Phase 6 Scenario Builder 101

Presentation to Agricultural Workgroup
9/16/15

Curtis Dell, USDA-ARS
Ag Modeling Subcommittee Chair
and
Matt Johnston, University of Maryland
Non-Point Source Analyst, Chesapeake Bay Program

Committee/Scenario Builder Time Frame

- Scenario Builder modifications presented today will be used in October 1, 2015 Phase 6 calibration runs
- AMS will reconvene starting in January, 2016 to evaluate output from calibration runs
- AgWG is encouraged to review the calibration runs beginning in January, 2016, and provide comments/questions/recommendations to the AMS
- By March, revised AMS recommendations presented for AgWG approval
- CBPO staff will work with AMS to incorporate any changes through the summer of 2016





Load for a land use in a segment =

Estimated Average Load + Sensitivity * Δ Inputs

*

BMPs

*

Watershed Delivery Variance

*

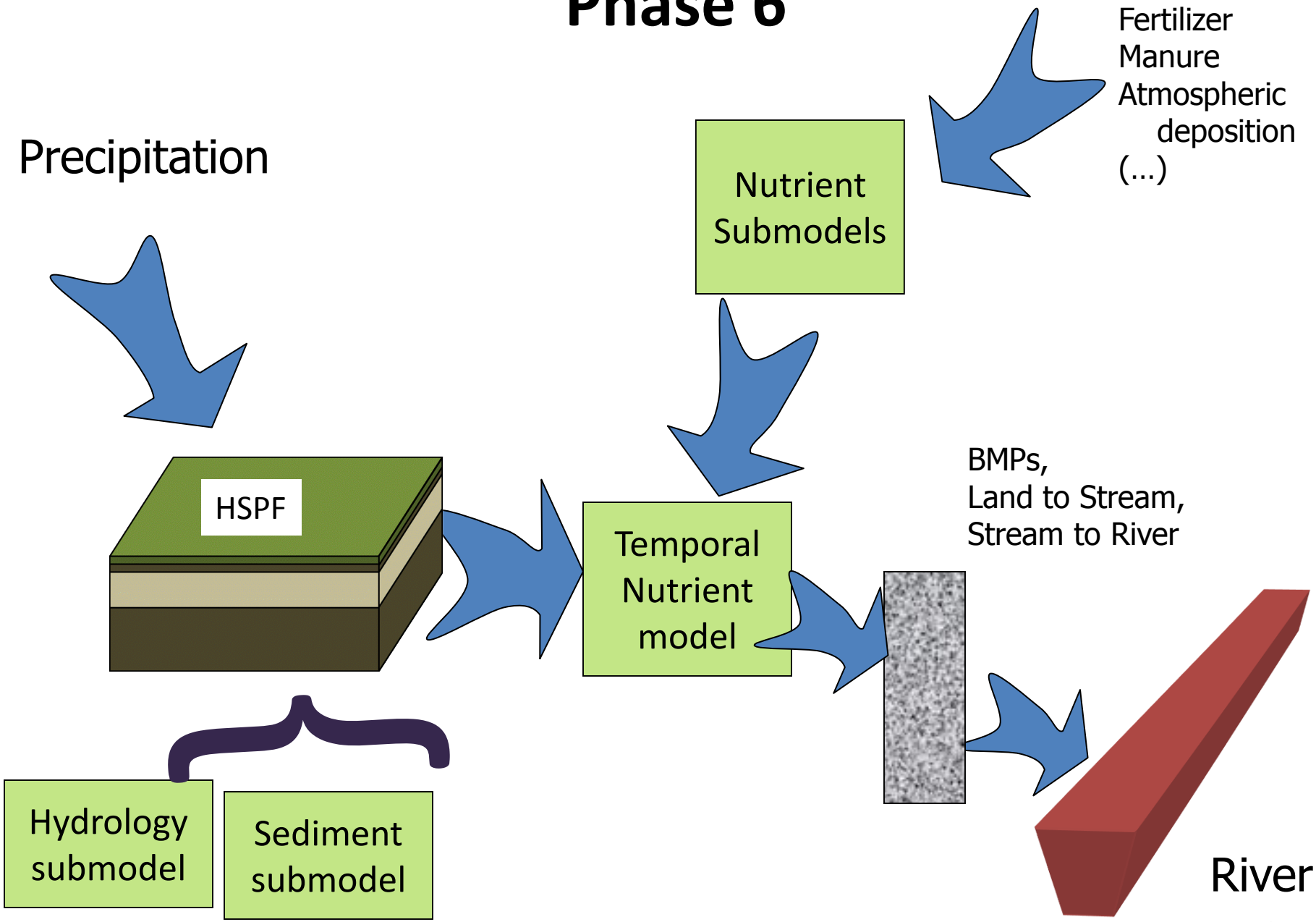
Stream Delivery

*

River Delivery

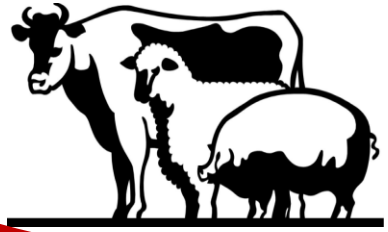
Phase 6

Phase 6

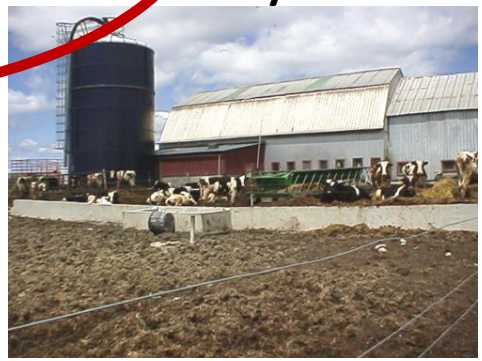

Fertilizer
Manure
Atmospheric deposition
(…)
Nutrient Submodels
Precipitation
HSPF
Temporal Nutrient model
BMPs,
Land to Stream,
Stream to River
Hydrology submodel
Sediment submodel
River

Phase 6 Scenario Builder Conceptual Model

Livestock Manure (and Biosolids)



Barnyard



Fertilizer

Nutrient Application Prescription

Pasture

Access Area

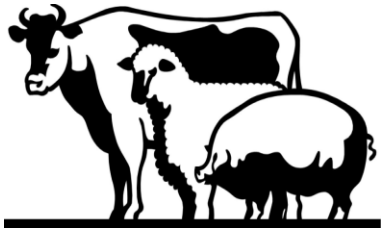
River

Crops

Image Credits
https://utextension.tennessee.edu/lincoln/4-H/Pages/Livestock-Skillathons-%28Beef,-Sheep-and-Swine%29.aspx
Rebelwoodsranch.com
Seaburst.com
http://pubs.ext.vt.edu/442/442-308/442-308.html
http://nh.water.usgs.gov/project/champlain_bmp/ag.htm

Estimating Livestock Manure

Livestock Manure



Data Needed:

- Populations
- Estimates of Manure Produced per Animal
- Estimates of Manure Concentrations
- Estimates of Mineralization of Organic Nutrients

Equation to Estimate Manure per Animal Type

Animal Population
X
Lbs of Manure Produced/Animal
X
Lbs of nutrient species/Lb Manure

Once initial estimates of nutrients are made, then Organic Nitrogen is multiplied by a mineralization factor to estimate the amount of manure available from animals.

Estimating Livestock Manure (cont'd) Populations

Data Needed:

- USDA-NASS 5-Yr Ag Census Inventory – All Livestock (helps inform distribution of turkeys and broilers to county)
- USDA-NASS 5-Yr Sales Numbers – For Hogs for Slaughter and Pullets
- NASS Annual Poultry Production – For Broilers and Turkeys

Population for Hogs for Slaughter and Pullets

(Ag Census County Inventory X 1/Production Cycles) + ((Ag Census County Animals Sold/Production Cycles) X (Production Cycles – 1/Production Cycles)

Hogs for Slaughter Cycle = 2; Pullets Cycle = 1

Population for Livestock and Layers =
Ag Census County Inventory

Population for Broilers and Turkeys =
(Statewide Birds Produced) X (Countywide Ag Census Inventory/Statewide Ag Census Inventory)

Estimating Livestock Manure (cont'd)
Manure Production and Concentrations

Animal Type	Manure Source	Lbs Dry Manure/Animal/Yr	Lbs TN/Lb Dry Manure	LbsTP/Lb Dry Manure
Beef	Use Beef - Cow (confinement) from ASAE 2005 for manure values	5,475.00	0.028788	0.006467
Dairy	Use Lactating Cow, Dry Cow and Heifer from ASAE 2005 for manure values	4,404.33	0.042221	0.006764
Other Cattle	Use average of Beef and Dairy from above to estimate manure values	4,939.67	0.035504	0.006616
Horses	Use average of Horse- Sedentary and Horse - Intense Exercise from ASAE 2005 for manure values	3,102.50	0.031672	0.005941
Hogs for Breeding	Use Gestating Sow and Lactating Sow ASAE 2005 for manure values	657	0.070273	0.019417
Hogs for Slaughter	Use Grow-Finish from ASAE 2005 for manure values	120	0.083333	0.014167
Sheep and Lambs	Use ASAE 2003 for manure values	240.9	0.038182	0.007909
Goats	Use ASAE 2003 for manure values	680.91	0.034615	0.008462

- Poultry litter estimates vary by year and are explained in detail in the PLS report.

