Chesapeake Bay Program Phase 6 Beta 3 Watershed Model Webinar

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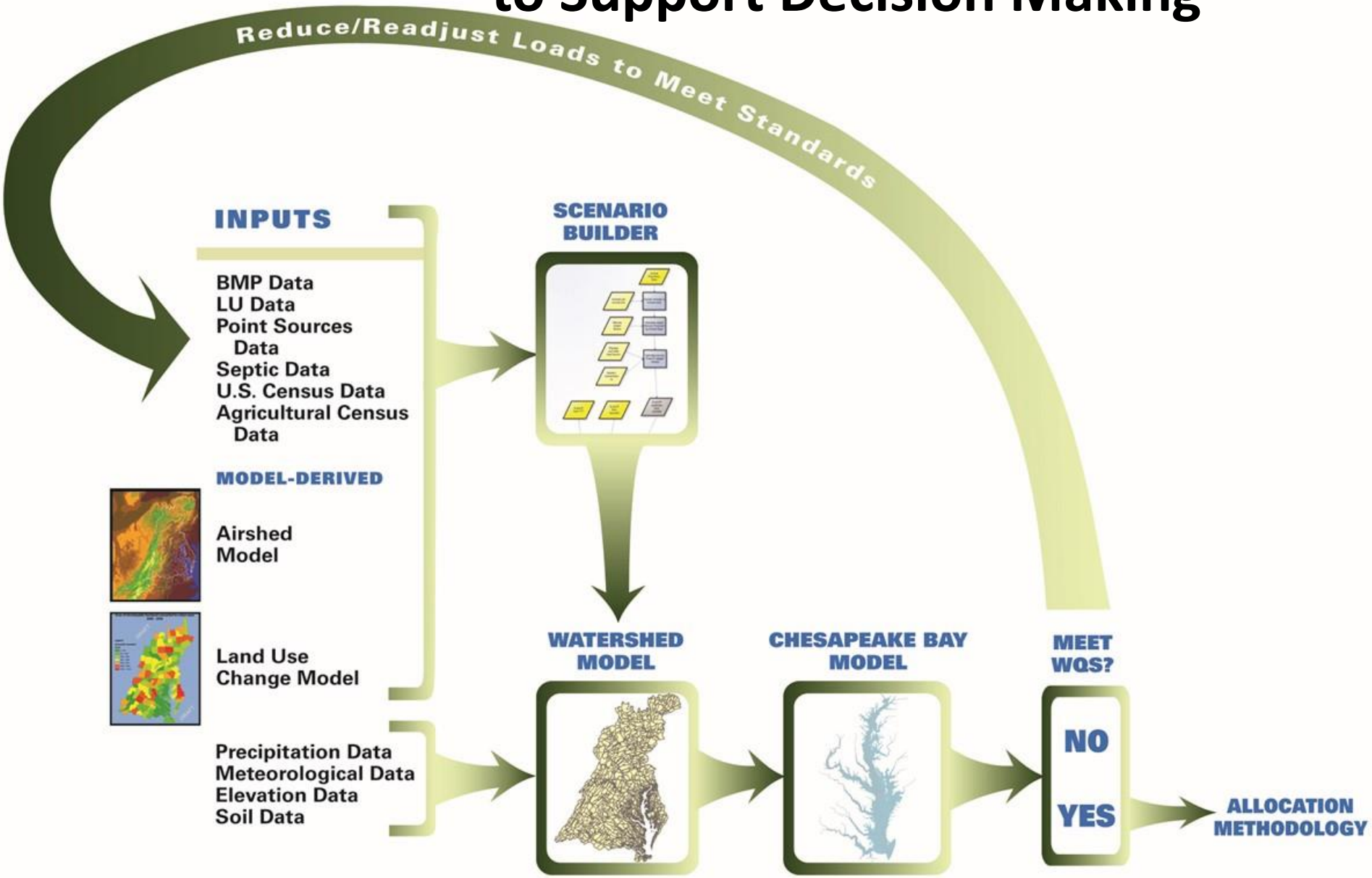
Non-Point Source Data Analyst
7/11/16

Outline

- Introduce Phase 6 Model structure for nutrient inputs and delivery
- Describe differences between Beta 3a and Beta 3b
- Review results of Beta 3a and Beta 3b
- Provide detailed methods for developing nutrient inputs
- Provide response to questions

Chesapeake Bay Partnership Models to Support Decision Making







Phase 6 Model Structure

Average Load + Δ Inputs * Sensitivity

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Land Use Acres

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BMPs

*

Land to Water

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Stream Delivery

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River Delivery

Direct Loads

Phase 6

Setting

Calculation

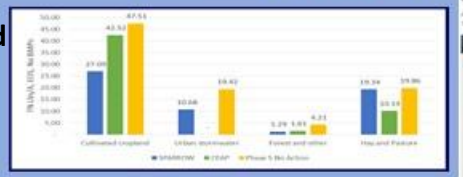
Science Quality

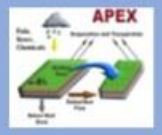
Delivered Load from a land use =

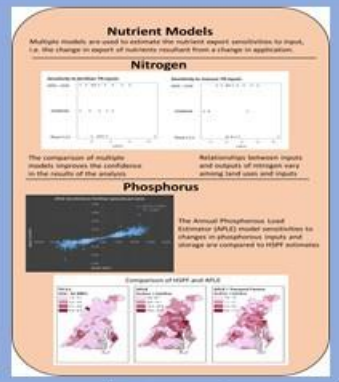
Avg No BMP Nutrient Load

+

Sensitivity * Change in Inputs







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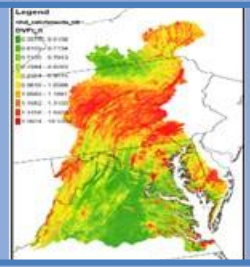
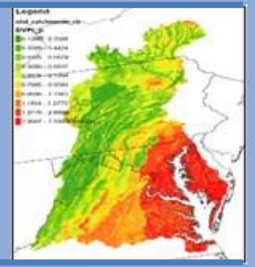
Land to water

SPARROW
For nitrogen:
Soil, vegetation,
and climate variables



SPARROW
For Phosphorus
Soil, slope,
and climate
variables



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BMPs

Effect of BMPs

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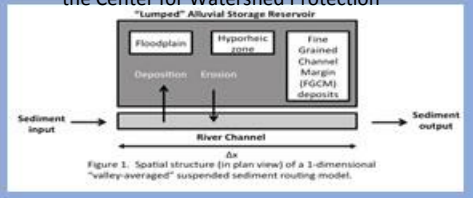
Stream Delivery

Sparrow

Potential models from USGS and
the Center for Watershed Protection



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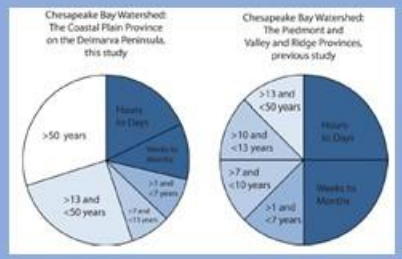
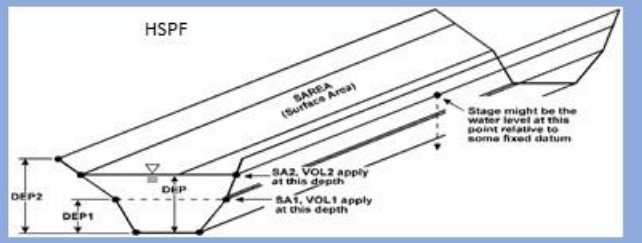
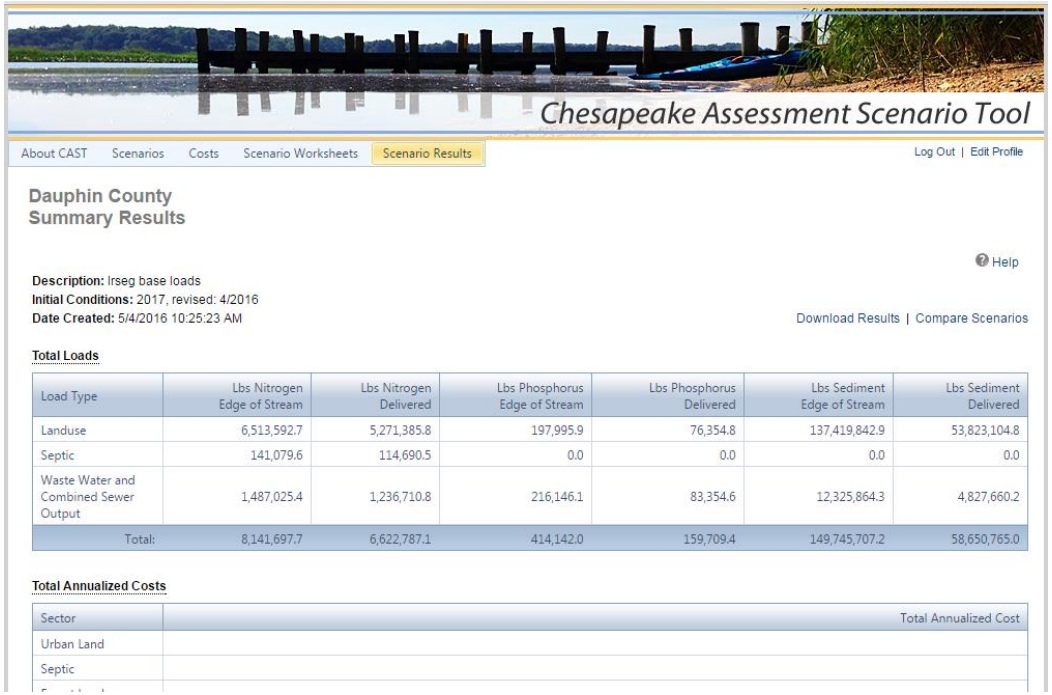
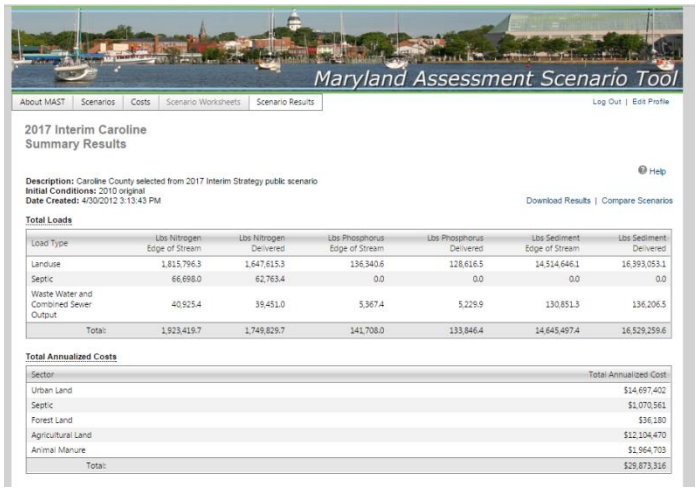
River Delivery

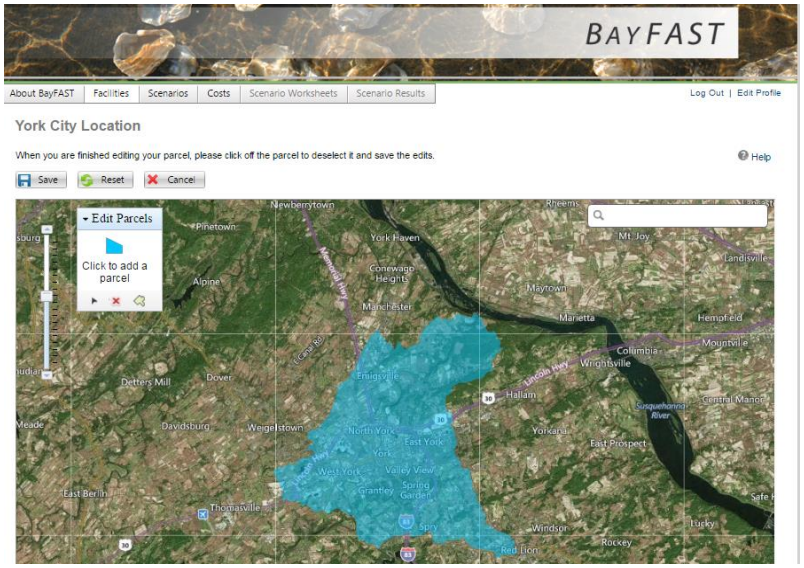




On-Line Tools







Slide from Olivia Devereux





Phase 6 Model Documentation

Section 1: Overview

Section 2: Average Loads + Section 3: Inputs * Section 4: Sensitivity

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Section 5: Land Use

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Section 6: BMPs

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Section 8: Direct Loads

Section 7: Land to Water

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Section 9: Stream Delivery

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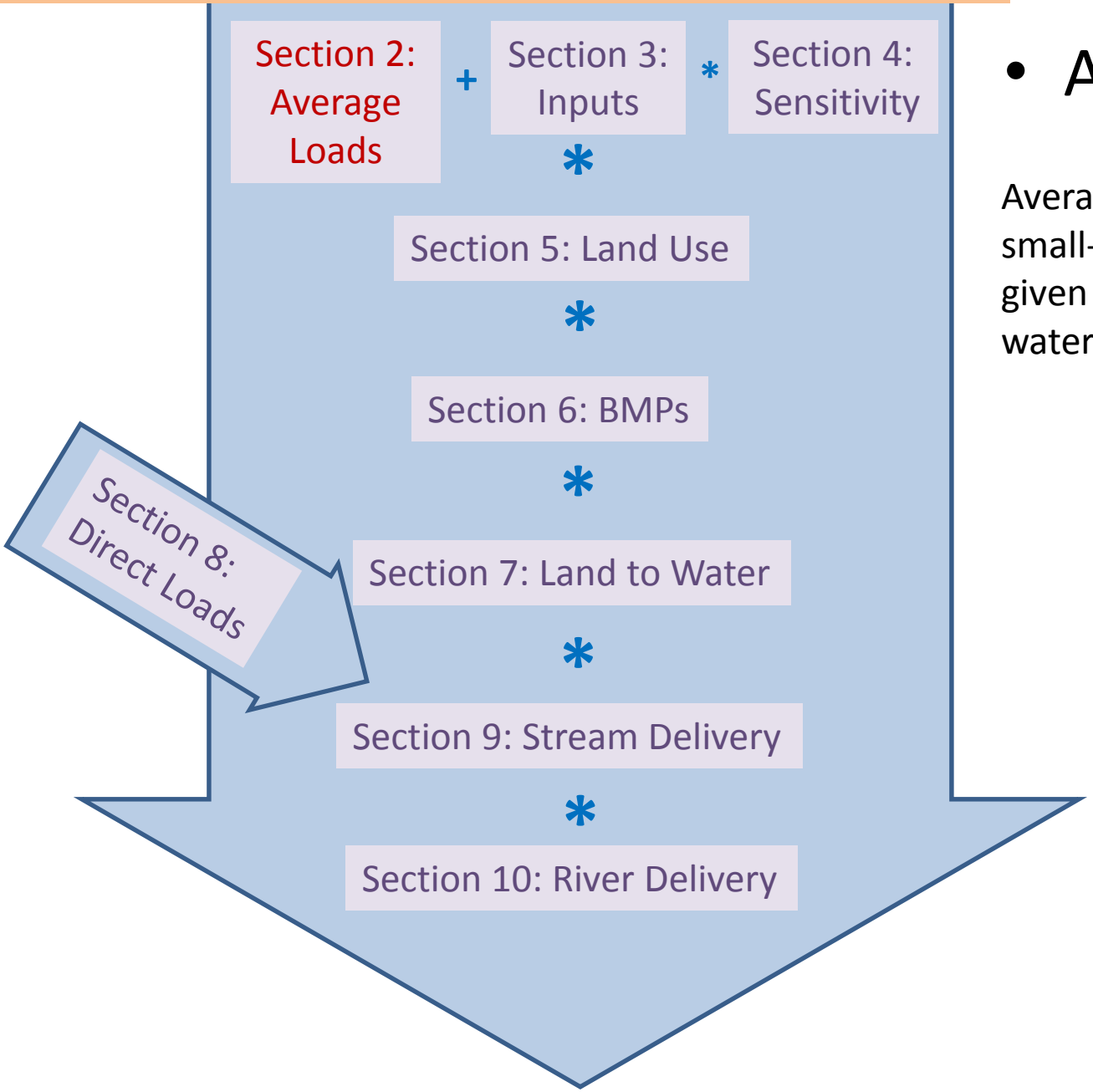
Section 10: River Delivery

Section 11: Applications

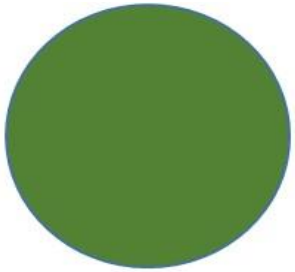
Phase 6 Model Documentation



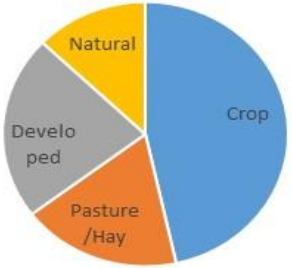
- Average Loads

Average Loads – Average edge-of-small-stream loading rate for a given land use for the entire CB watershed

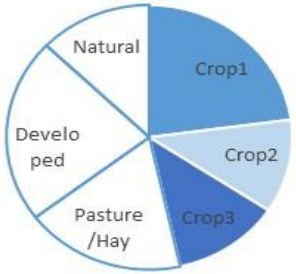
Average Loads



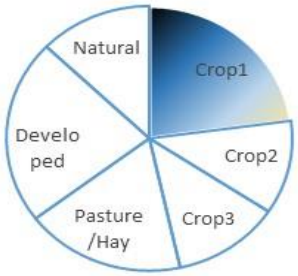
Estimate Total Non-point Source Load
Modeling Workgroup
Monitoring Data



