours will be available.

Free. Must pre-register by 10/18. Call Susan at 802-524-6501 x432, email Susan.brouillette@uvm.edu, or visit https://2022fallfarmmeeting.eventbrite.com.

To request a disability related accommodation to participate in this program, please contact Susan Brouillette at (802) 524-6501 or 1-800-639-2130 (toll-free in Vt. only) by September 29 so we may assist you.

Thank you to our event collaborators and supporters.

This material is based upon work supported by USDA/NIFA under Award Number 2018-70027-28588.

Northwest Crops and Soils Program | 278 So. Main Street, Suite 2 | St. Albans, VT 05478-1866
802-524-6501 or 1-800-639-2130 (toll-free in Vt.) | susan.brouillette@uvm.edu
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Appendix D.

Forage Inventory Assessment

Masterfeeds
an Alltech company

Farm Name:

Herd Ave Bodyweight (lbs)	DIM NDF-forage (% BW)	Cows (#)	Heifers (#)

Annual forage Requirements For The Herd

Total Forages Cows (tons MS)	Total Forages Heifers (tons MS)	Total Forages Herd (tons MS)	Forage DM loss (%)

Actual Acreage

Corn Silage (acres)	Haylage (acres)	Dry Hay (acres)	Cereal Silage (acres)

Yields

Corn Silage (tons MS/acre)	Haylage (tons MS/acre)	Dry Hay (tons MS/acre)	Cereal Silage (tons MS/acre)

Types of Forage Stored on the Farm

Corn Silage (tons MS)	Haylage (tons MS)	Dry Hay (tons MS)	Cereal Silage (tons MS)
0	0	0	0

Forages to Harvest (tonnes MS)	Harvested Forages (tonnes MS)	Actual Acreage (acres)	Acreage Required (acres)
	0.00	0	0.00

Acreage to Meet Herd's Forage Requirements

Corn Silage (acres)	Haylage (acres)	Dry Hay (acres)	Cereal Silage (acres)
0	0	0	0

Diagnostics

Corn Silage (acres)	Haylage (acres)	Dry Hay (acres)	Cereal Silage (acres)