Estimating Livestock Manure (cont'd)
Nutrient Concentrations and Mineralization

- Total Nitrogen is further broken down into NH_4^+ and organic N.
- NH_4^+ is determined by multiplying the TN by the fraction of NH_4^+ assumed to be present in Phase 5 TN.
- The remaining TN is assumed AT FIRST to be organic.
- Phase 5 mineralization factor is applied to this organic portion. The remaining portion to determine the NEW amount of mineralized (and plant-available) N, and the NEW amount of organic (not plant-available) N.

This is how it breaks down using cattle as an example:

$NH_4^+ = 0.0073$
$NO_3^- = 0.0000$
Original Organic N = 0.0215
Mineralization Rate = 0.35
New Mineralizable N = Original Organic N X Mineralization Rate = 0.0075271
New Organic N = Original Organic N – New Mineralizable N = 0.013979

- Phase 5 fractions of PO_4 and mineralized P are applied to TP. Note that 100% of organic TP is assumed to be mineralized.
- Some in-field volatilization will also be calculated by Scenario Builder, lowering the amount of plant-available nitrogen.

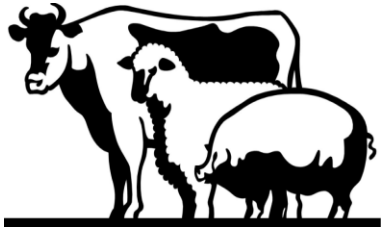
Mineralization (cont'd)

Animal	Current Scenario Builder (MAWP, 2006) Single Year	Cornell (2005) 3-Yr	UMD (2011) 3-Yr	MAWP AVG (2013) 3-Yr
pullets	0.6	0.72	NA	0.75
turkeys	0.6	0.72	NA	0.75
broilers	0.6	0.72	0.73	0.75
layers	0.6	0.72	0.75	0.75
hogs and pigs for breeding	0.5	0.52	0.73	0.575
hogs for slaughter	0.5	0.52	0.73	0.575
horses	0.5	0.42	0.35	NA
beef	0.35	0.52	0.62	0.53
dairy	0.35	0.52	0.62	0.53
other cattle	0.35	0.52	0.62	0.53
sheep and lambs	0.35	0.52	0.5	NA
angora goats	0.35	NA	0.5	NA
milk goats	0.35	NA	0.5	NA

- MAWP, 2006. Mid-Atlantic Nutrient Management Handbook. Mid-Atlantic Regional Water Program. http://extension.psu.edu/plants/nutrient-management/educational/nutrient-management-general/mid-atlantic-nutrient-management-handbook. Pg. 218
- Cornell, 2005. Nitrogen Credits from Manure. Cornell University. http://www.extendonondaga.org/wp-content/uploads/2013/01/Nitrogen-Credits-from-Manure.pdf. Pg. 2
- MAWP, 2013. Technical Analysis for Nutrient Crediting of Manure Conversion Technologies. Mid-Atlantic Regional Water Program. https://www.aaec.vt.edu/people/faculty/URLs/Kurt_Paper.pdf. Pg. 27
- UMD, 2011. Mineralization Rates for Organic Nutrient Sources (July, 2011 Update). University of Maryland Extension. https://extension.umd.edu/sites/default/files/_images/programs/anmp/Mineralization_rates_organic_sources_07-11%20(3).pdf

Phase 6 Scenario Builder Conceptual Model

Livestock Manure (and Biosolids)



Barnyard

Fertilizer

Nutrient Application Prescription

Pasture

Access Area

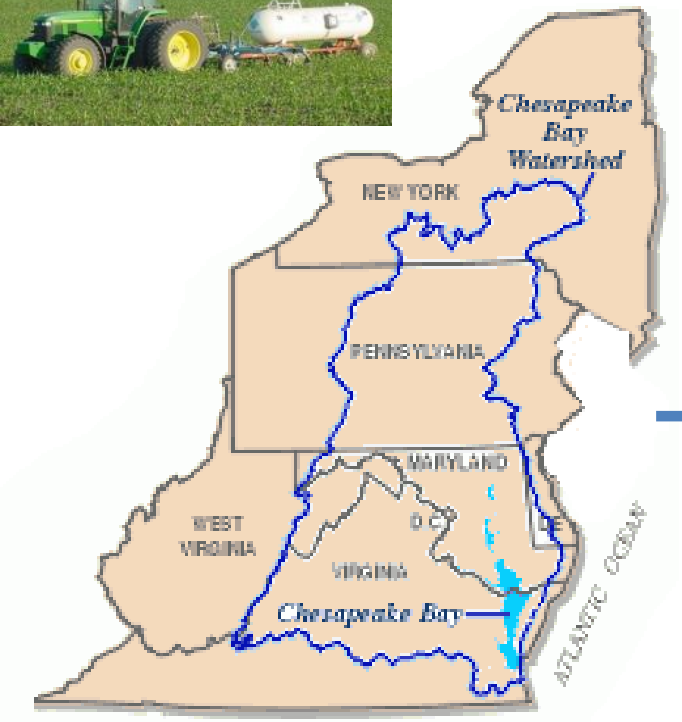
River

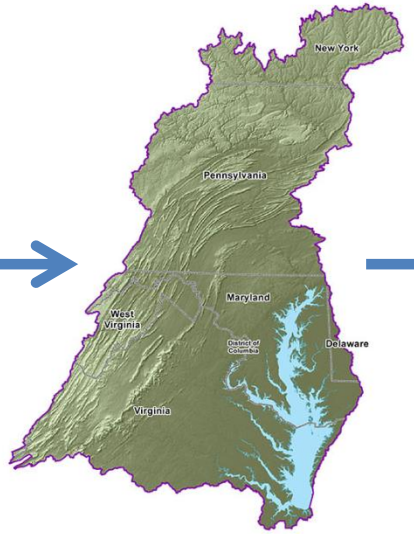
Crops

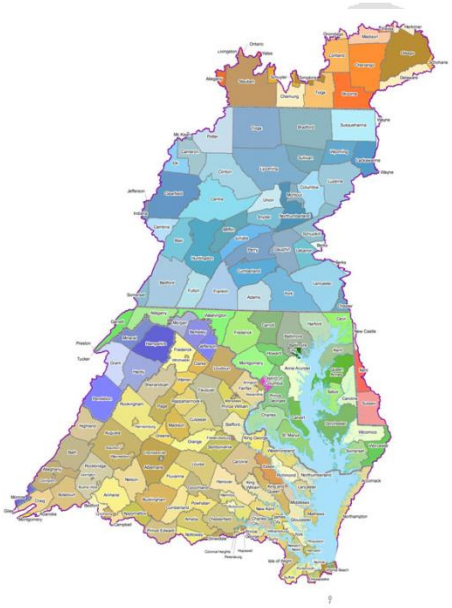
Image Credits
https://utextension.tennessee.edu/lincoln/4-H/Pages/Livestock-Skillathons-%28Beef,-Sheep-and-Swine%29.aspx
Rebelwoodsranch.com
Seaburst.com
http://pubs.ext.vt.edu/442/442-308/442-308.html
http://nh.water.usgs.gov/project/champlain_bmp/ag.htm