Divide into Broad Classes
Modeling Workgroup
Multiple models

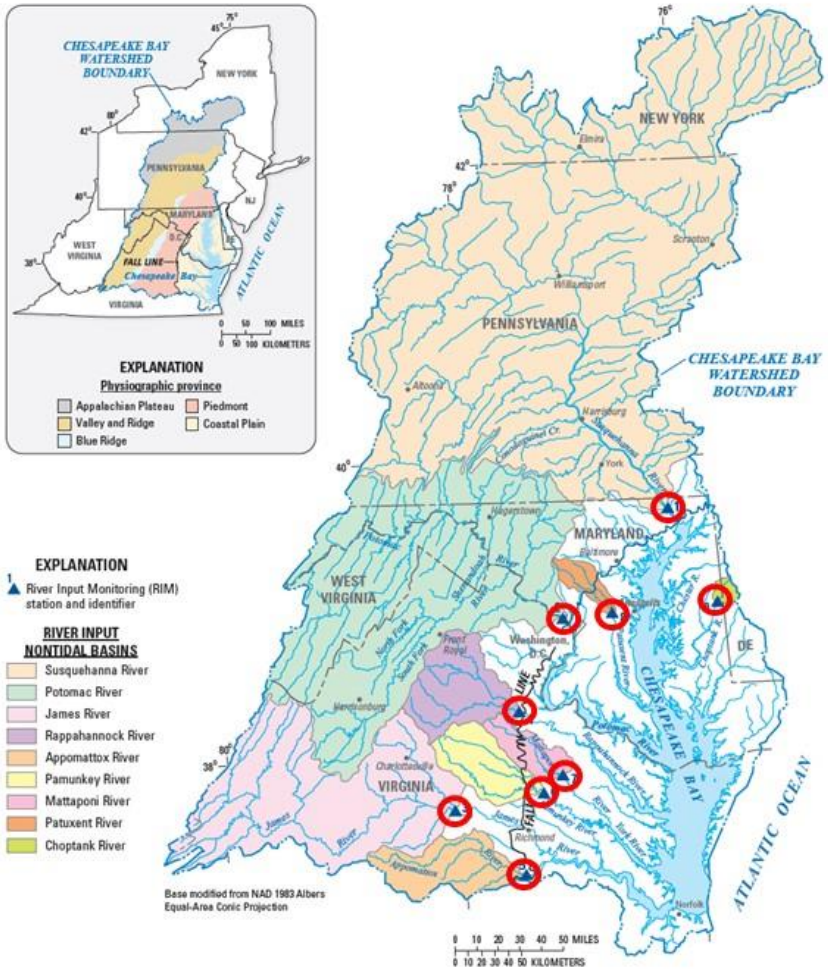


Split Classes into individual land uses
WQGIT Workgroups
Multiple lines of evidence

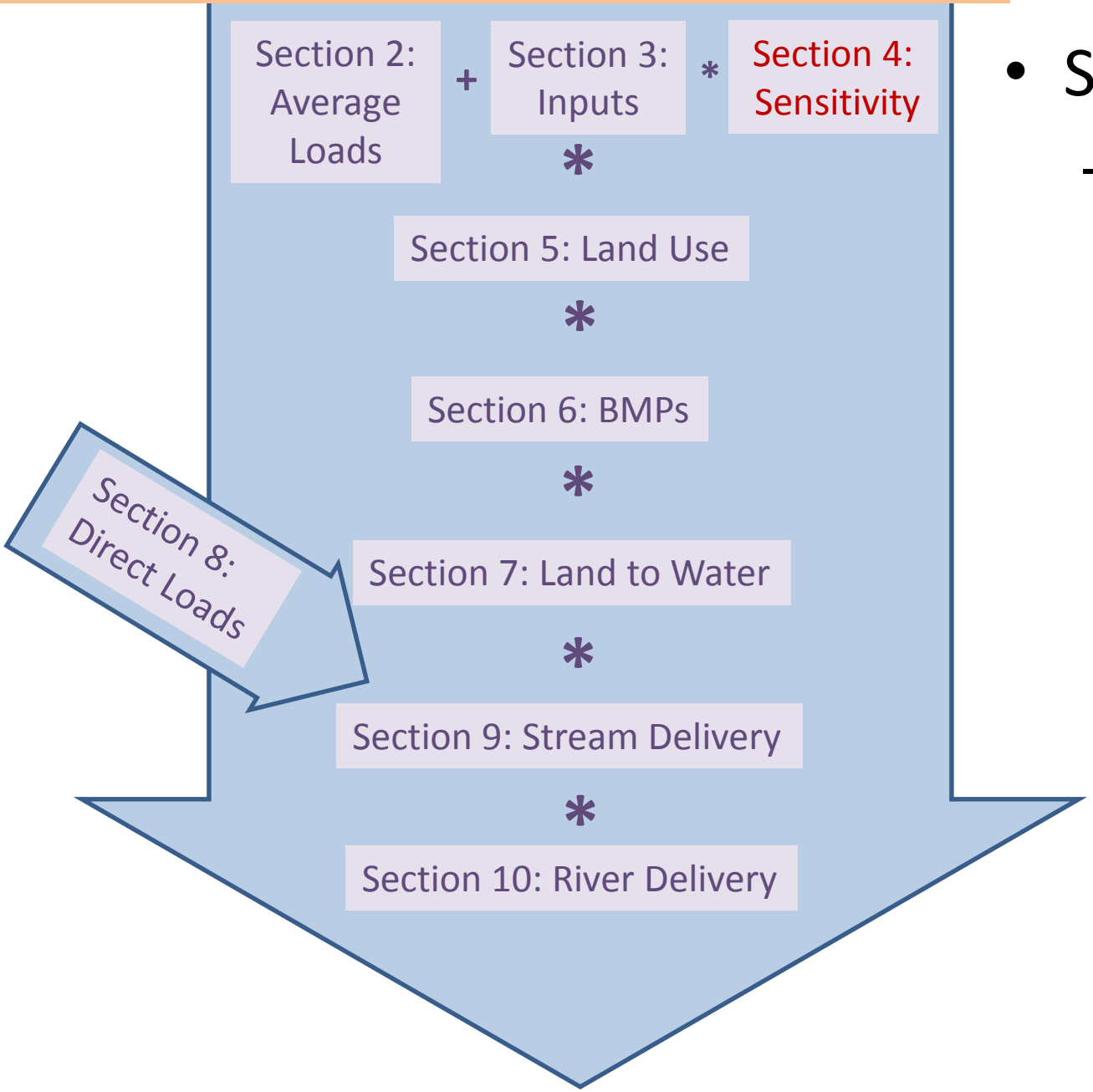


Assign targets to land uses within land segments
Modeling Workgroups
Multiple models

Average Loads – Average edge-of-small-stream loading rate for a given land use for the entire CB watershed

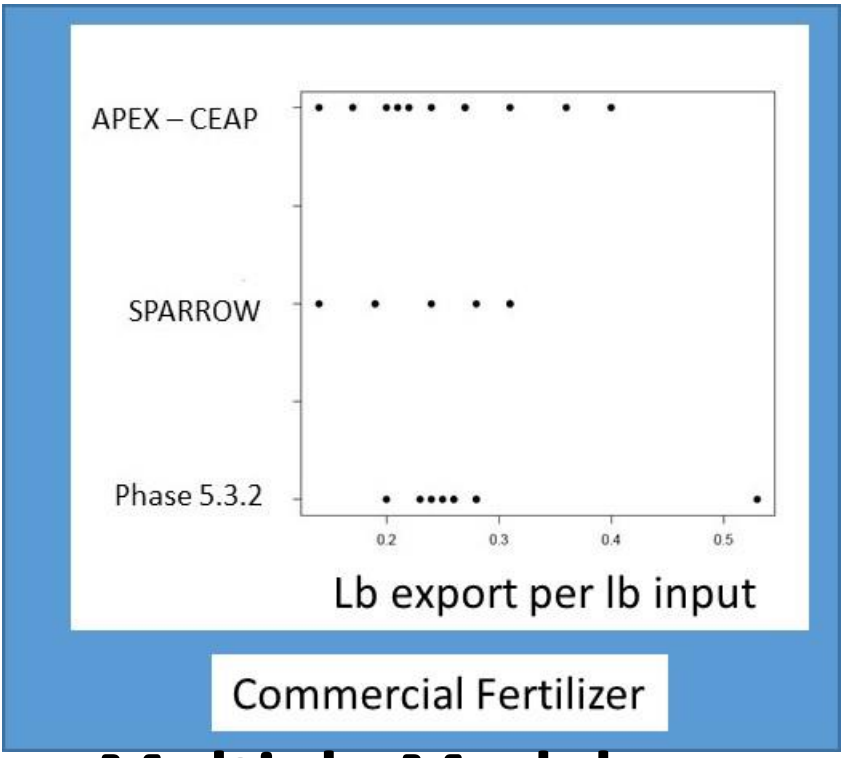


Phase 6 Model Documentation



- Sensitivity
  - Change in output per change in input

Sensitivity to inputs



Multiple Models

Nitrogen Sensitivities

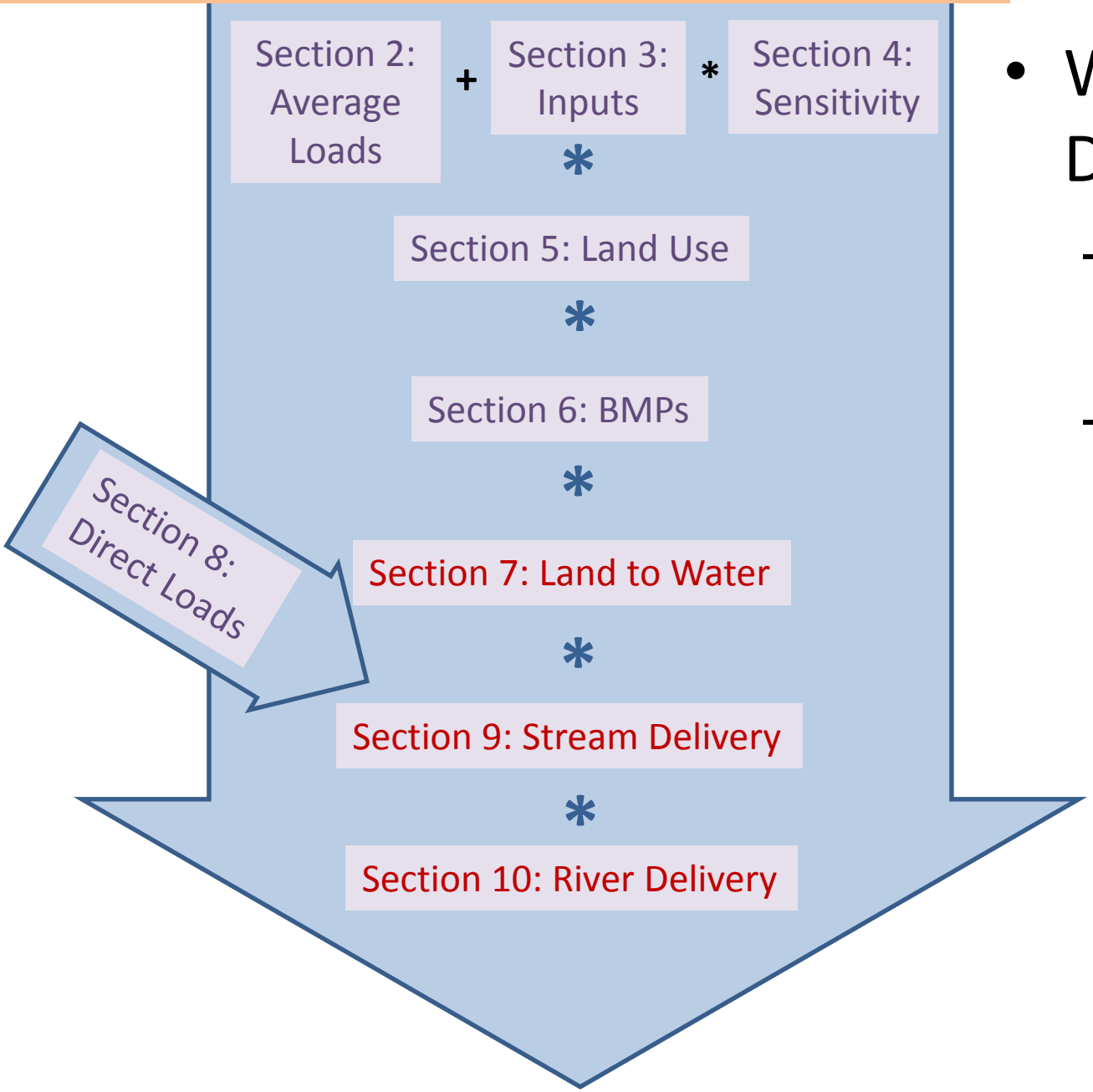
	NH3	NO3	ORGN
Atmospheric Deposition	0.01	0.226	0.083
Fertilizer	0.018	0.19	0.073
Manure	0.005	0.067	0.104
Fixation	0.01	0.19	0.101
Crop Uptake	0	-0.057	0
Vegetative Cover	-0.012	0.012	-0.404

APLE Hightill Landuse Sensitivities using Constant Mehlich 3 Soil P

Table 1. Phosphorus Loss APLE Model Sensitivity to change in inputs				
Inputs	**Units**	**MEDIAN SLOPE**	**MEDIAN SR**	**Relative Sensitivity**
Mehlich	ppm	0.015	0.696	Sensitive
Sediment	ton/ac	0.168	0.633	Sensitive
Runoff	inches	0.057	0.403	Moderately sensitive
Manure	lbs/acre	0.007	0.111	Slightly sensitive
Fertilizer	lbs/acre	0.004	0.068	Slightly sensitive
Uptake	lbs/acre	0	0	Insensitive