Estimating Fertilizer Available

Fertilizer

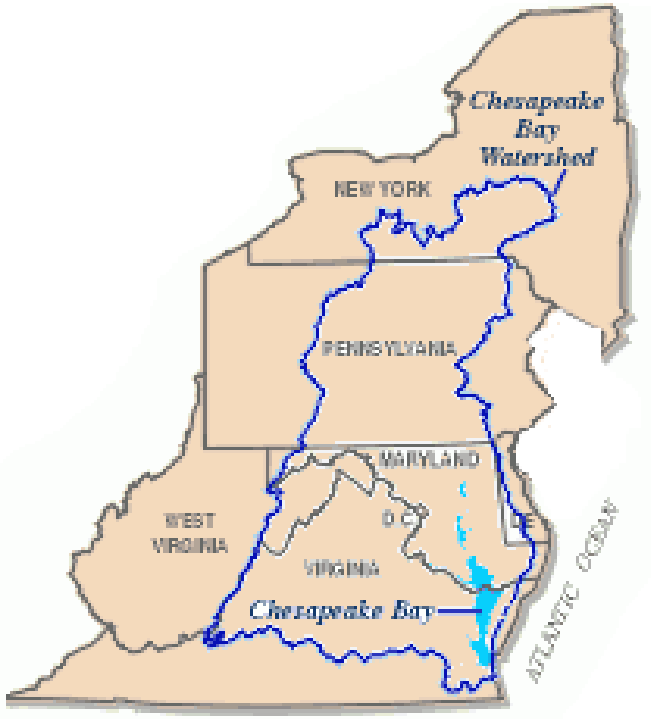






6 statewide to watershedwide to countywide

6 Statewide (REGIONAL) Farm Fertilizer Sales



Data Needed:

•AAPFCO Farm/Non-Farm/Unknown Lbs of Fertilizer Sold by County

Steps:

•Sum fertilizer sold across all six states.
•Sum “farm” fertilizer sold across all six states.
•Determine rolling 3-year average of the fraction farm-to-total fertilizer sold across all six states.
•Multiply total fertilizer sold across all six states by rolling 3-year average to determine 6 Statewide (REGIONAL) farm fertilizer sales.

Watershed-wide Farm Fertilizer Sales

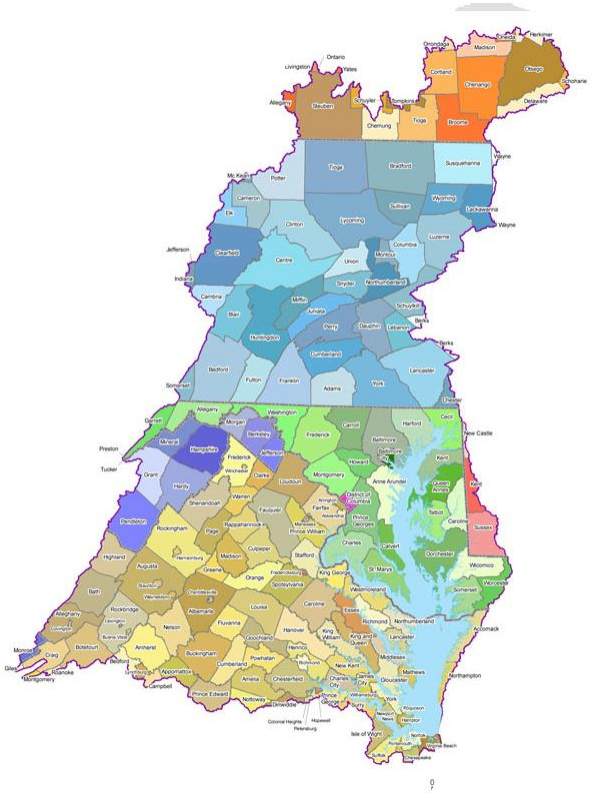
Data Needed:

•6 Statewide (REGIONAL) Farm Fertilizer Sales
•Ag Census county expenditures on fertilizer

Steps:

•Add up Ag Census county expenditures across all 6 states, and across just those counties in the watershed.
•Determine the fraction of expenditures that occurred just within the watershed.
•Multiply the 6 Statewide (REGIONAL) farm fertilizer sales by this fraction to determine watershed-wide farm fertilizer sales.

County-by-county farm fertilizer available



Data Needed:

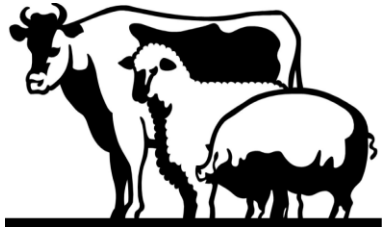
- Watershed-wide farm fertilizer sales
- Ag Census county expenditures on fertilizer
- SB county estimate of fertilizer crop need NOT met with manure

Steps:

- Determine fertilizer crop need for each county and manure available for each county
- Subtract manure available from fertilizer crop need to determine remaining fertilizer crop need
- Determine fraction of county's remaining fertilizer crop need out of ENTIRE watershed's remaining fertilizer crop need
    - Multiply by 0.5
- Determine fraction of county Ag Census expenditures on fertilizer out of ENTIRE watershed's Ag Census expenditures on fertilizer.
    - Multiply by 0.5
- Add together the two weighting factors for the county
- Multiply Watershed-wide farm fertilizer sales by the sum of the weighting factors

Phase 6 Scenario Builder Conceptual Model

Livestock Manure (and Biosolids)



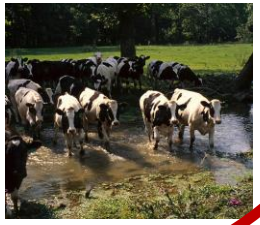
Fertilizer

Barnyard

Nutrient Application Prescription

Pasture

Access Area



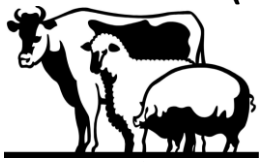
River

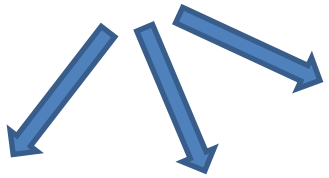
Crops

Image Credits
https://utextension.tennessee.edu/lincoln/4-H/Pages/Livestock-Skillathons-%28Beef,-Sheep-and-Swine%29.aspx
Rebelwoodsranch.com
Seaburst.com
http://pubs.ext.vt.edu/442/442-308/442-308.html
http://nh.water.usgs.gov/project/champlain_bmp/ag.htm

Distributing Manure to Pasture, Access Areas and Barnyard

Livestock Manure (and Biosolids)





Pasture

Access Area

Barnyard

Data Needed:

•Confine Area, Pasture and Access Area Fractions from states

•Multiply total manure produced by fraction in each month to determine how much is available to direct deposition, access area and barnyard

GrowthRegion	AnimalName	Month	ConfineAreaFraction	PastureFraction	AccessAreaFraction
MD_1	beef	1	0.30	0.70	0.00
MD_1	beef	2	0.30	0.70	0.00
MD_1	beef	3	0.20	0.80	0.00
MD_1	beef	4	0.20	0.80	0.00
MD_1	beef	5	0.00	0.82	0.18
MD_1	beef	6	0.00	0.82	0.18
MD_1	beef	7	0.00	0.82	0.18
MD_1	beef	8	0.00	0.82	0.18
MD_1	beef	9	0.00	0.92	0.08
MD_1	beef	10	0.00	0.92	0.08
MD_1	beef	11	0.00	0.92	0.08
MD_1	beef	12	0.30	0.70	0.00

Storage and Handling Loss

Barnyard

Animal Type (Survey Region or Source)	Fraction Recoverable Manure (Before CNMP)	Fraction Storage and Handling Loss
Beef (PA, NY, NJ Fattened Cattle)	0.6	**0.4**
Dairy (North Central, Northeast Milk Cows)	0.51	**0.49**
Other Cattle (Average Beef and Dairy)	0.55	**0.45**
Horses (Northeast Pastured)	0.59	**0.41**
Hogs for Breeding (North Central and Northeast)	0.75	**0.25**
Hogs for Slaughter (Northeast Pastured)	0.7	**0.3**
Sheep and Lambs (Northeast Pastured)	0.59	**0.41**
Angora Goats (Northeast Pastured)	0.59	**0.41**
Milk Goats (Northeast Pastured)	0.59	**0.41**
Pullets (North Central and Northeast)	0.85	**0.15**
Layers (North Central and Northeast)	0.85	**0.15**
Turkeys (East)	0.765	**0.235**
Broilers (Northeast)*	0.75	**0.25**

**Phase 6 Model broiler nutrient estimates are based upon litter available to crops after storage and handling loss, so the amount of litter will be increased by 0.25 to estimate storage and handling losses.*
Source: USDA-NRCS, 2003. Costs Associated with Development and Implementation of Comprehensive Nutrient Management Plans. June, 2003.