Requires estimate of soil P

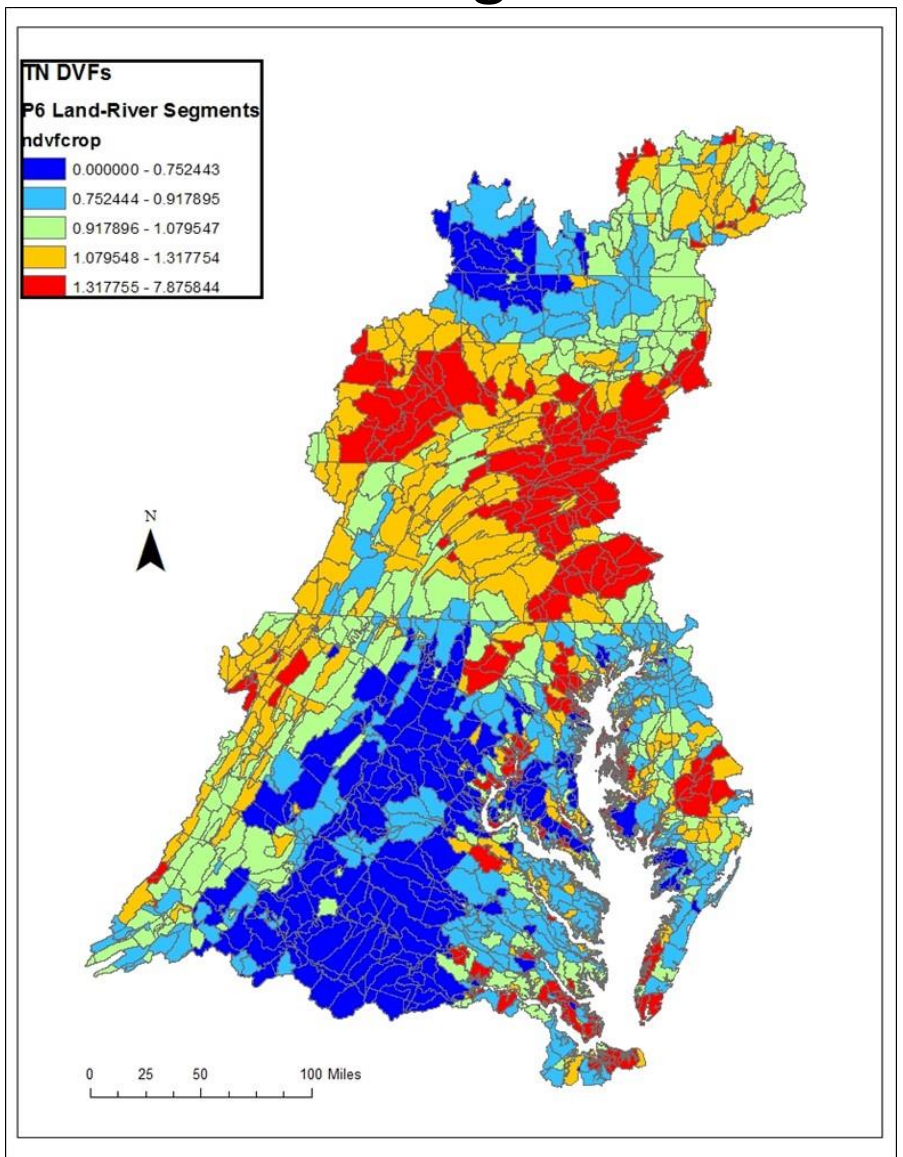
Phase 6 Model Documentation



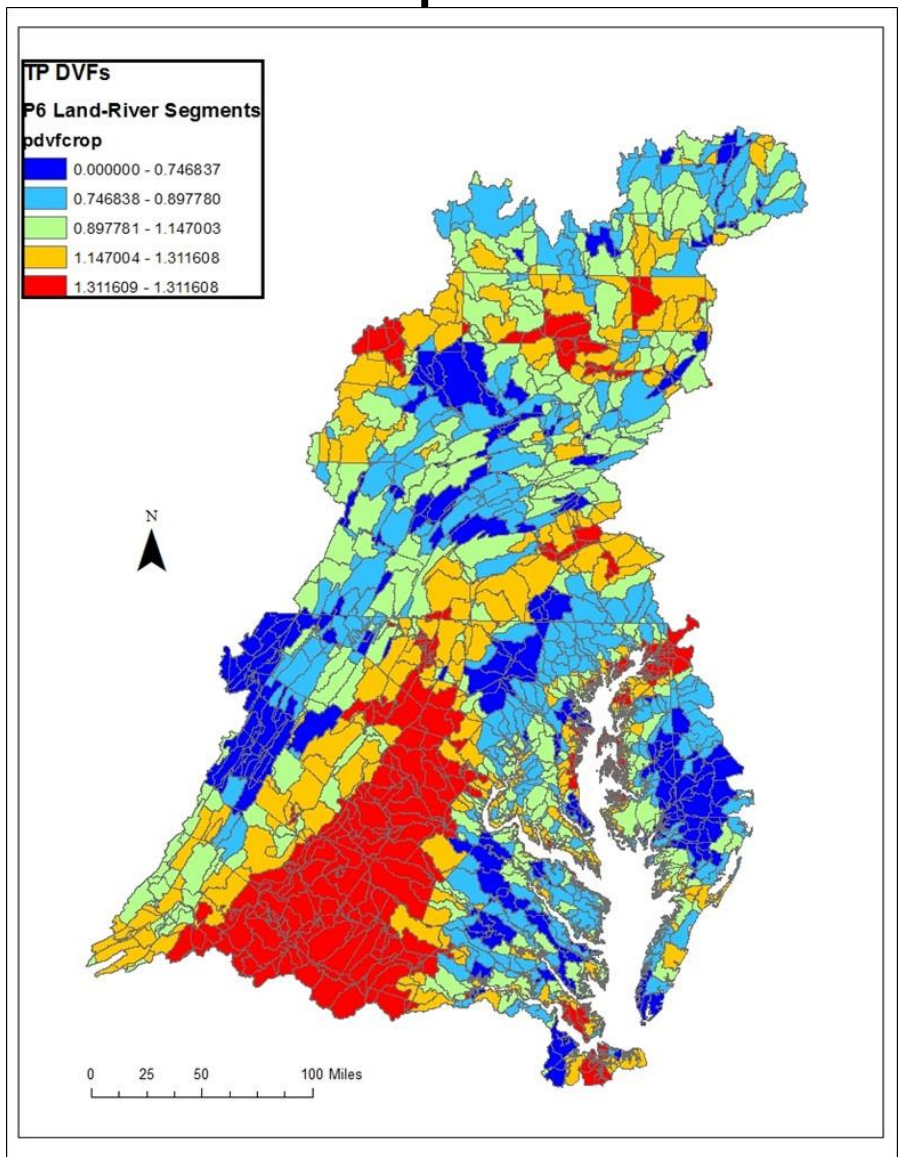
- Watershed Delivery system
  - Spatially distribute loads
  - Check for agreement with monitoring data
    - Modeling workgroup

Crop Land to Water Factors

Nitrogen

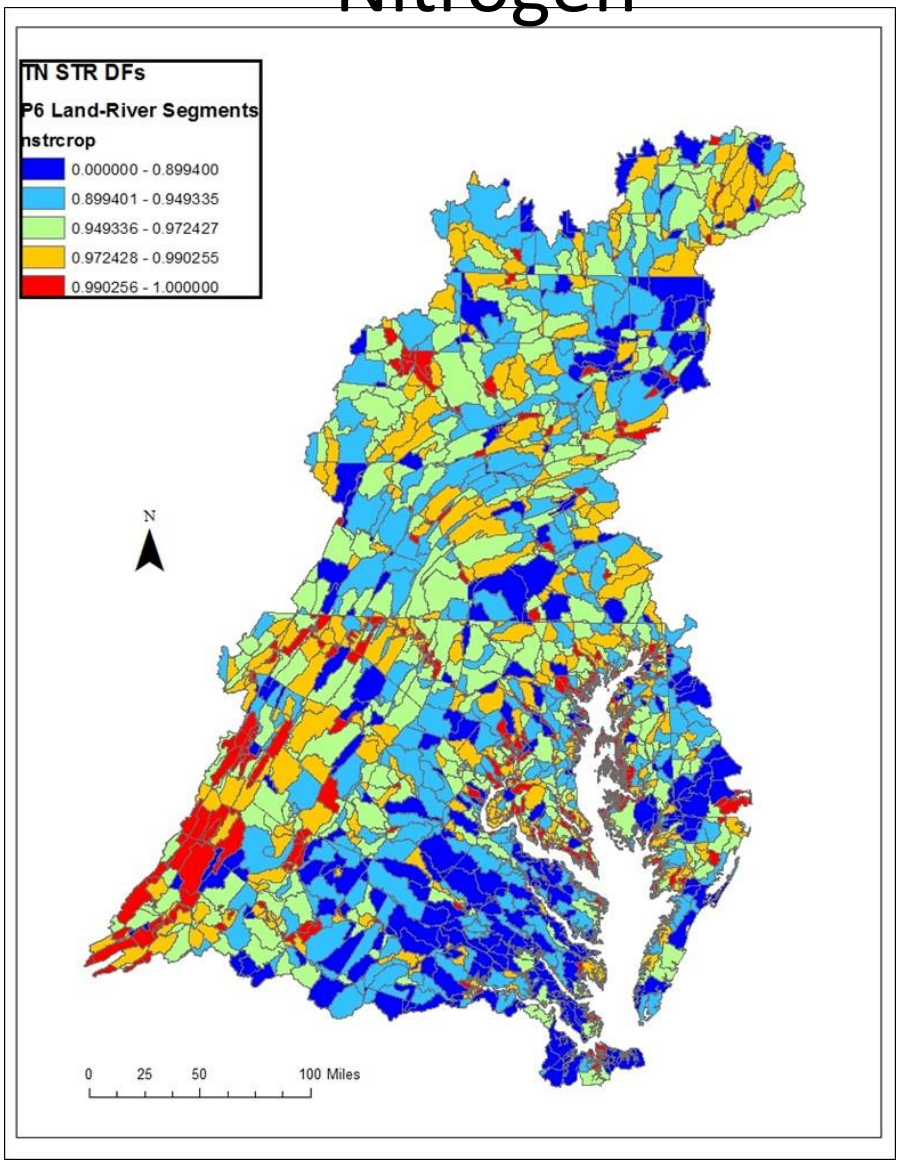


Phosphorus

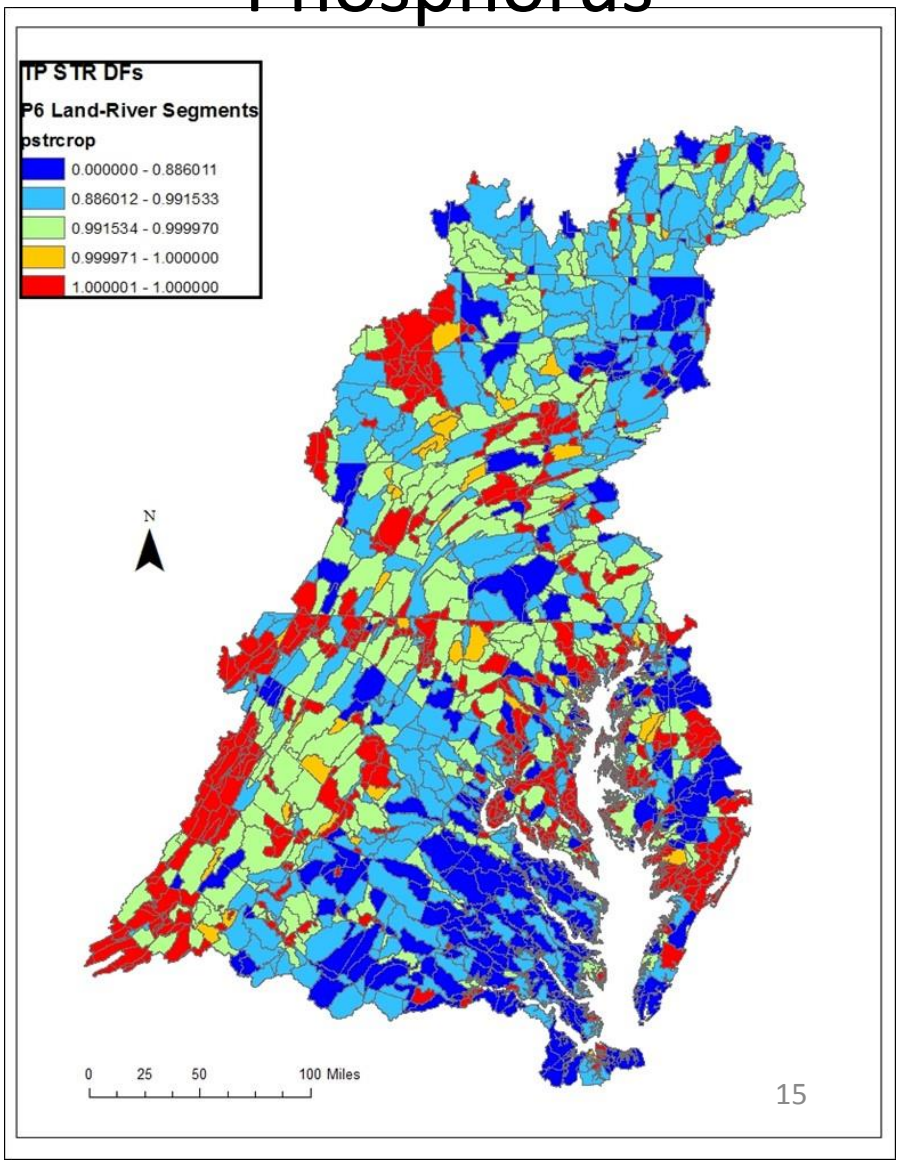


Stream-to-River Delivery Factors

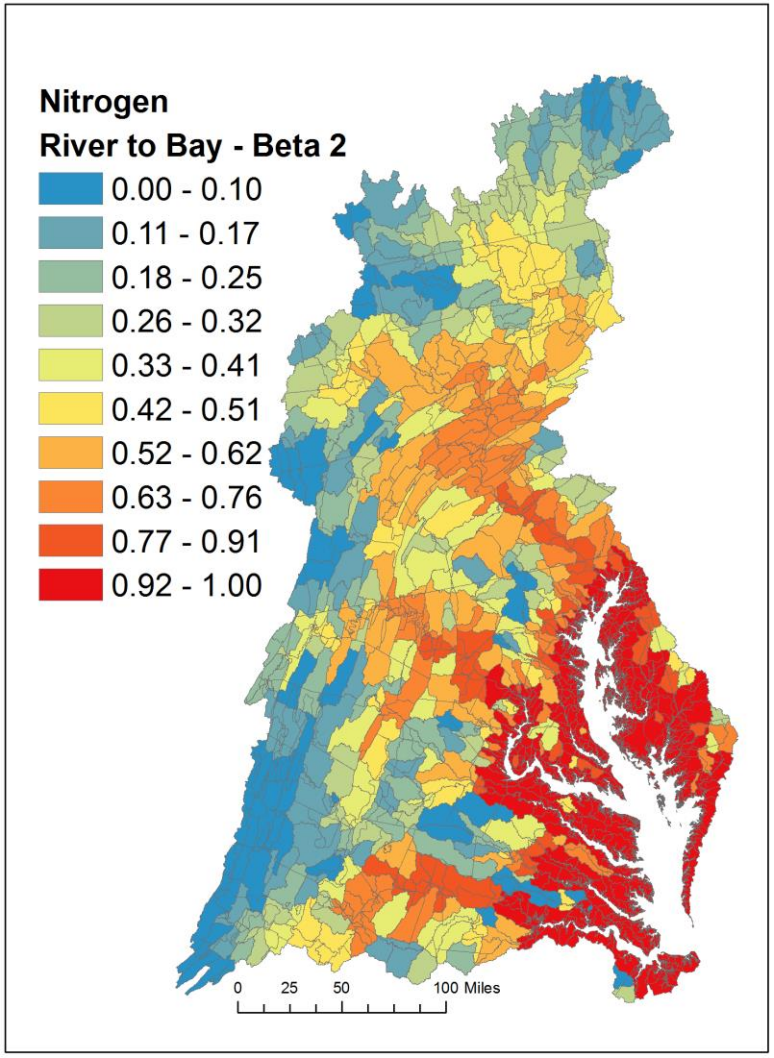
- Nitrogen

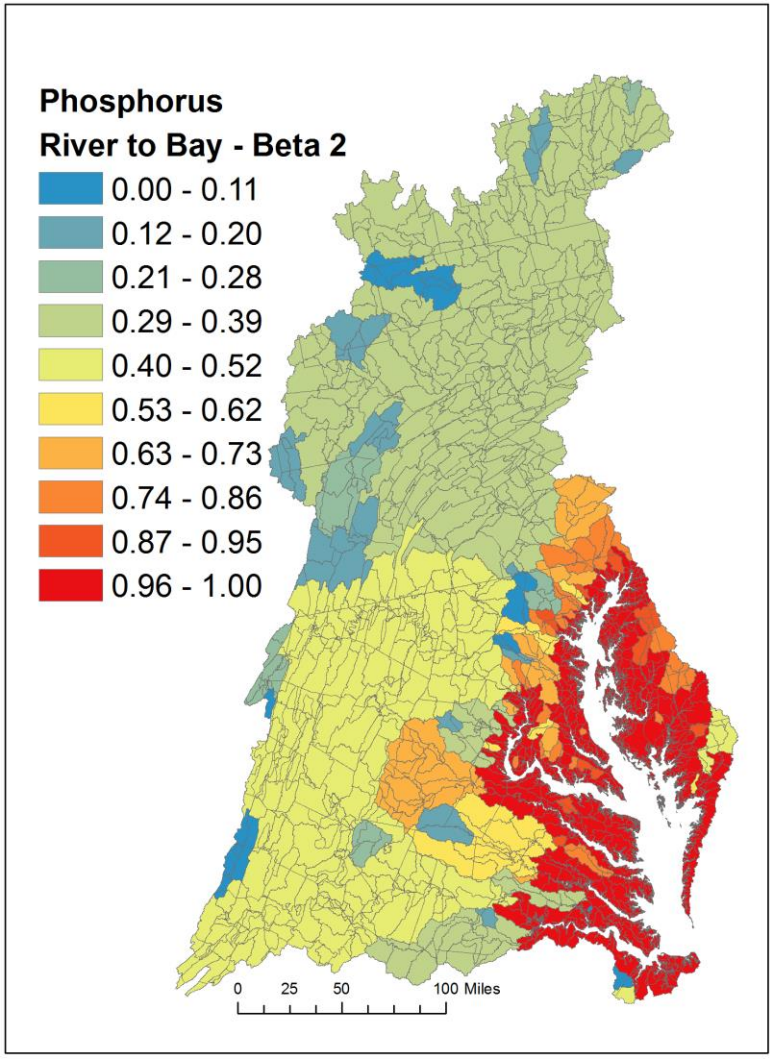


- Phosphorus



River to Bay factors





Nutrient Inputs





Phase 6 Model Structure

Average Load + Δ Inputs * Sensitivity

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Land Use Acres

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BMPs

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Land to Water

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Stream Delivery

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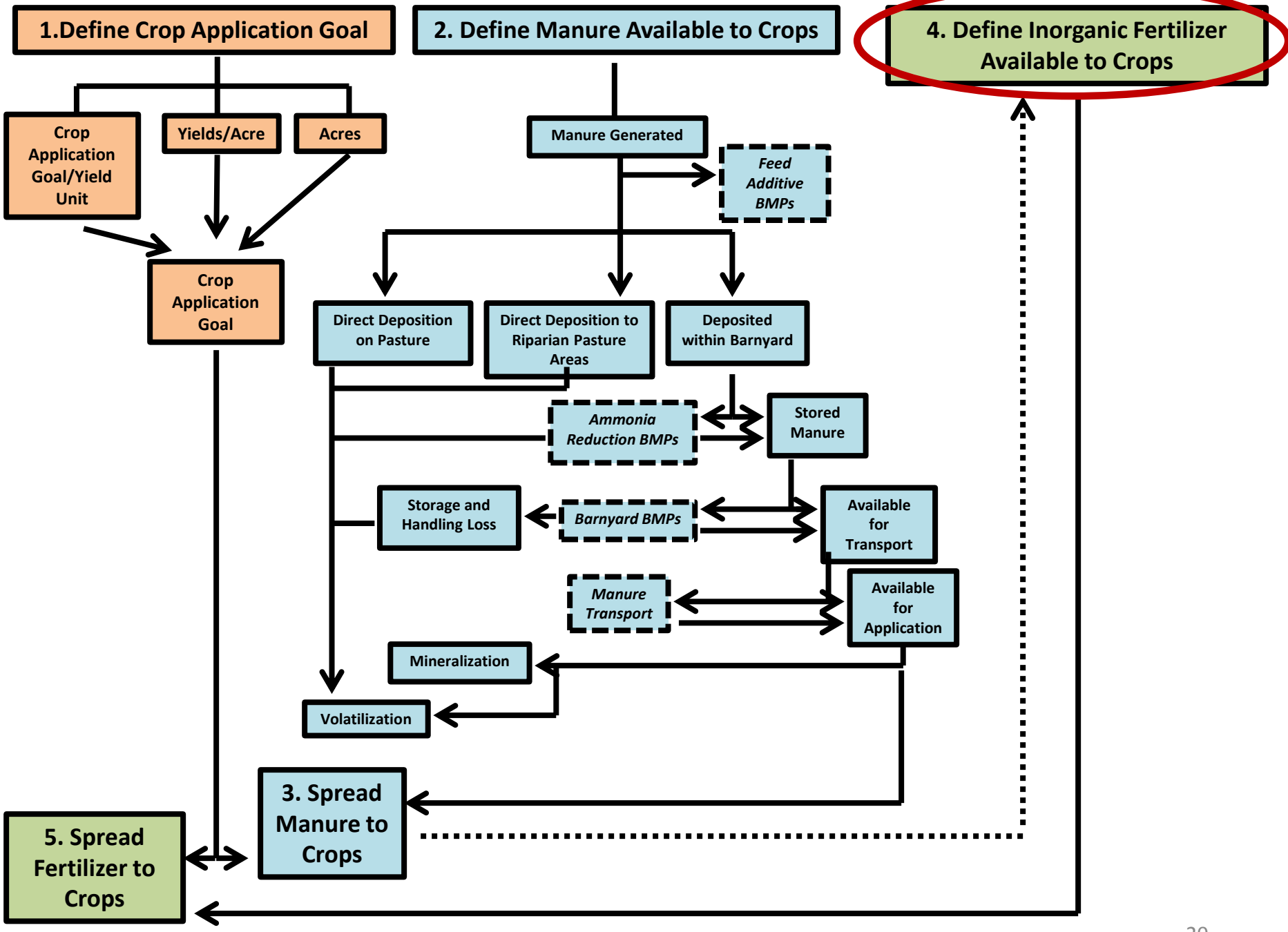
River Delivery

Direct Loads

Phase 6

Nutrient Spread Components in Beta 3

- 1) Define Crop Application Goal
- 2) Define Manure Available to Crops
- 3) Spread Manure to Crops
- **4) Define Inorganic Fertilizer Available to Crops**
- **5) Spread Inorganic Fertilizer to Crops**

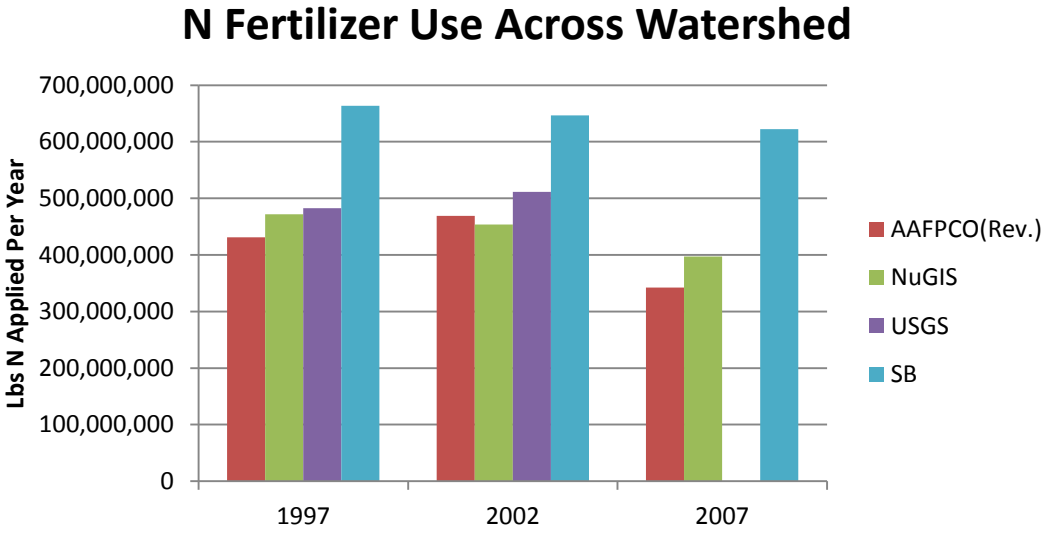

1.Define Crop Application Goal
2. Define Manure Available to Crops
4. Define Inorganic Fertilizer Available to Crops
Crop Application Goal/Yield Unit
Yields/Acre
Acres
Crop Application Goal
Manure Generated
Feed Additive BMPs
Direct Deposition on Pasture
Direct Deposition to Riparian Pasture Areas
Deposited within Barnyard
Ammonia Reduction BMPs
Stored Manure
Storage and Handling Loss
Barnyard BMPs
Available for Transport
Manure Transport
Available for Application
Mineralization
Volatilization
3. Spread Manure to Crops
5. Spread Fertilizer to Crops

Define Inorganic Fertilizer Available to Crops

- **Question: Should fertilizer available to crops be estimated using AAPFCO fertilizer sales data?**
  - YES. Fertilizer applied in a county should be a fraction of the total fertilizer sold across the watershed based upon: A) each county's relative unmet crop application goal after manure, and B) each county's relative dollars spent on fertilizer and soil amendments (Beta 3a).
  - NO. Fertilizer should be applied to fulfill all unmet crop application goals in a county after manure is applied (Beta 3b).

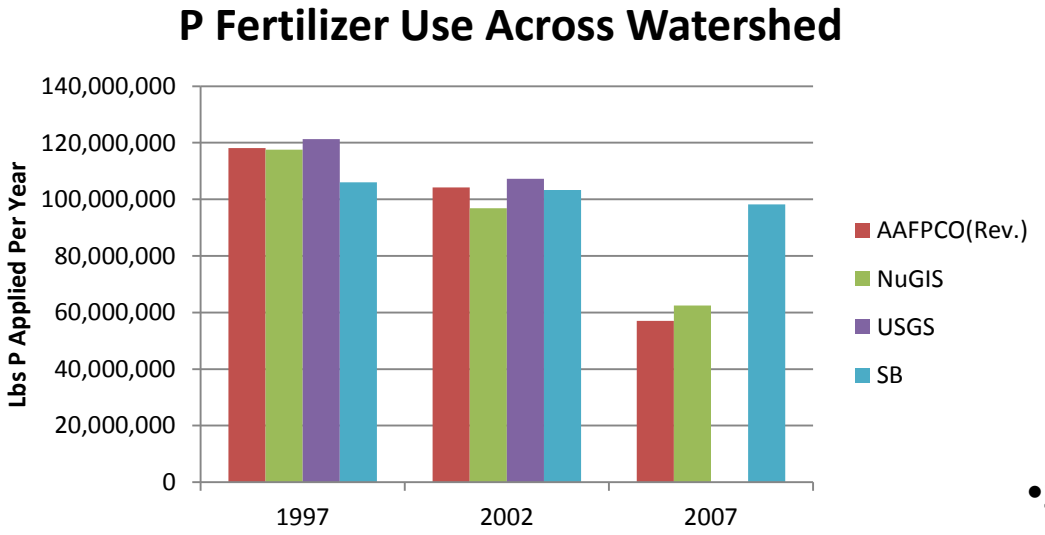
How did we get here?

Comparing Across Methods



Differences in N Fertilizer Use Between AAFPCO Revised Method and Others

Year	NuGIS	USGS	SB
1997	-8.6%	-10.7%	-35.0%
2002	3.4%	-8.3%	-27.4%
2007	-13.8%	NA	-45.0%



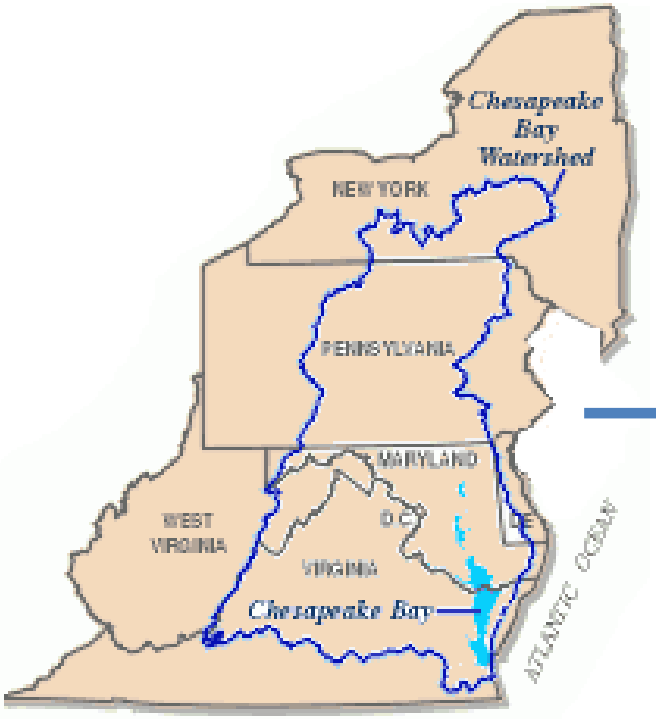
Differences in P Fertilizer Use Between AAFPCO Revised Method and Others

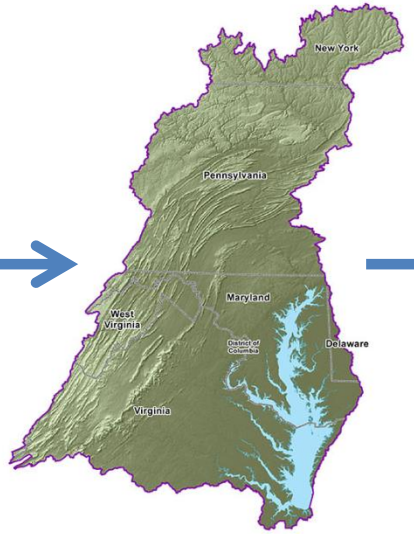
Year	NuGIS	USGS	SB
1997	0.4%	-2.6%	11.5%
2002	7.6%	-2.8%	1.0%
2007	-8.7%	NA	-41.9%

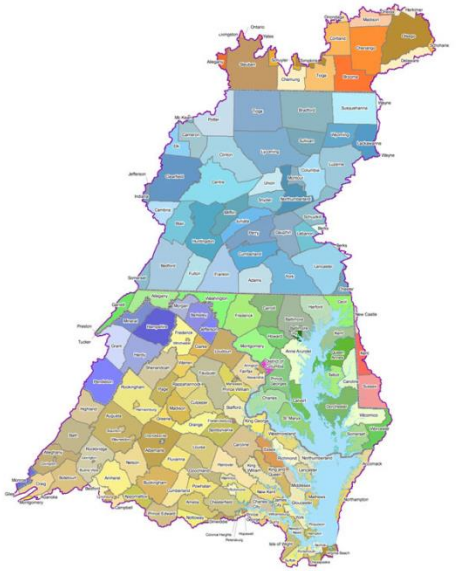
•Slide taken from May 14, 2014 presentation to AMS.

Inorganic: Going from Sales to Use (Beta 3a)

- Begin with regional-level sales, break those down to watershed-level sales, and break those down to countv-level







•Sum AAPFCO sales across 6 states, and estimate sales used by farms.

•Calculate dollars spent on fertilizer from Ag Census in counties inside and outside watershed to “clip” watershed-only sales.

•Calculate fertilizer need by county as a combination of fractional dollars spent on fertilizer and fertilizer need after manure is applied. Use value to distribute fertilizer to each county.

Example of Fertilizer Distribution Method for Nitrogen in 2012

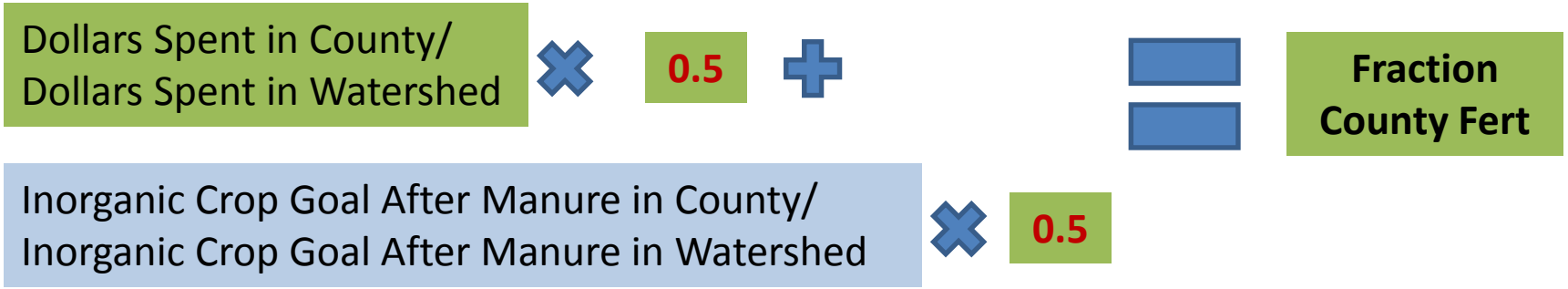
- **Regional Farm Sales = 603,579,944 lbs N** or
  - *(Sum of lbs N sold across 6 states) X (3-year rolling average fraction of Farm Sales)*

- **Watershed-Wide Farm Sales = 413,741,002 lbs N** or
  - *(Regional Farm Sales)X (Fraction of Ag Census Expenditures on Fertilizer and Soil Amendments that occurred within the Watershed)*

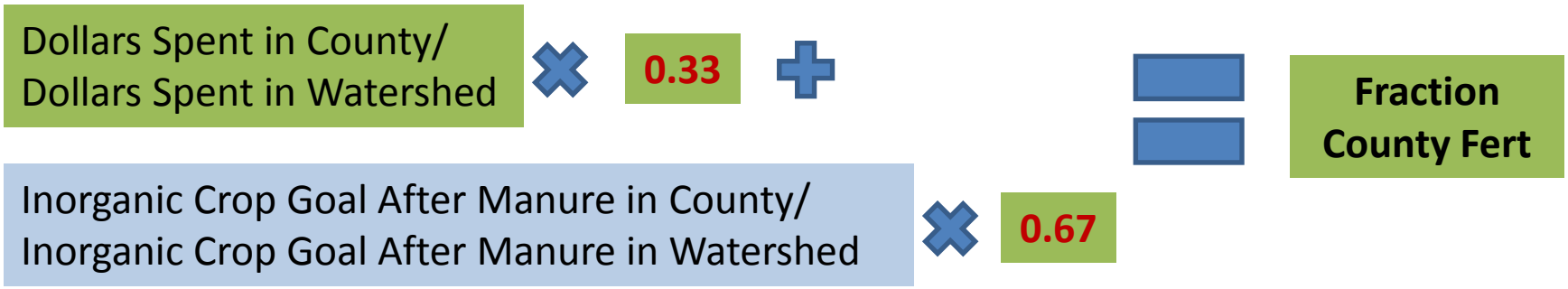
- **Fertilizer Available for Hypothetical County = 8,274,820 lbs N** or **2%** of Watershed-Wide Farm Sales or
  - *(Watershed-Wide Farm Sales) X [(Fraction of Ag Census Expenditures on Fertilizer within County X **0.5**)+(Fraction of Fertilizer Goal within County X **0.5**)]*

Potential Change if Beta 3a is Selected

Current Approach for Establishing Fraction of Fertilizer Used by County



Potential Approach



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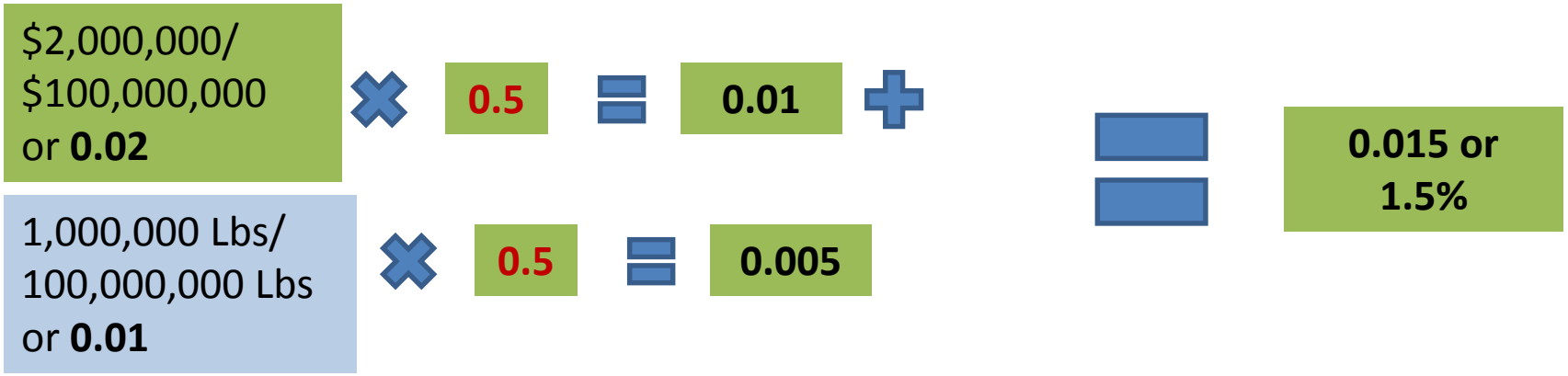
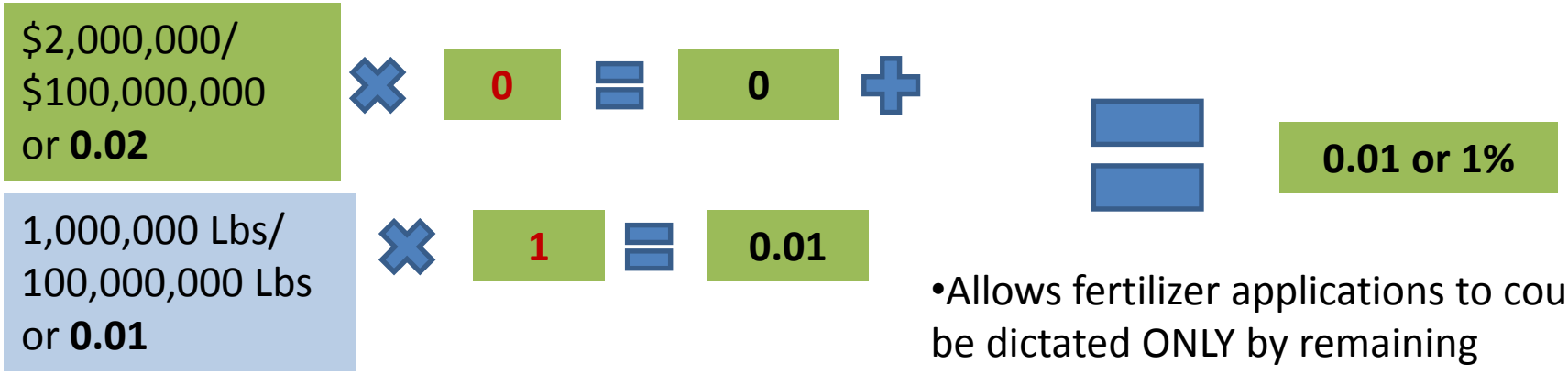