- Storage and Handling Loss factor determines the pre-BMP and volatilization nutrient load from animal feeding operations.
- Volatilization, BMPs and further nutrient retention between the operation and the simulated stream further reduce these loads.
- AMS strongly recommends the AWMS review literature to update these pre-BMP loss factors

Acres of Feeding Operations

Data Needed:

- Average area needed to produce one animal (acres/animal)
- Total animals produced

Source Name	Open-Air Barnyard (sq feet)			Roofed Structures (sq feet)			All Area (sq feet)	Cycles (NRCS)	Adjusted All Area (sq ft)	All Area (acres/animal)
	MAX	MIN	MED	MAX	MIN	MED	Total	Total	Total	Total
Pullets*						1.0	1.0	2.25	0.44	0.000010
Turkeys				2.0	2.0	2.0	2.0	2.00	1.02	0.000023
Broilers*						0.85	0.85	6.00	0.14	0.000003
Layers				1.7	1.7	1.7	1.7	1.00	1.72	0.000040
Hogs for Slaughter				9.7	9.7	9.7	9.7	2.00	4.84	0.000111
Hogs and Pigs for Breeding				13.6	13.6	13.6	13.6	1.00	13.56	0.000311
Beef (Beef Heifers)**	60.3	50.6	55.4	35.5	18.3	26.9	82.3	1.00	82.31	0.001890
Dairy (Dairy heifers)**	96.8	96.8	96.8	28.6	28.6	28.6	125.5	1.00	125.46	0.002881
Other Cattle**	50.6	39.8	45.2	24.7	11.8	18.3	63.5	1.00	63.48	0.001458
Horses **	147.3	147.4	147.4	147.3	147.3	147.3	294.7	1.00	294.66	0.006765
Sheep and Lambs*						25.0	25.0	1.00	25.02	0.000574
Goats*						15.0	15.0	1.00	15.00	0.000344

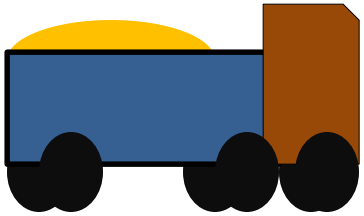
Manure Transport and AWMS

•AWMS first lowers the amount of storage and handling loss and increases the amount available for land application within the county of production or another county.

•Manure transport then moves manure across county lines.

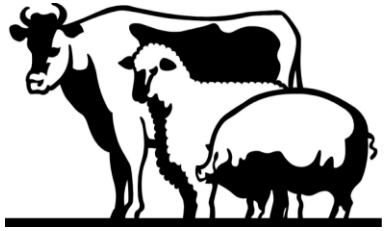
Manure Storage

Transport



Phase 6 Scenario Builder Conceptual Model

Livestock Manure (and Biosolids)



Barnyard

Fertilizer

Nutrient Application Prescription

Pasture

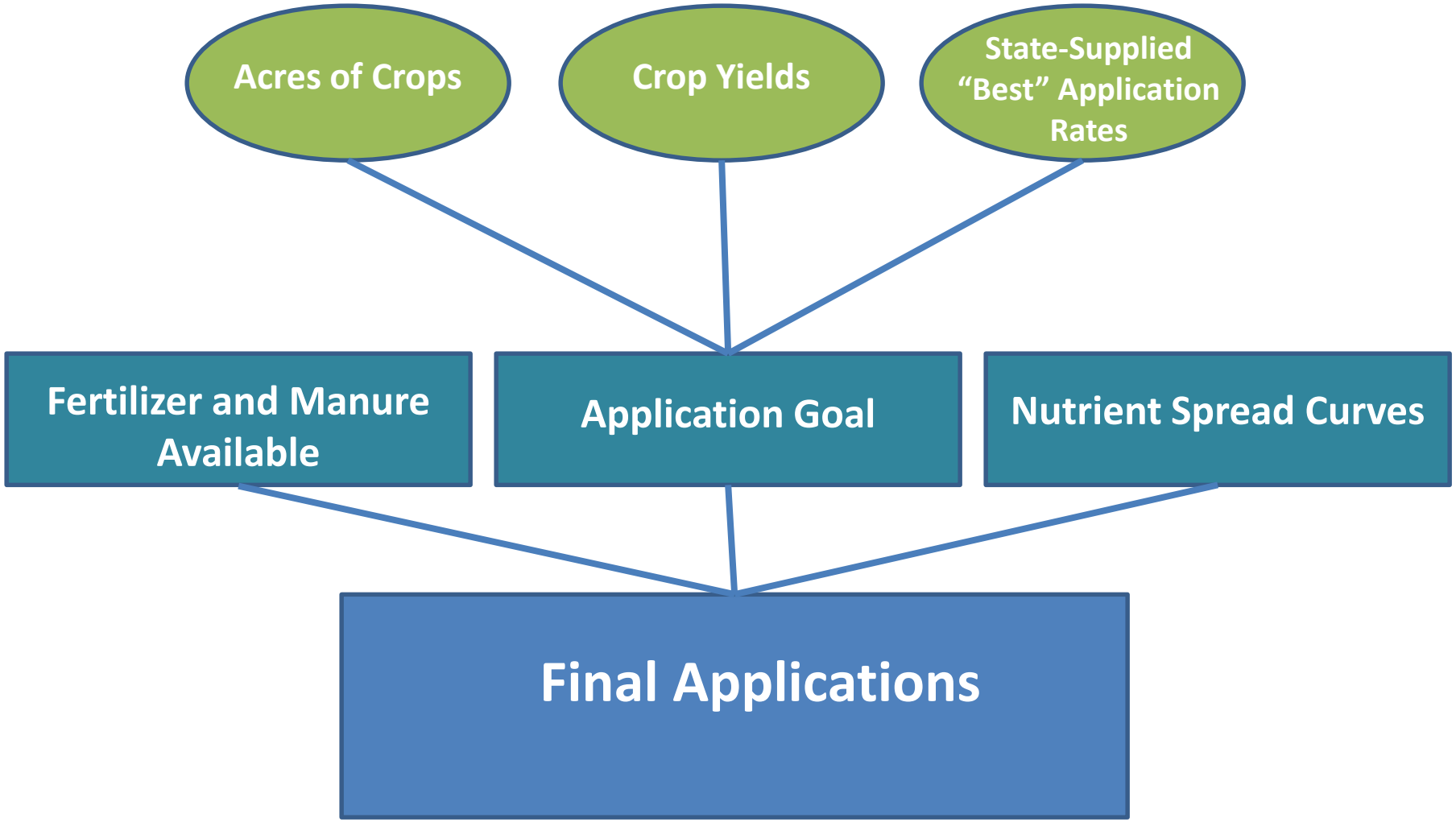
Access Area

River

Crops

Image Credits
https://utextension.tennessee.edu/lincoln/4-H/Pages/Livestock-Skillathons-%28Beef,-Sheep-and-Swine%29.aspx
Rebelwoodsranch.com
Seaburst.com
http://pubs.ext.vt.edu/442/442-308/442-308.html
http://nh.water.usgs.gov/project/champlain_bmp/ag.htm

“Prescribing” Applications to Crops



Application Goal Example

Data Needs:

- Ag Census acres of crops (or projected acres)
- State-supplied applications per yield unit
- State-supplied application per month
- NASS annual crop survey yearly yields for major crops
- Ag Census yields for other crops

Equation:

Acres X Application/Yield Unit X Yield X Fraction Applied in Month

Year	County	CropName	Nutrient	LbsPerYieldUnit	Yield	ApplicationGoal
2012	Anne Arundel	Corn for Grain Harvested Area	TN	1.0000	129.13	129.13
2012	Anne Arundel	Corn for Grain Harvested Area	TP	0.1247	129.13	16.10

Year	County	CropName	Nutrient	DaysAfter Planting	FractionApplied	FertilizerOnly
2012	Anne Arundel	Corn for Grain Harvested Area	TN	-20	0.6	0
2012	Anne Arundel	Corn for Grain Harvested Area	TN	0	0.2	1
2012	Anne Arundel	Corn for Grain Harvested Area	TN	45	0.2	1

1,000 Acres X 1 Lb N/Bushel of Corn X 129.13 Bushels of Corn X 0.6 =
77,478 Lbs N (20 days before planting)