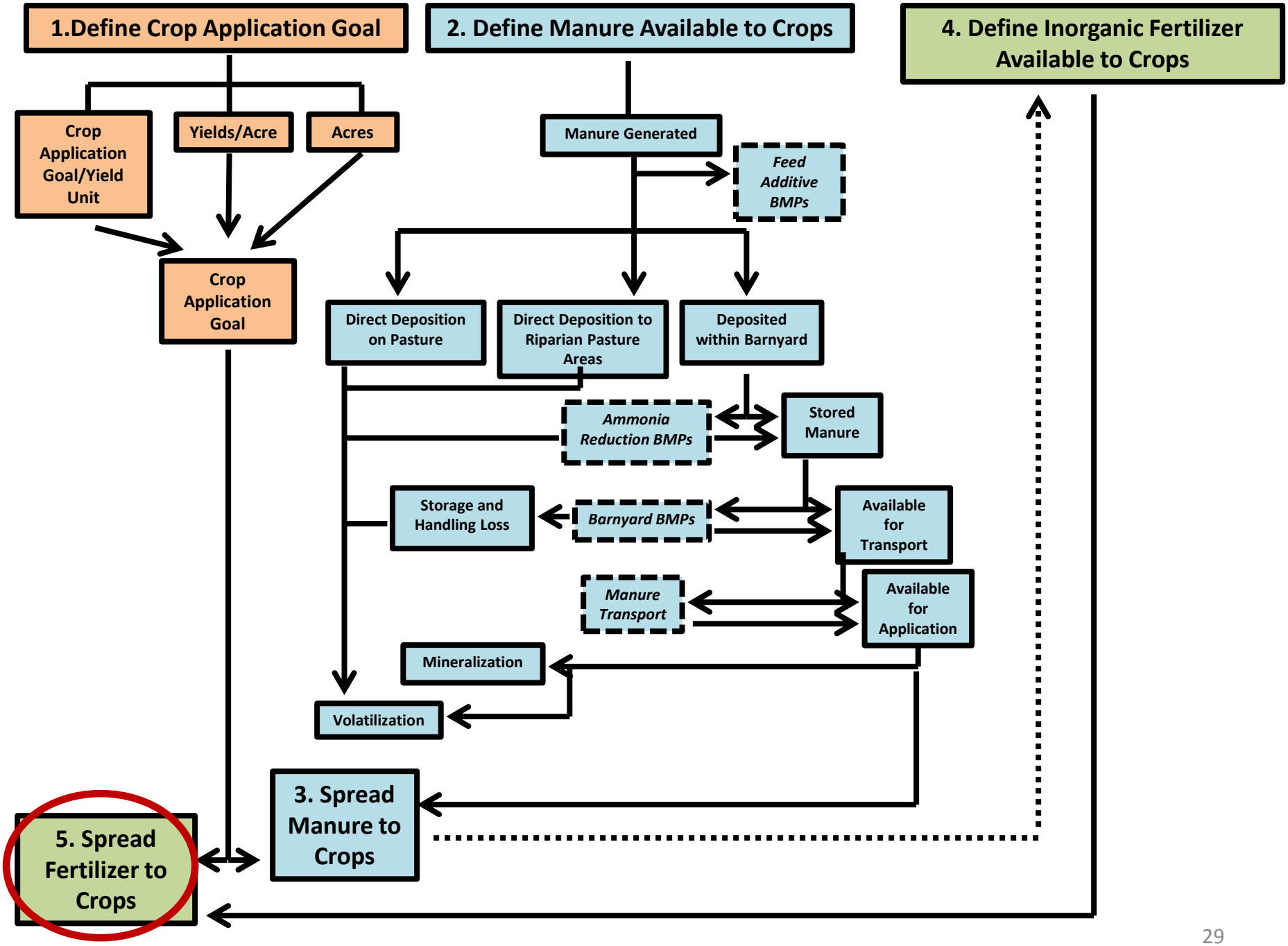
Potential Approach



- Allows fertilizer applications to counties be dictated ONLY by remaining application goal (like Beta 3b).
- Matches fertilizer sales watershed-wide (like Beta 3a).

Inorganic Fertilizer Available: Beta 3b

- Calculate Inorganic Crop Application Goal AFTER manure applications.
- Spread unlimited supply of inorganic fertilizer until inorganic crop application goal is met.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Direct Deposition to Riparian Pasture Areas
Deposited within Barnyard
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Storage and Handling Loss
Barnyard BMPs
Available for Transport
Manure Transport
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Mineralization
Volatilization
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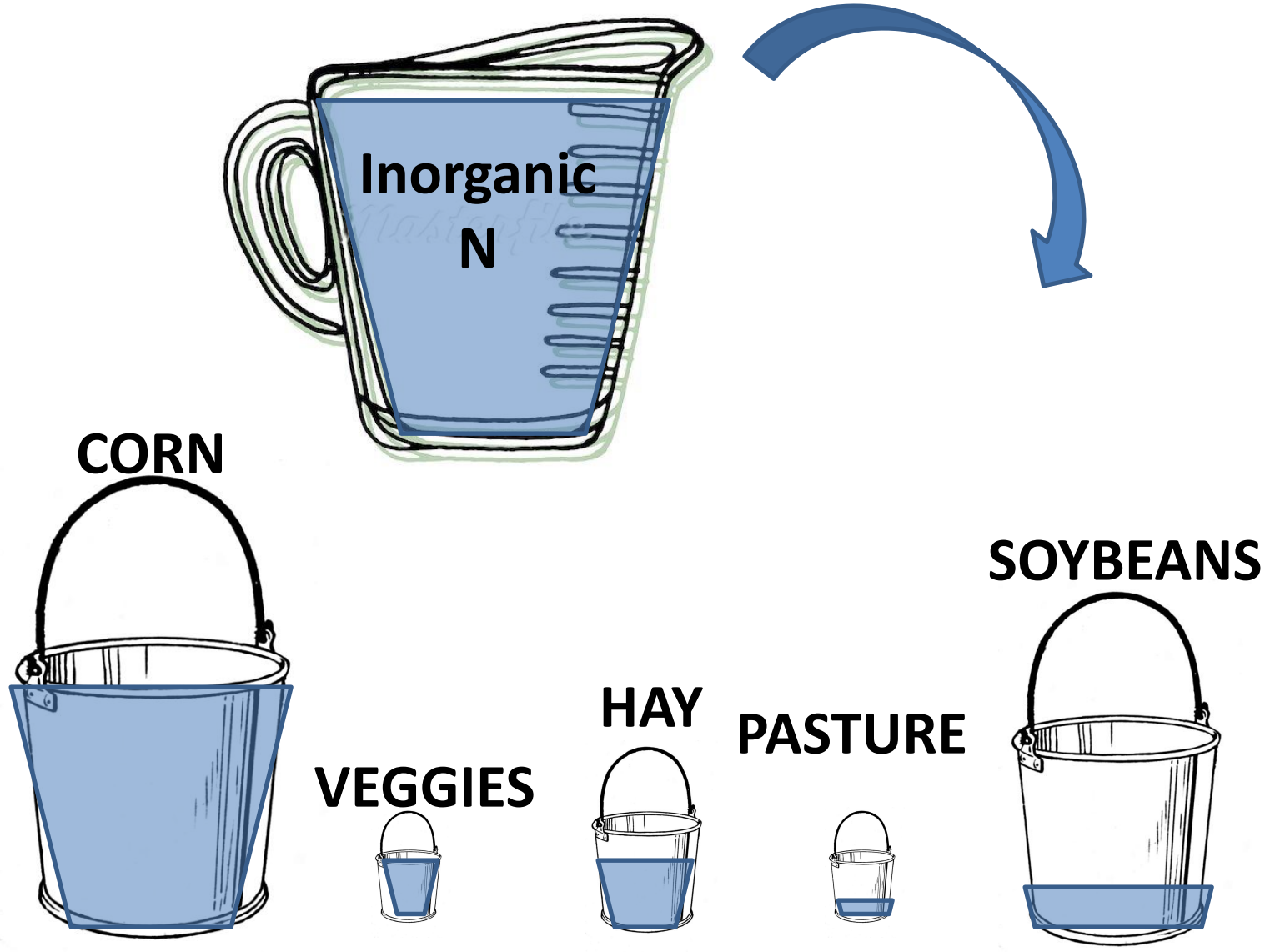
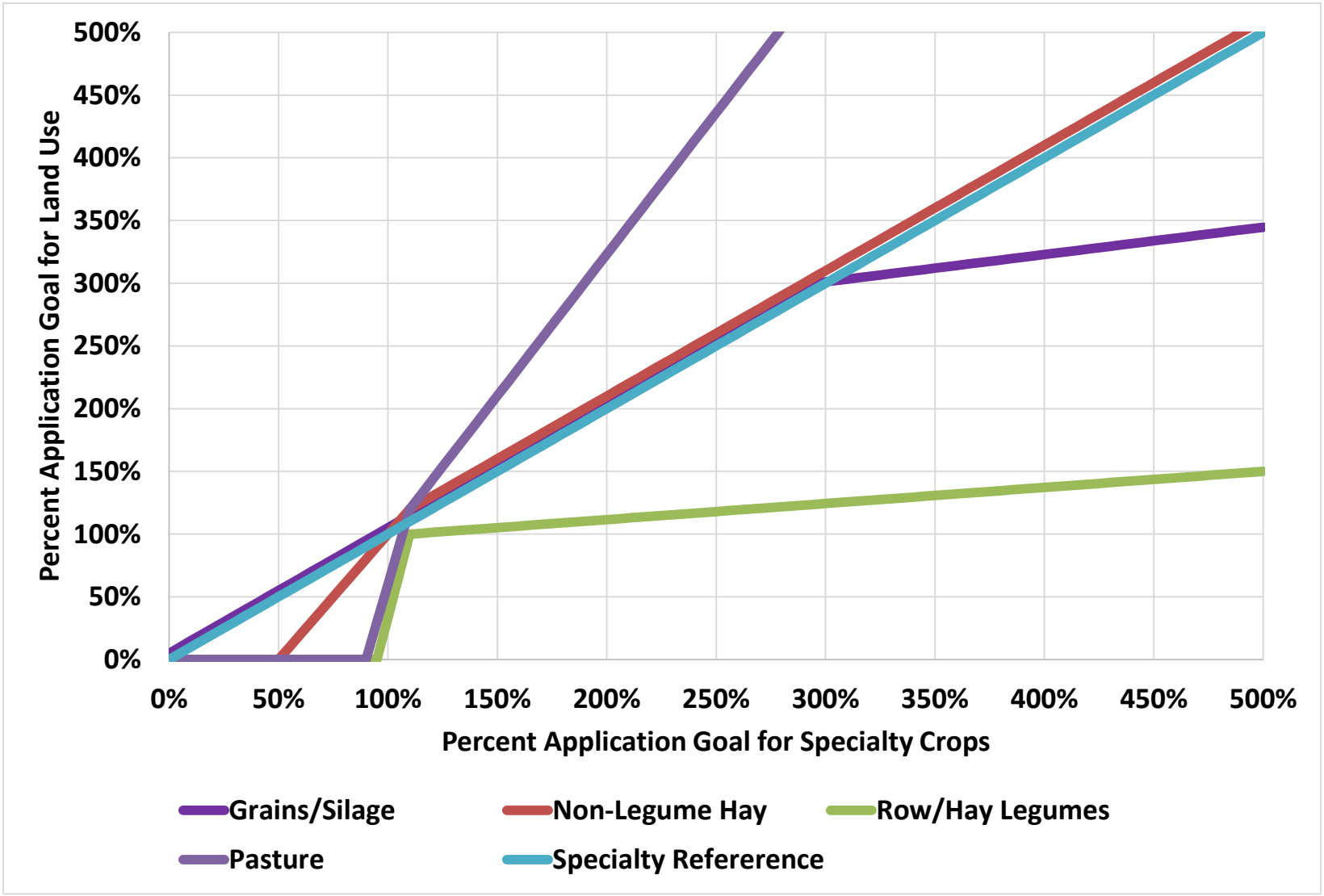
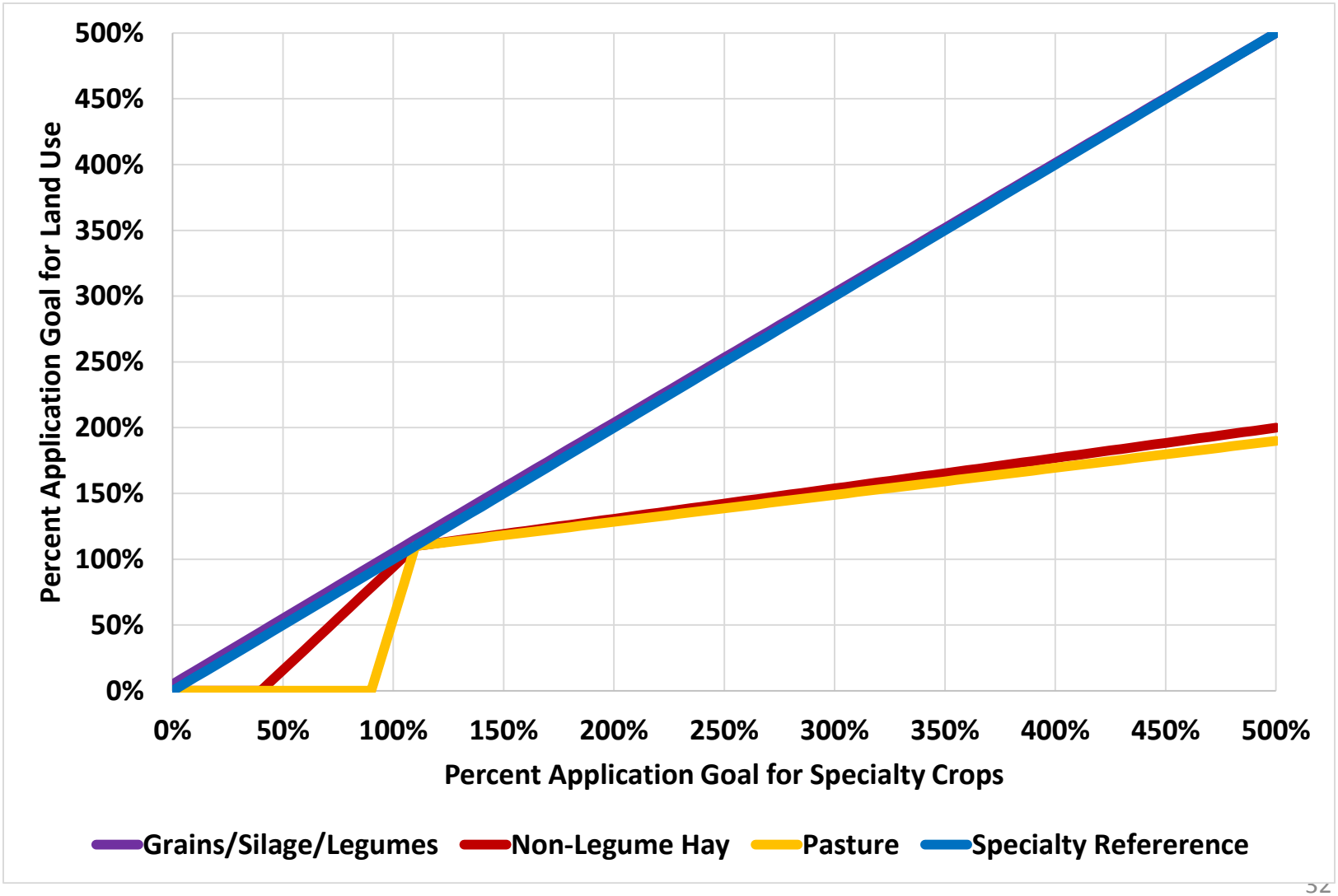
Filling the Buckets of Inorganic Crop Application Goal