Crop Yields

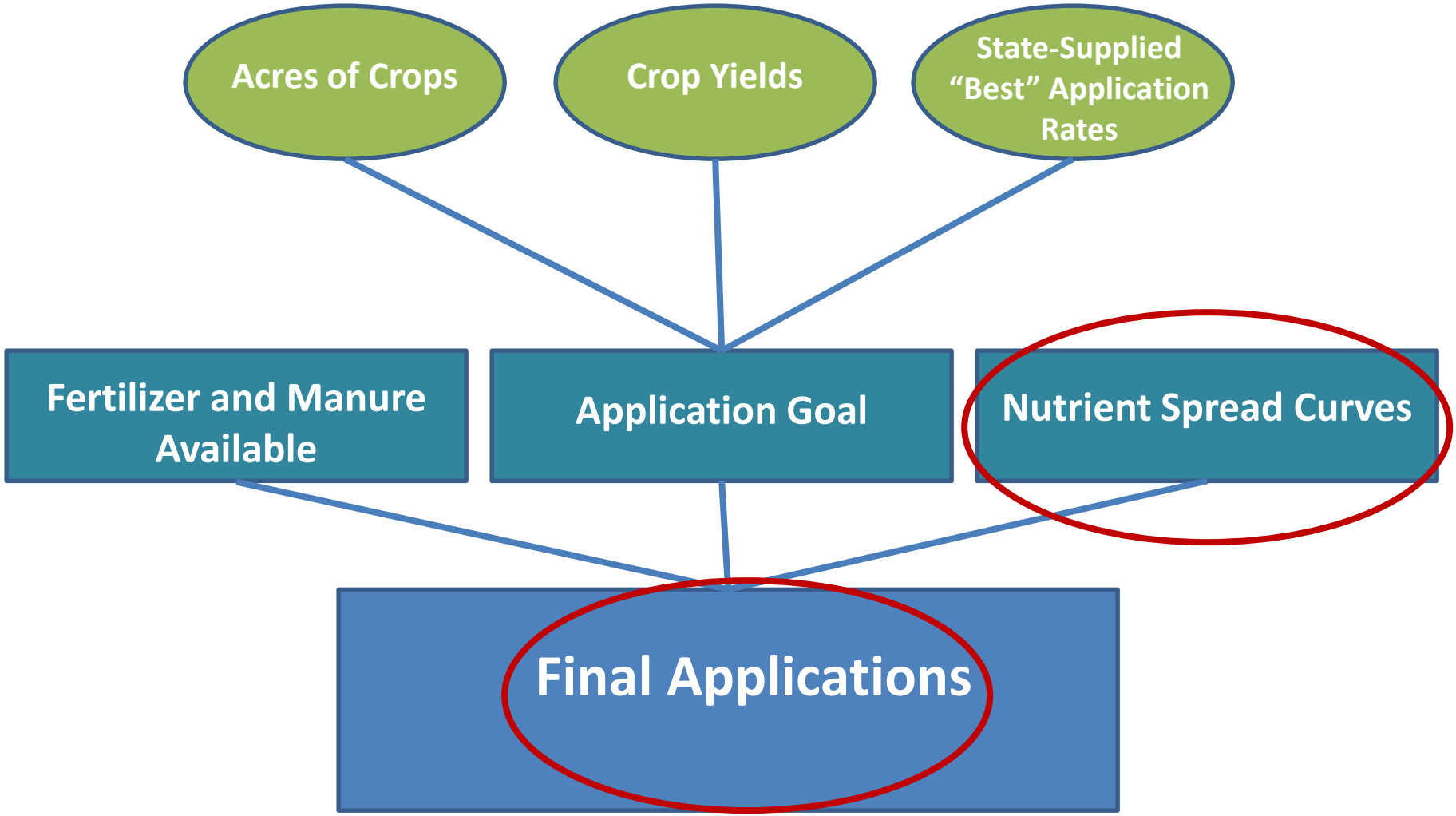
- Annual yields available from NASS for:
  - Alfalfa Hay Harvested Area
  - Barley for grain Harvested Area
  - Corn for Grain Harvested Area
  - Corn for silage or greenchop Harvested Area
  - Oats for grain Harvested Area
  - Soybeans for beans Harvested Area
  - Wheat for Grain Harvested Area

- Ag Census yields used for:
  - Buckwheat Harvested Area
  - Emmer and spelt Harvested Area
  - Rye for grain Harvested Area
  - Sorghum for Grain Harvested Area
  - Sorghum for silage or greenchop Area
  - Triticale Harvested Area

- Best 3 out of available 5 yields x 1.1 used regardless of which dataset they came from.

- No yields used to set application goals for other crops. For example, the yield on pasture was set equal to 1, so the application/ yield unit became the application/ acre.

“Prescribing” Applications to Crops



Crops to LU

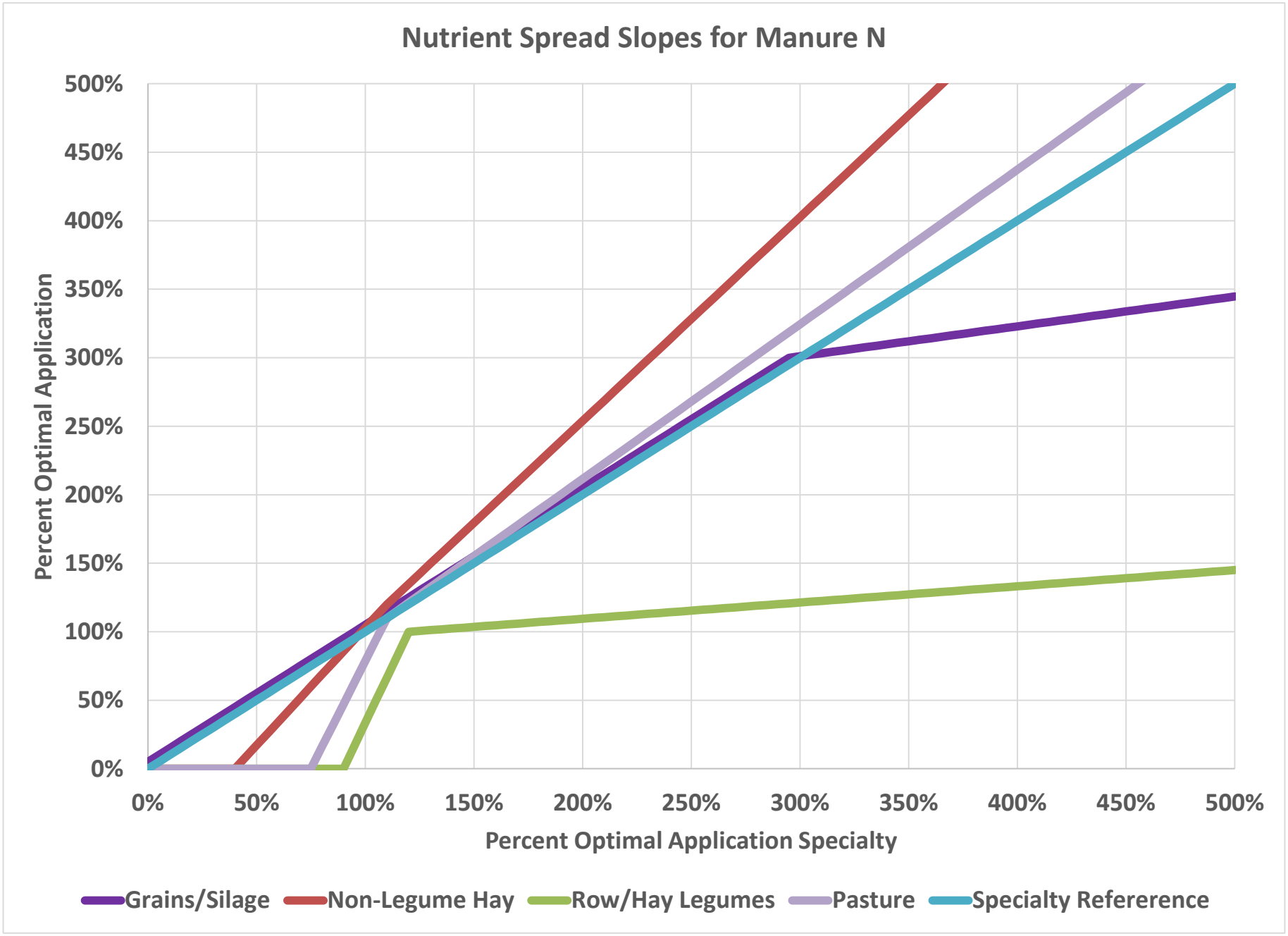
Land Use Name	Manure Eligible
Ag Open Space	N
Full Season Soybeans	Y
Grain with Manure	Y
Grain without Manure	N
Legume Hay	Y
Silage with Manure	Y
Silage without Manure	N
Small Grains and Grains	Y
Small Grains and Soybeans	Y
Specialty Crop High	Y
Specialty Crop Low	Y
Other Agronomic Crops	Y
Other Hay	Y
Pasture	Y
Farmstead	NA
Permitted Feeding Space	NA
Non-Permitted Feeding Space	NA