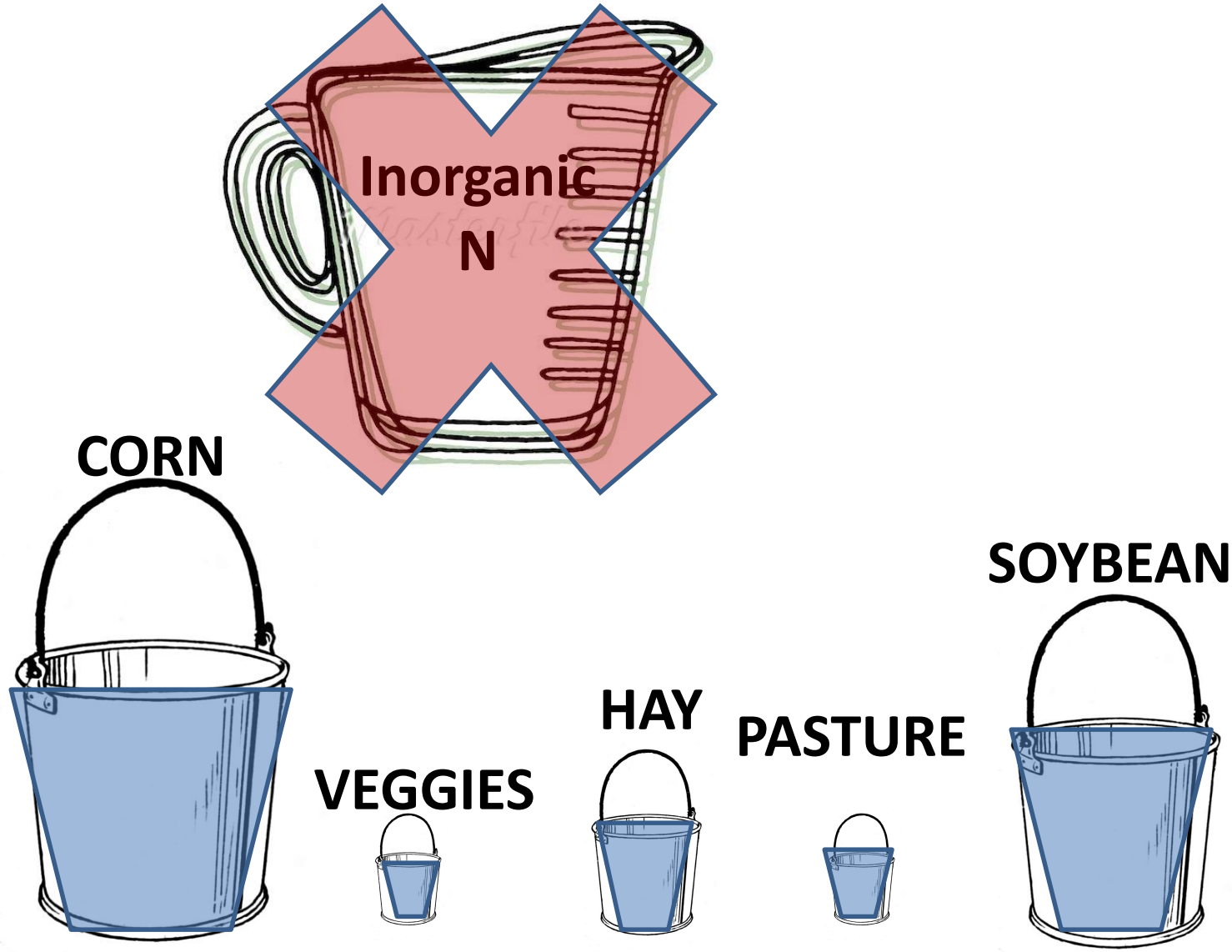
Inorganic: Prioritizing Inorganic Nitrogen Applications (Beta 3a)



Inorganic: Prioritizing Inorganic Phosphorus Applications (Beta 3a)



Filling the Buckets of Inorganic Crop Application Goal (Beta 3b)

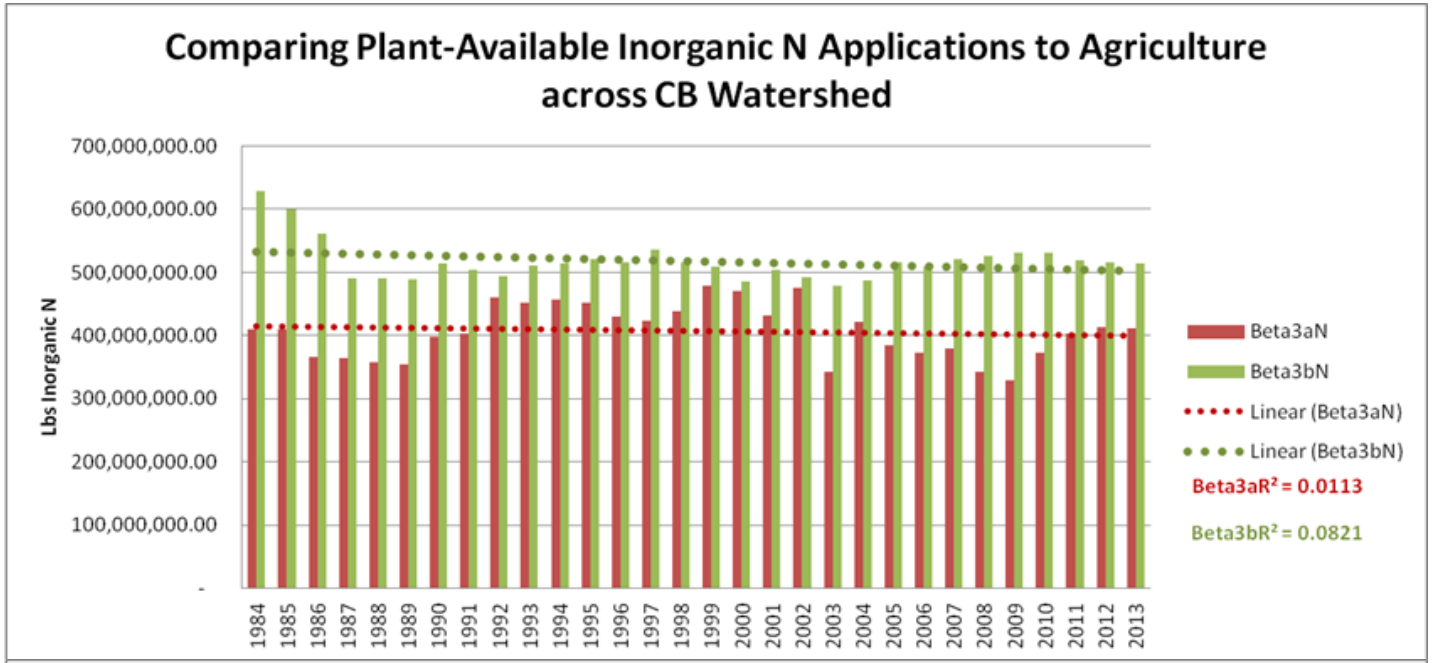


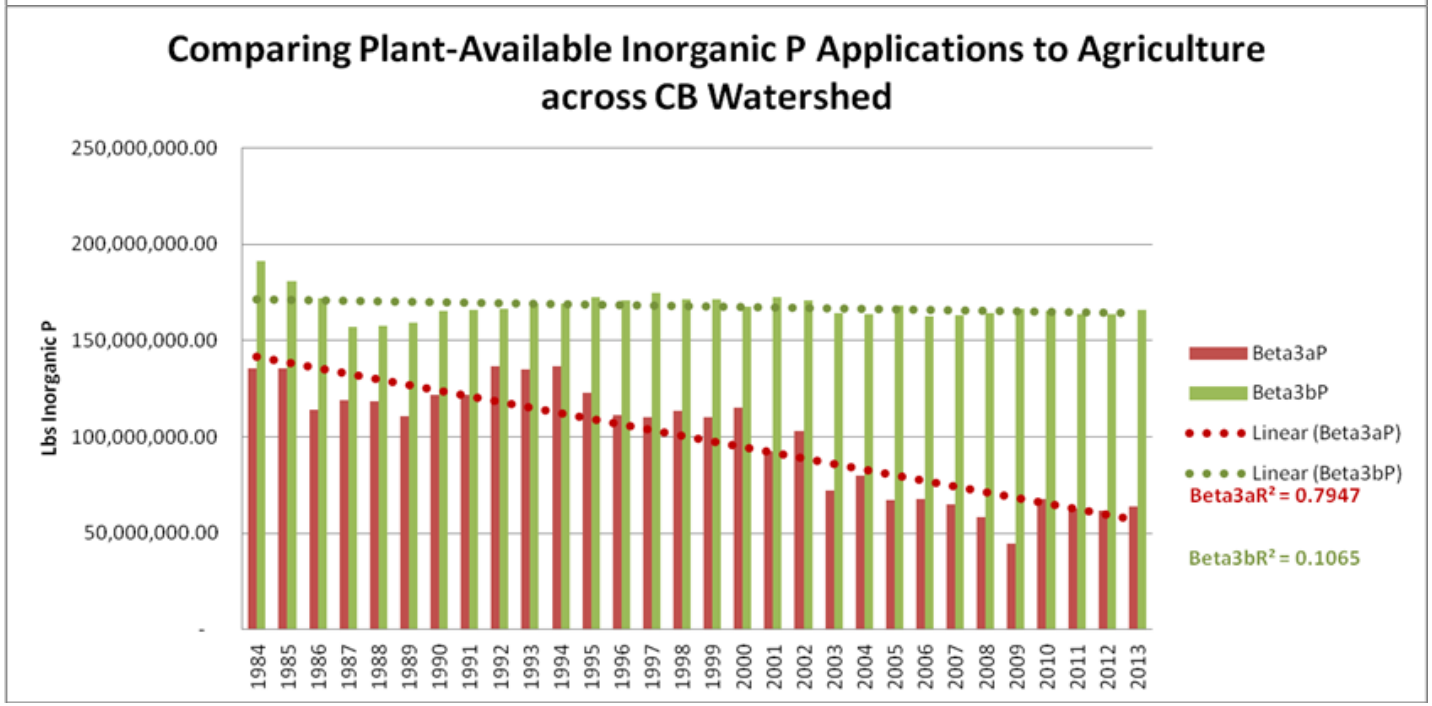
RESULTS

Where to Find Results/Documentation?

- Raw data (large files) available at:
  - https://archive.chesapeakebay.net/Modeling/Phase6/Ph6Calibration_Beta2/ 20160401/inputs/ScenarioBuilder/
- Documentation (Beta 2, but many methods did not change for Beta 3) available at:

  4) https://archive.chesapeakebay.net/Modeling/Phase6/Ph6Calibration_Beta2/ 20160401/Documentation/
- Data Visualization Tool available at:
  - https://public.tableau.com/profile/olivia.devereux#!/vizhome/ChesapeakeBayPhase6WatershedModelInputs/NutrientsApplied
- Scatter plots and legume fixation:
  - Data to be sent out to Ag Workgroup members following webinar.
- Webinar Presentation available at:
  - http://www.chesapeakebay.net/calendar/event/24182/


Comparing Plant-Available Inorganic N Applications to Agriculture across CB Watershed
Lbs Inorganic N
700,000,000.00
600,000,000.00
500,000,000.00
400,000,000.00
300,000,000.00
200,000,000.00
100,000,000.00
-
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Beta3aN
Beta3bN
Linear (Beta3aN)
Linear (Beta3bN)
Beta3aR² = 0.0113
Beta3bR² = 0.0821


Comparing Plant-Available Inorganic P Applications to Agriculture across CB Watershed
Lbs Inorganic P
250,000,000.00
200,000,000.00
150,000,000.00
100,000,000.00
50,000,000.00
-
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Beta3aP
Beta3bP
Linear (Beta3aP)
Linear (Beta3bP)
Beta3aR² = 0.7947
Beta3bR² = 0.1065

Statewide Comparison of Plant-Available Applications to MD AIR 2012

Plant-Available N

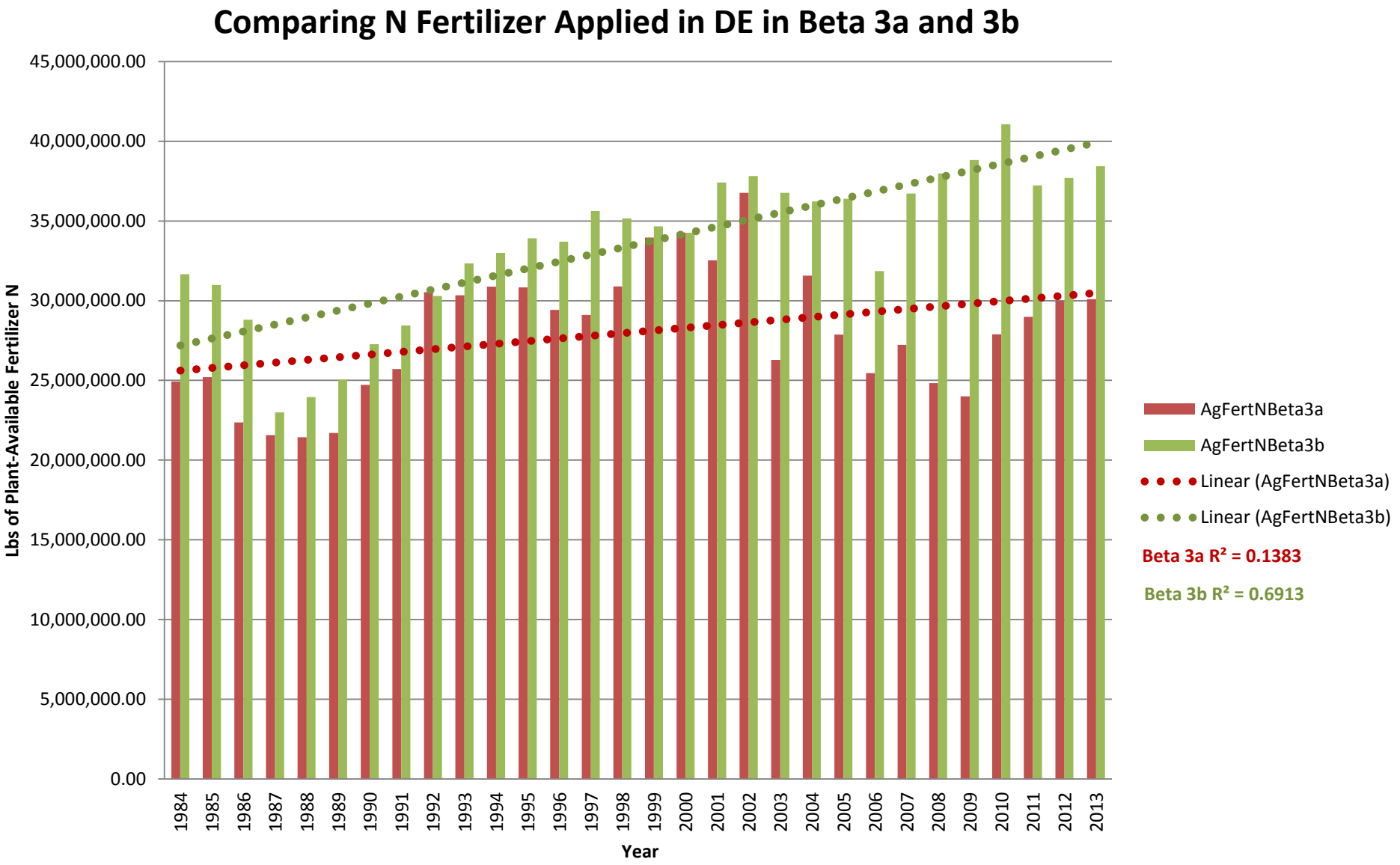
Scenario	Lbs Fertilizer	Lbs Manure	Lbs Total	% Delta from AIR for Fertilizer	% Delta from AIR for Manure	% Delta from AIR for Total
2012 MD AIR	76,946,211	17,518,877	94,465,088	NA	NA	NA
2012 3a	78,715,404	17,992,645	96,708,049	2.3%	2.7%	2.4%
2012 3b	95,019,384	17,992,645	113,012,029	23.5%	2.7%	19.6%

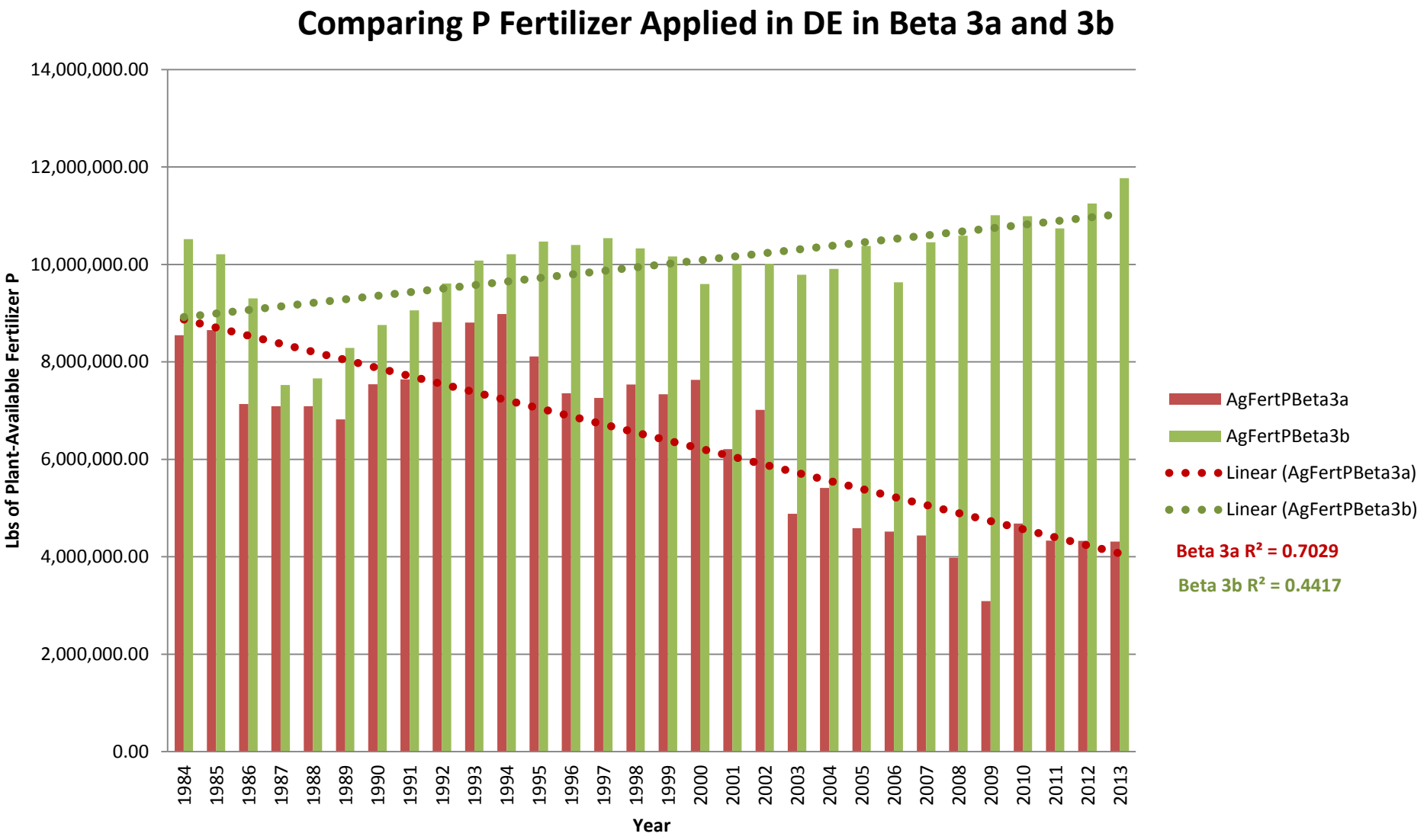
Plant-Available P

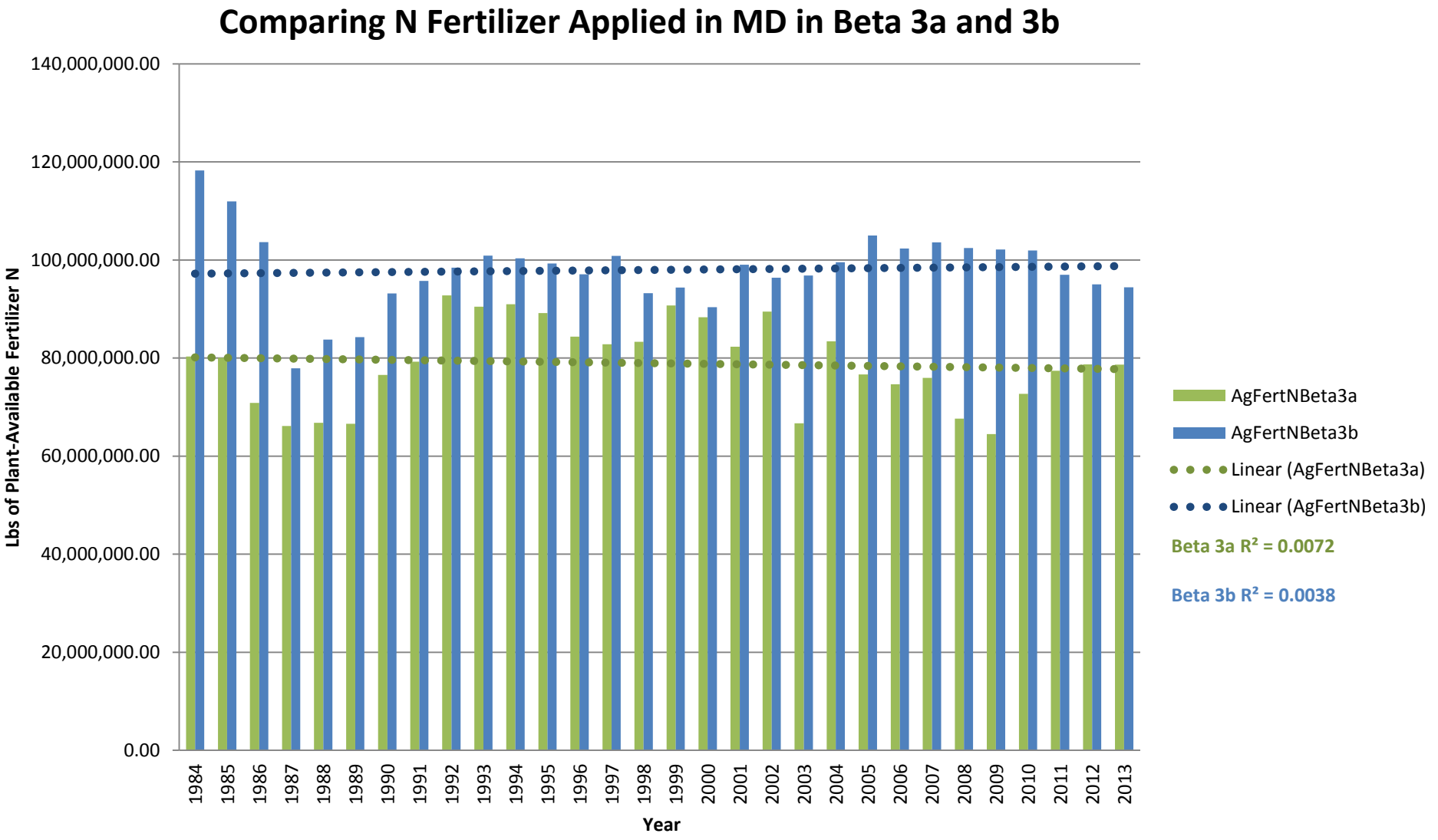
Scenario	Lbs Fertilizer	Lbs Manure	Lbs Total	% Delta from AIR for Fertilizer	% Delta from AIR for Manure	% Delta from AIR for Total
2012 MD AIR	8,087,974	9,014,740	17,102,714	NA	NA	NA
2012 3a	12,139,718	9,113,874	21,253,591	50.1%	1.1%	24.3%
2012 3b	32,411,068	9,113,874	41,524,942	300.7%	1.1%	142.8%

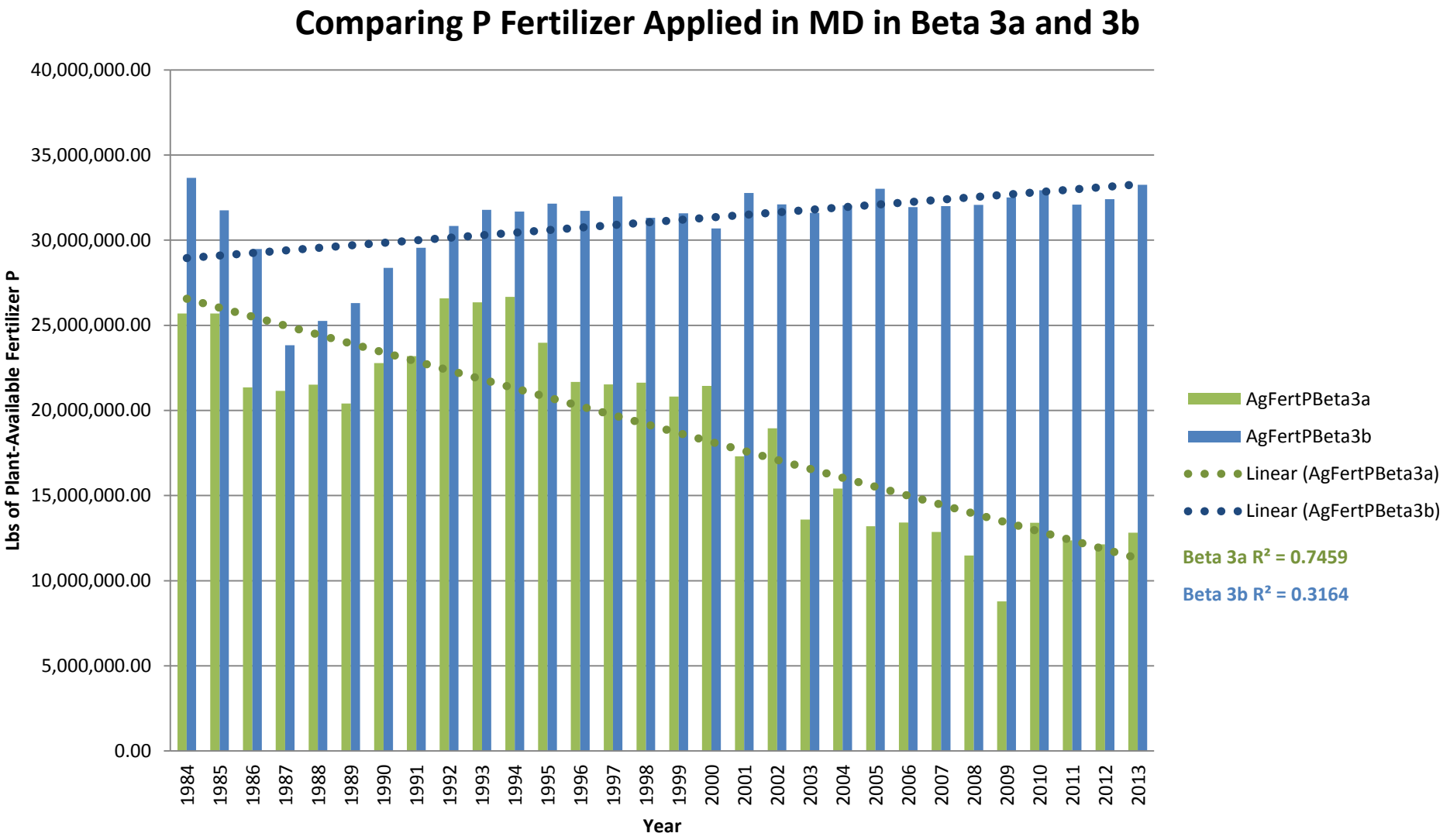
Watershed-Wide Comparison of Beta 3a and 3b Fertilizer Applications (avg. 2001-2006) to USDA CEAP

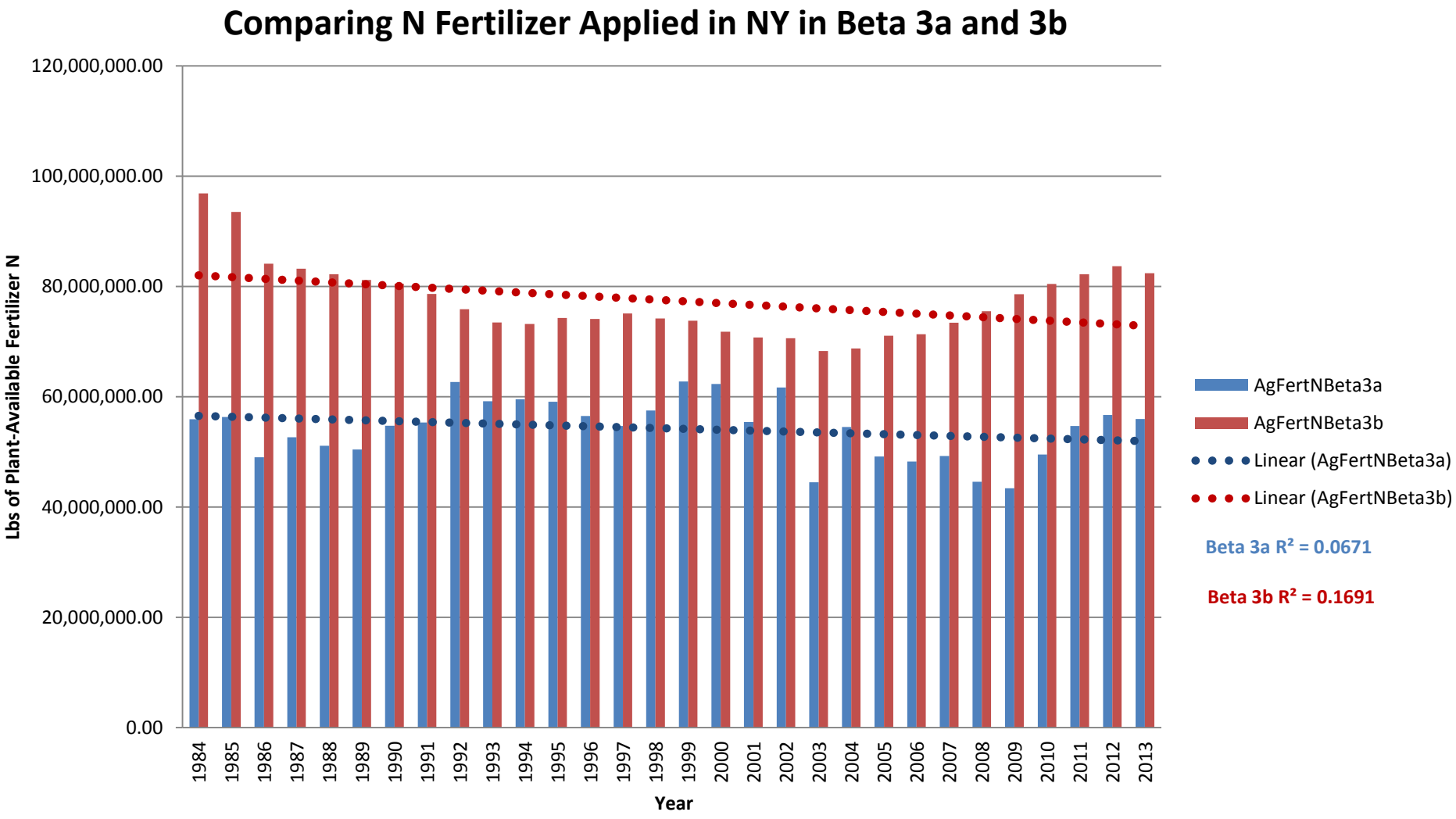
Data Source	Lbs Inorganic PAN	Lbs Inorganic P	% Delta from CEAP N	% Delta from CEAP P
Beta 3A	405,182,999	80,360,063	-0.2%	-0.6%
Beta 3B	497,976,530	167,020,450	22.6%	106.5%
CEAP	406,020,000	80,870,000	NA	NA


Comparing N Fertilizer Applied in DE in Beta 3a and 3b
Lbs of Plant-Available Fertilizer N
45,000,000.00
40,000,000.00
35,000,000.00
30,000,000.00
25,000,000.00
20,000,000.00
15,000,000.00
10,000,000.00
5,000,000.00
0.00
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
AgFertNBeta3a
AgFertNBeta3b
Linear (AgFertNBeta3a)
Linear (AgFertNBeta3b)
Beta 3a R² = 0.1383
Beta 3b R² = 0.6913

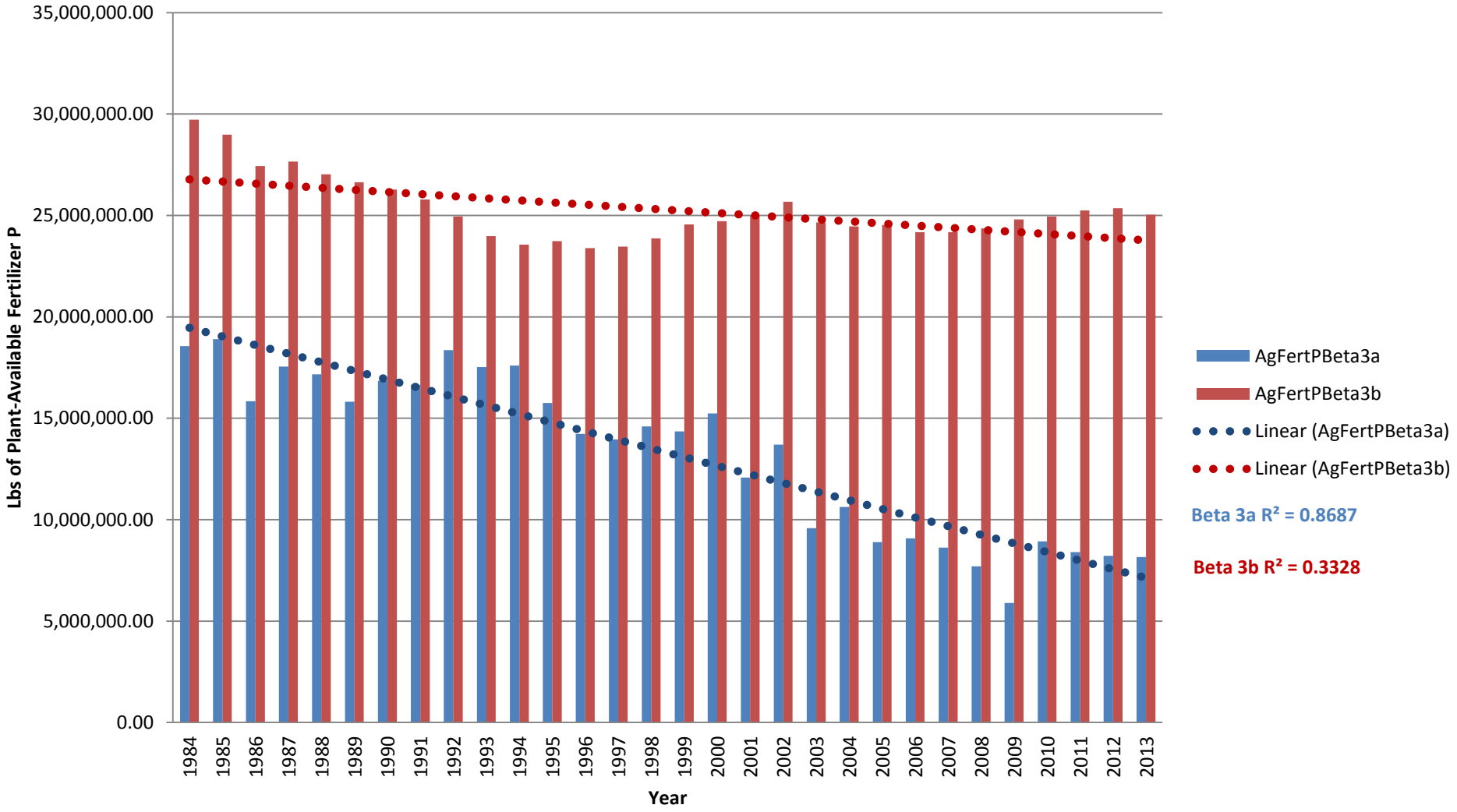

Comparing P Fertilizer Applied in DE in Beta 3a and 3b
Lbs of Plant-Available Fertilizer P
14,000,000.00
12,000,000.00
10,000,000.00
8,000,000.00
6,000,000.00
4,000,000.00
2,000,000.00
0.00
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
AgFertPBeta3a
AgFertPBeta3b
Linear (AgFertPBeta3a)
Linear (AgFertPBeta3b)
Beta 3a R² = 0.7029
Beta 3b R² = 0.4417