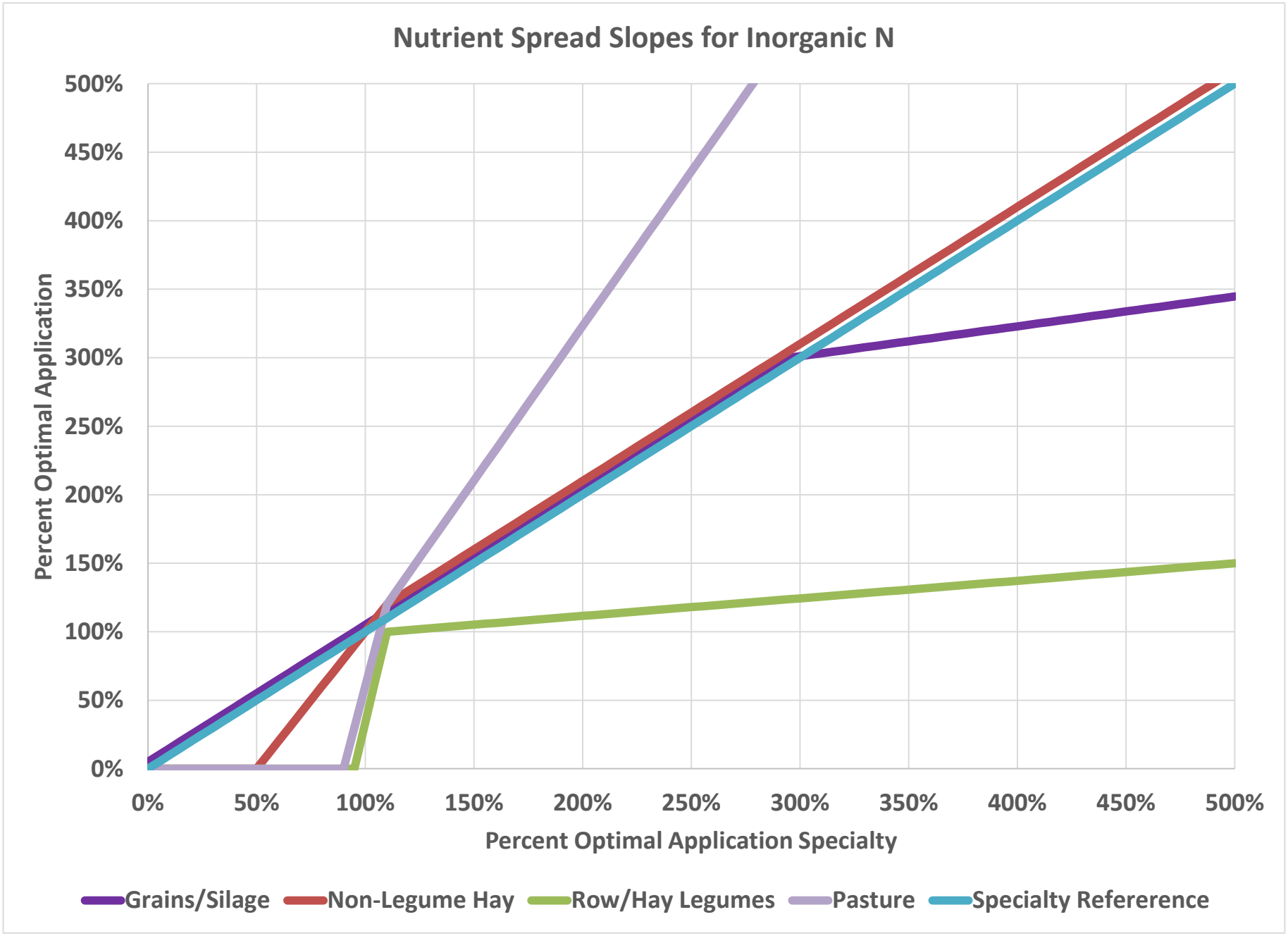
CropName	Phase6 MajorLanduse
Cotton Harvested Area	Other Agronomic crops
Dry edible beans, excluding limas Harvested Area	Other Agronomic crops
Peanuts for nuts Harvested Area	Other Agronomic crops
Sod harvested Area	Other Agronomic crops
Sod harvested Protected Area	Other Agronomic crops
Sweet Corn Harvested Area	Other Agronomic crops
tobacco Harvested Area	Other Agronomic crops

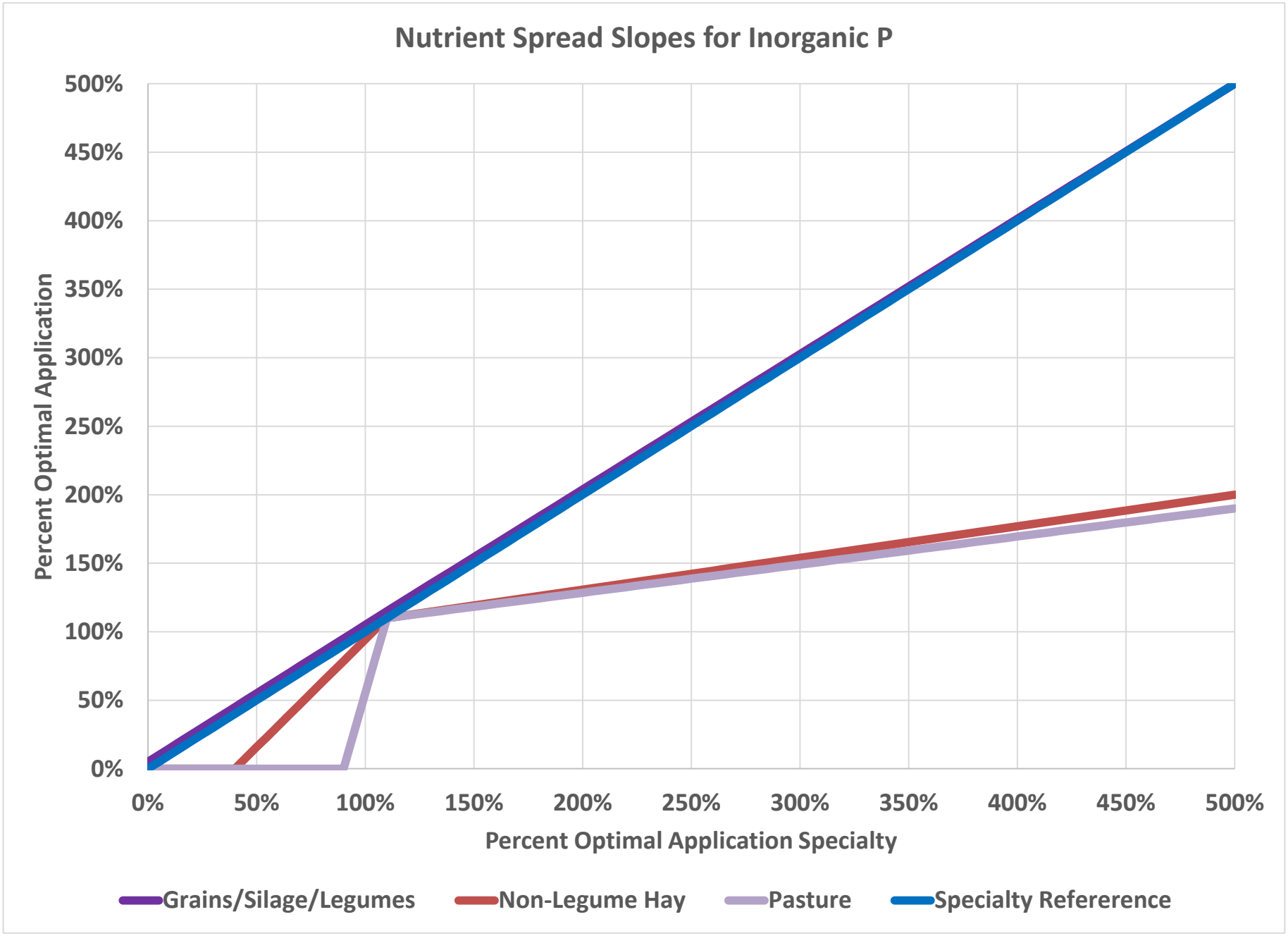
- Applications are made directly to crops, BUT crops are lumped into land uses.
- Overall application on a single land use represents application on multiple crops.

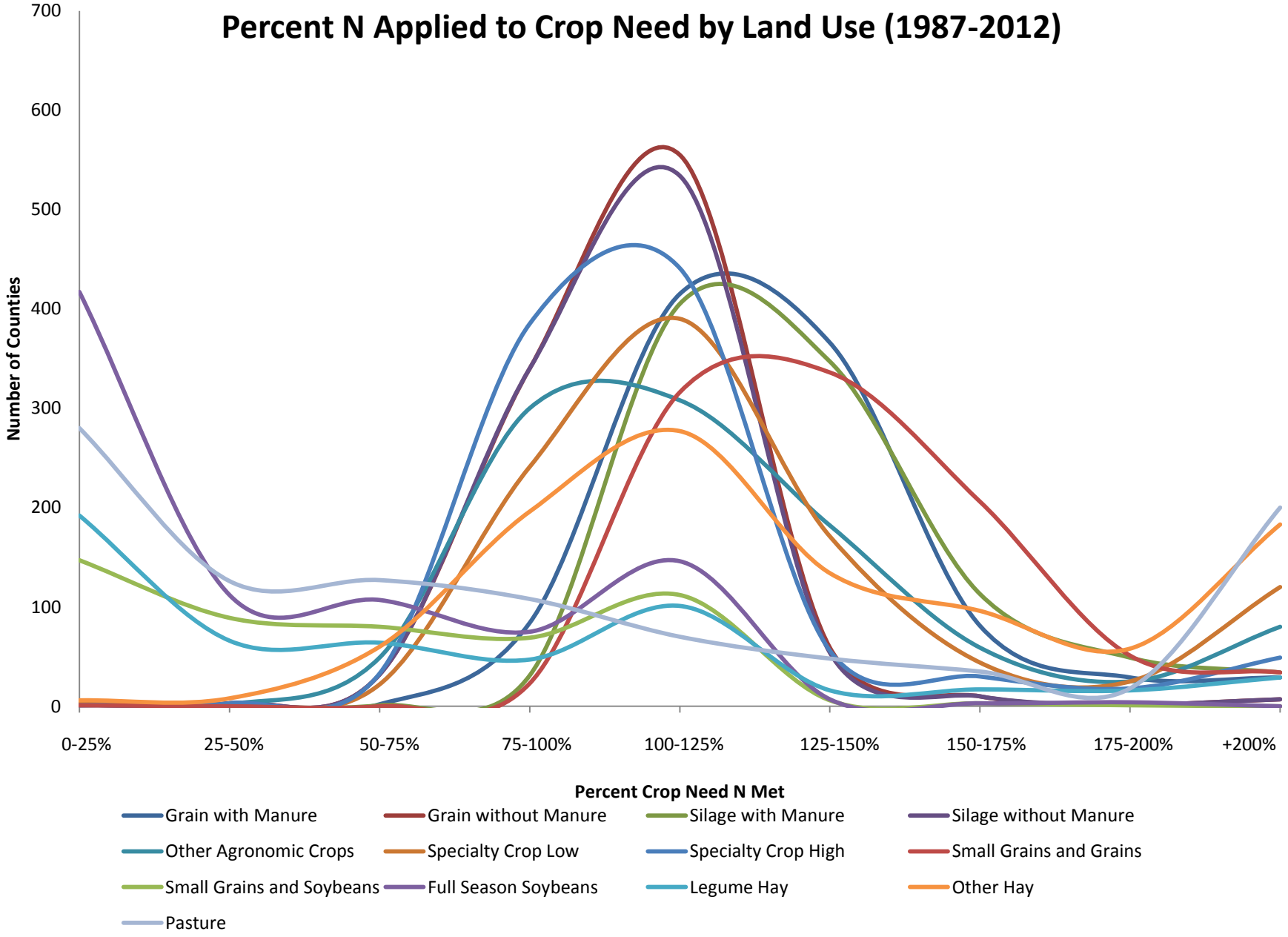
Acres of Manure Eligibility

- Grain with Manure and Silage with Manure are two land uses that are created by multiplying their constituent crops by a manure fraction found in the Ag Census for that county.
- **Manure Fraction = Acres Receiving Manure/ (Harvested Cropland Acres + Pasture Acres – Soybeans Harvested Acres)**
- Values are only available for 2007 and 2012.
- The 2007 value is assumed to be constant back to 1985.
- Future values are assumed to be constant with 2012 until a new Ag Census is released.

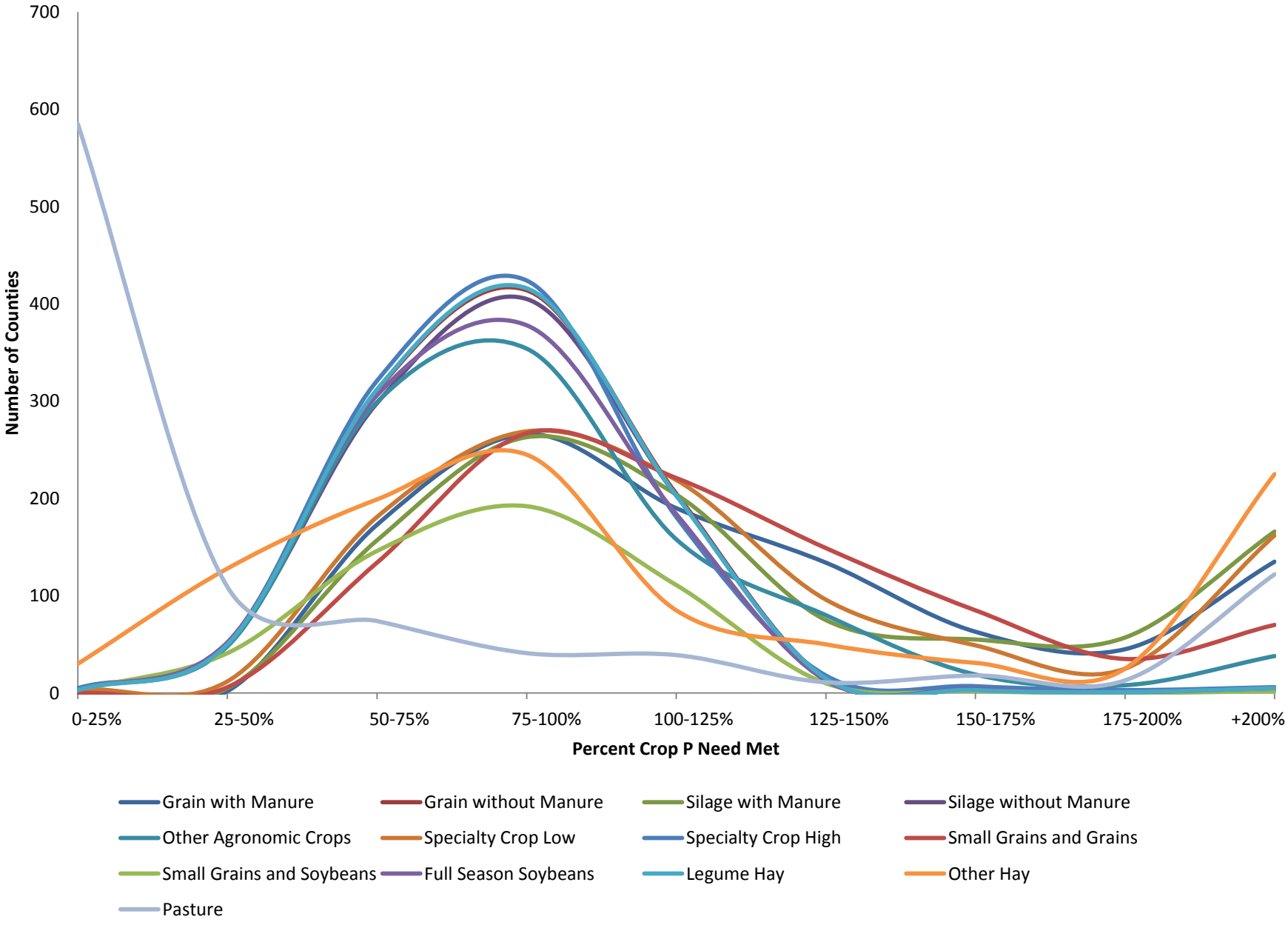

Nutrient Spread Slopes for Manure N
Percent Optimal Application
500%
450%
400%
350%
300%
250%
200%
150%
100%
50%
0%
0%
50%
100%
150%
200%
250%
300%
350%
400%
450%
500%
Percent Optimal Application Specialty
Grains/Silage
Non-Legume Hay
Row/Hay Legumes
Pasture
Specialty Refererence


Nutrient Spread Slopes for Inorganic N
Percent Optimal Application
500%
450%
400%
350%
300%
250%
200%
150%
100%
50%
0%
0%
50%
100%
150%
200%
250%
300%
350%
400%
450%
500%
Percent Optimal Application Specialty
Grains/Silage
Non-Legume Hay
Row/Hay Legumes
Pasture
Specialty Refererence


Nutrient Spread Slopes for Inorganic P
Percent Optimal Application
500%
450%
400%
350%
300%
250%
200%
150%
100%
50%
0%
0%
50%
100%
150%
200%
250%
300%
350%
400%
450%
500%
Percent Optimal Application Specialty
Grains/Silage/Legumes
Non-Legume Hay
Pasture
Specialty Refererence


Percent N Applied to Crop Need by Land Use (1987-2012)
Number of Counties
700
600
500
400
300
200
100
0
0-25%
25-50%
50-75%
75-100%
100-125%
125-150%
150-175%
175-200%
+200%
Percent Crop Need N Met
Grain with Manure
Grain without Manure
Silage with Manure
Silage without Manure
Other Agronomic Crops
Specialty Crop Low
Specialty Crop High
Small Grains and Grains
Small Grains and Soybeans
Full Season Soybeans
Legume Hay
Other Hay
Pasture

Percent P Applied to Crop Need by Land Use (1987-2012)

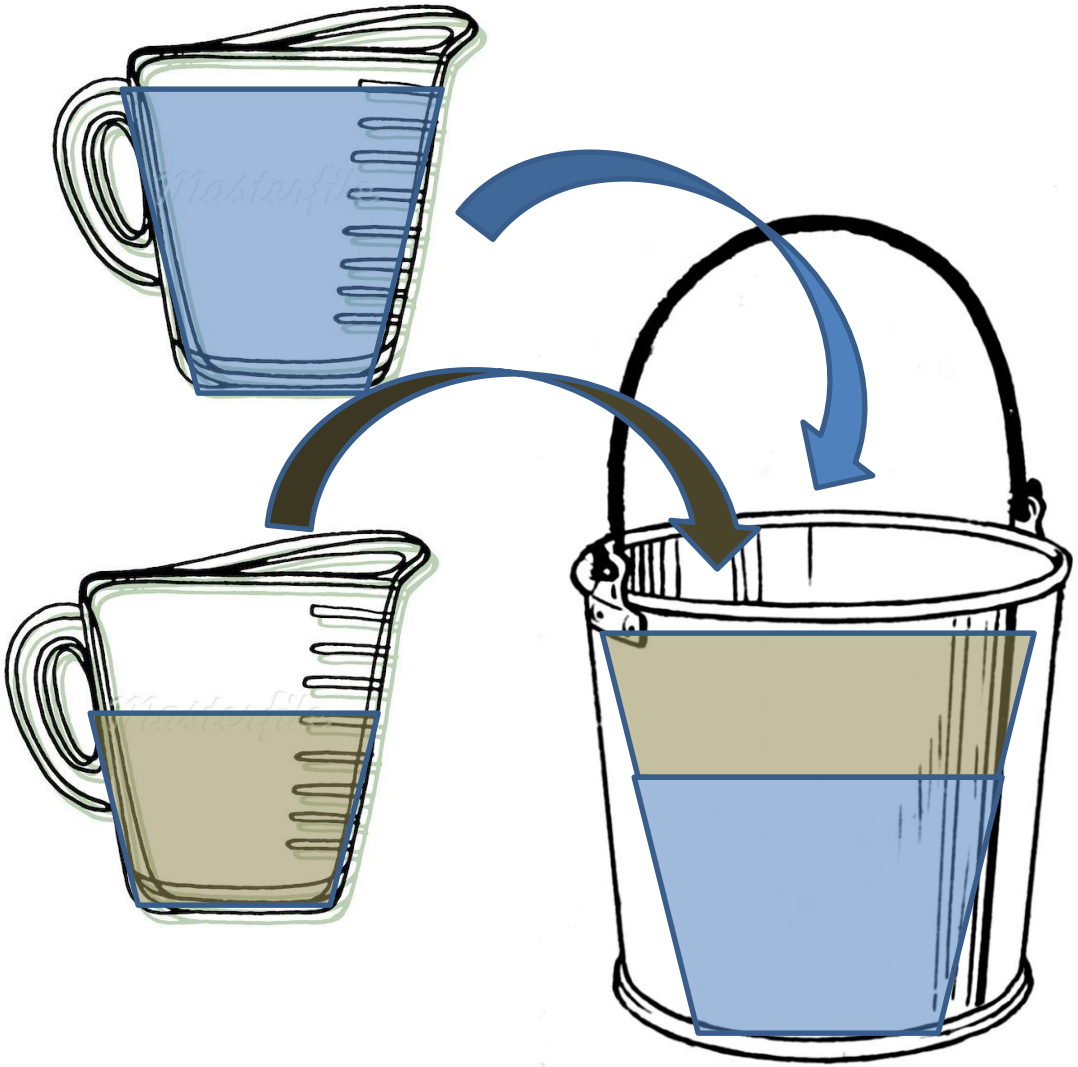


Matt will present findings from preliminary Scenario Builder runs after lunch

You want results? You got it!

- Applications by land use or crop
- Applications by county
- Applications by year
- Applications by nutrient type
- All will be available in spreadsheet format in January, 2016 for Ag Workgroup and other partners to review.
- Spreadsheets will be posted to Ag Workgroup site.
- Contact Matt Johnston (mjohnston@chesapeakebay.net) if you have questions.

Is my bucket full?



Washington County, MD 2012

LU	Acres	Crop Need Lbs N	Manure Applied Lbs N (No DD)	Fertilizer Applied Lbs N	Direct Deposit Lbs N	Total Lbs N Applied	Total Lbs N Applied/ Acre	Lbs N Applied/ Lbs Crop Need N
pas	23,955.00	359,325.00	0.00	0.00	4,715,303.95	0.00	0.00	-
soy	16,391.00	161,906.67	0.00	0.00	0.00	0.00	0.00	-
ohy	15,875.00	537,250.03	8,335.79	409,177.06	0.00	417,512.85	26.30	0.78
gom	14,001.04	1,487,254.08	0.00	1,389,519.86	0.00	1,389,519.86	99.24	0.93
sgg	11,277.42	1,110,182.76	225,660.69	936,050.75	0.00	1,161,711.44	103.01	1.05
lhy	8,798.00	0.00	0.00	0.00	0.00	0.00	0.00	-
gwm	6,985.96	742,080.92	456,813.88	488,499.02	0.00	945,312.90	135.32	1.27
som	6,914.12	701,193.91	0.00	655,115.27	0.00	655,115.27	94.75	0.93
swm	3,449.87	349,868.05	213,357.97	231,215.78	0.00	444,573.75	128.87	1.27
scl	1,640.30	42,077.62	3,552.25	35,615.95	0.00	39,168.20	23.88	0.93
oac	220.00	33,000.00	0.00	29,181.42	0.00	29,181.42	132.64	0.88
sch	210.68	19,243.90	439.29	16,820.14	0.00	17,259.43	81.92	0.90

Grains with Manure in Washington County, MD 2012

CropName	LU	Month	Acres	Lbs Manure N/ Acre	Lbs Fertilizer N/ Acre	Total Lbs N/ Acre
Corn for Grain Harvested Area	gwm	3	6,690.71	66.07	31.33	**97.40**
Corn for Grain Harvested Area	gwm	4	6,690.71	0.00	20.32	**20.32**
Corn for Grain Harvested Area	gwm	5	6,690.71	0.00	20.32	**20.32**
Sorghum for Grain Harvested Area	gwm	5	295.26	40.00	18.97	**58.97**
Sorghum for Grain Harvested Area	gwm	6	295.26	10.00	4.74	**14.74**





Load for a land use in a segment =

Estimated Average Load + **Sensitivity** * **Δ Inputs**

*

BMPs

*

Watershed Delivery Variance

*

Stream Delivery

*

River Delivery

Phase 6