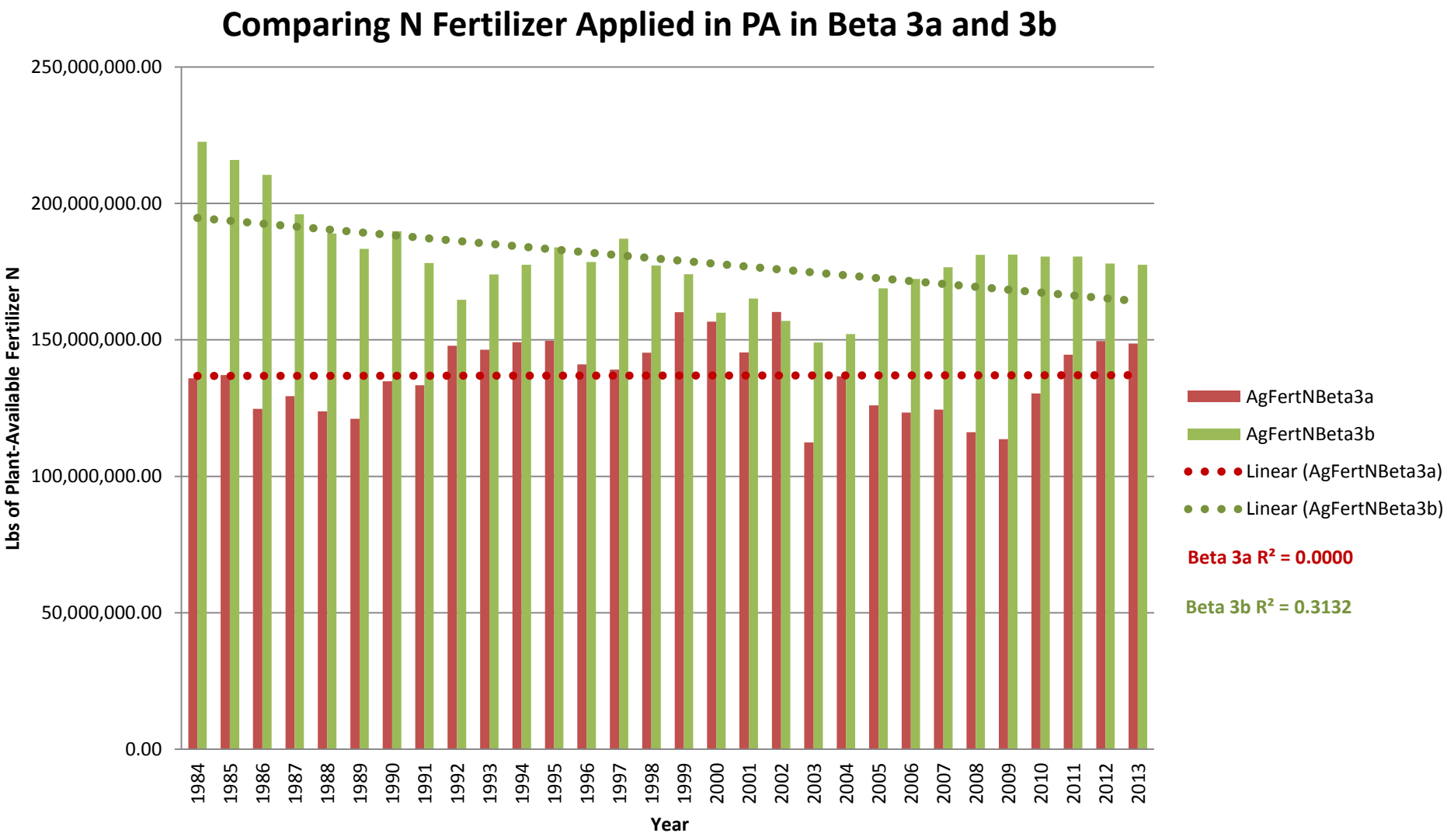

Comparing N Fertilizer Applied in MD in Beta 3a and 3b
140,000,000.00
120,000,000.00
100,000,000.00
80,000,000.00
60,000,000.00
40,000,000.00
20,000,000.00
0.00
Lbs of Plant-Available Fertilizer N
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
AgFertNBeta3a
AgFertNBeta3b
Linear (AgFertNBeta3a)
Linear (AgFertNBeta3b)
Beta 3a R² = 0.0072
Beta 3b R² = 0.0038

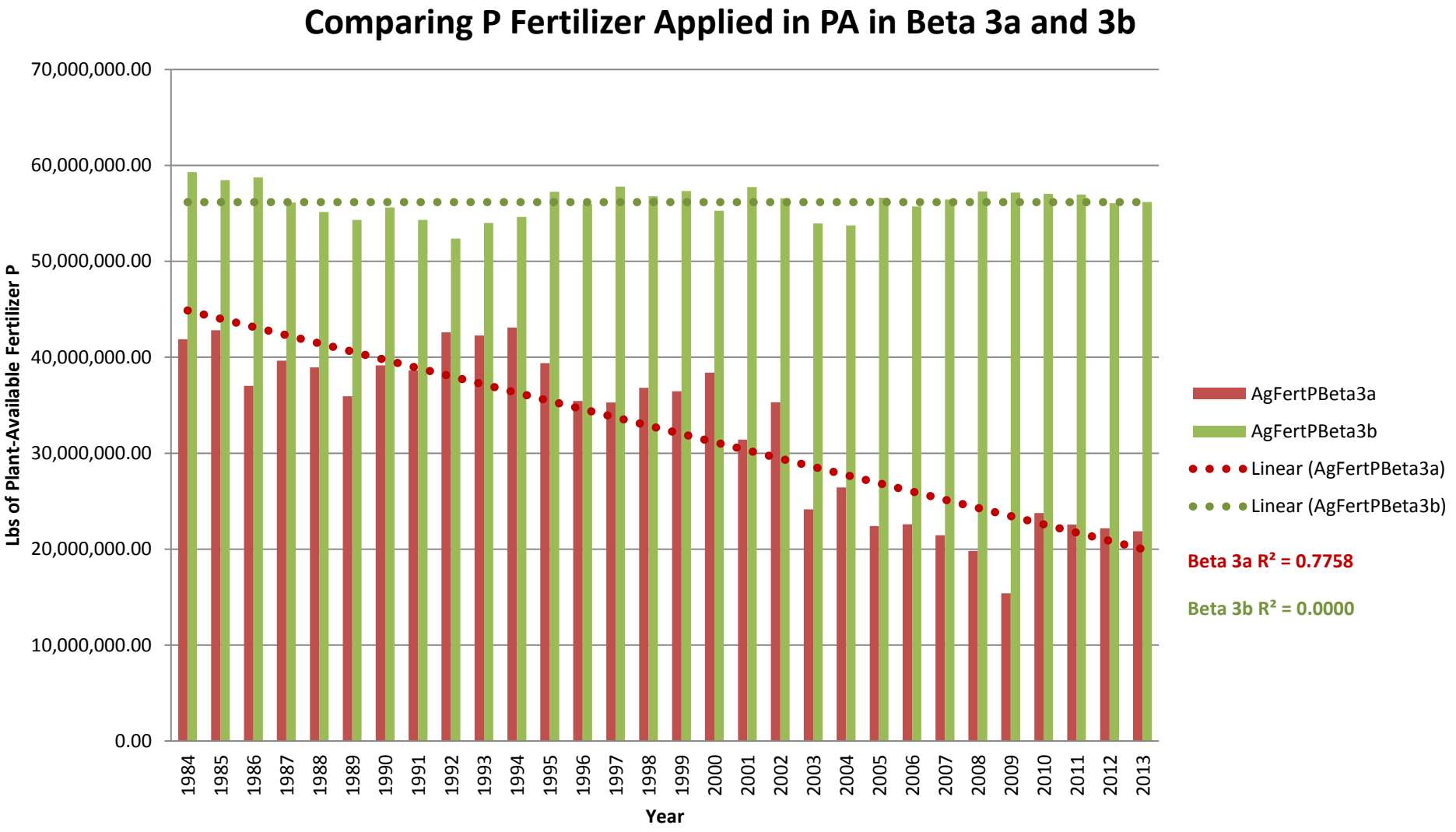

Comparing P Fertilizer Applied in MD in Beta 3a and 3b
Lbs of Plant-Available Fertilizer P
40,000,000.00
35,000,000.00
30,000,000.00
25,000,000.00
20,000,000.00
15,000,000.00
10,000,000.00
5,000,000.00
0.00
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
AgFertPBeta3a
AgFertPBeta3b
Linear (AgFertPBeta3a)
Linear (AgFertPBeta3b)
Beta 3a R² = 0.7459
Beta 3b R² = 0.3164

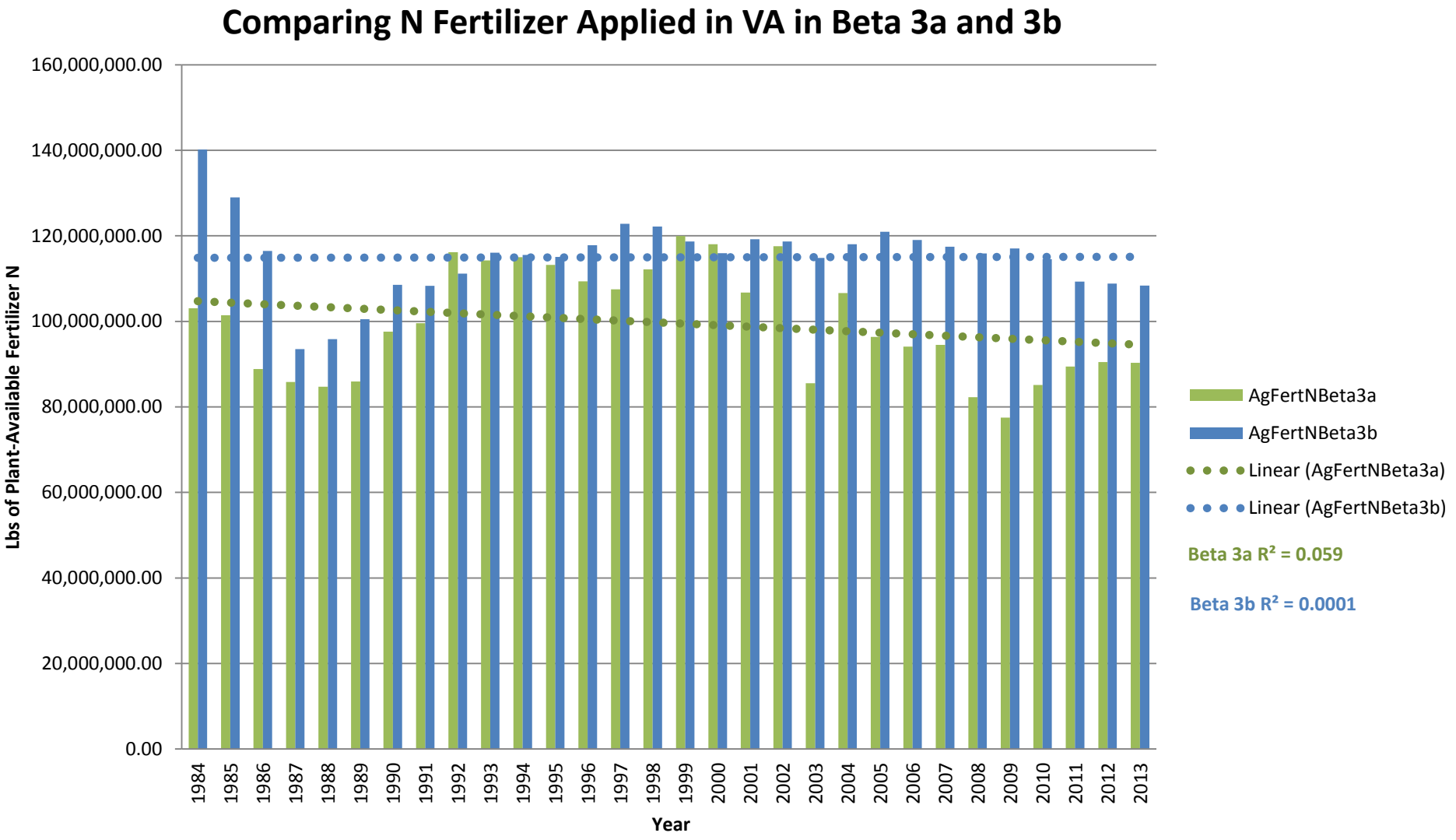

Comparing N Fertilizer Applied in NY in Beta 3a and 3b
120,000,000.00
100,000,000.00
80,000,000.00
60,000,000.00
40,000,000.00
20,000,000.00
0.00
Lbs of Plant-Available Fertilizer N
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
AgFertNBeta3a
AgFertNBeta3b
Linear (AgFertNBeta3a)
Linear (AgFertNBeta3b)
Beta 3a R² = 0.0671
Beta 3b R² = 0.1691

Comparing P Fertilizer Applied in NY in Beta 3a and 3b

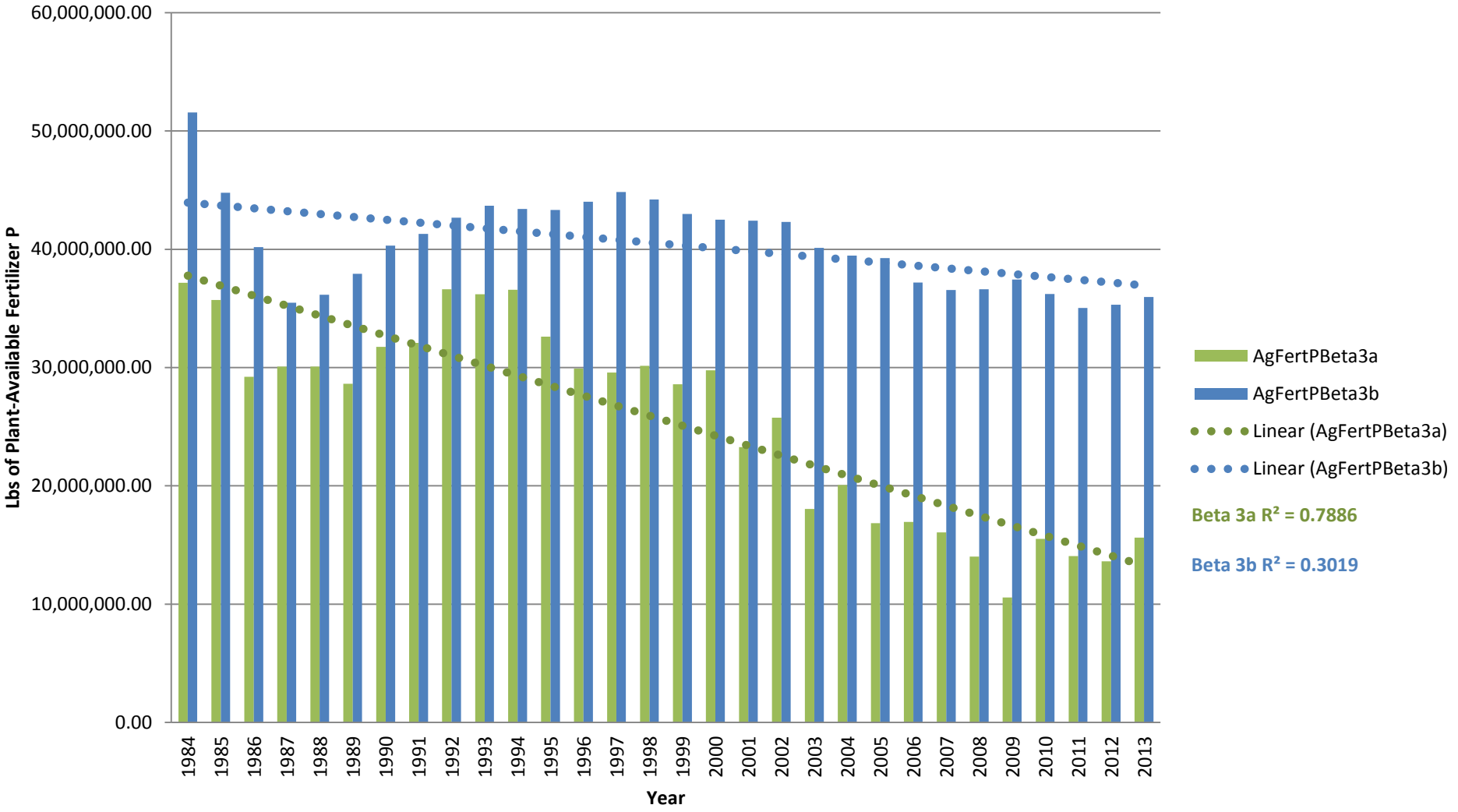


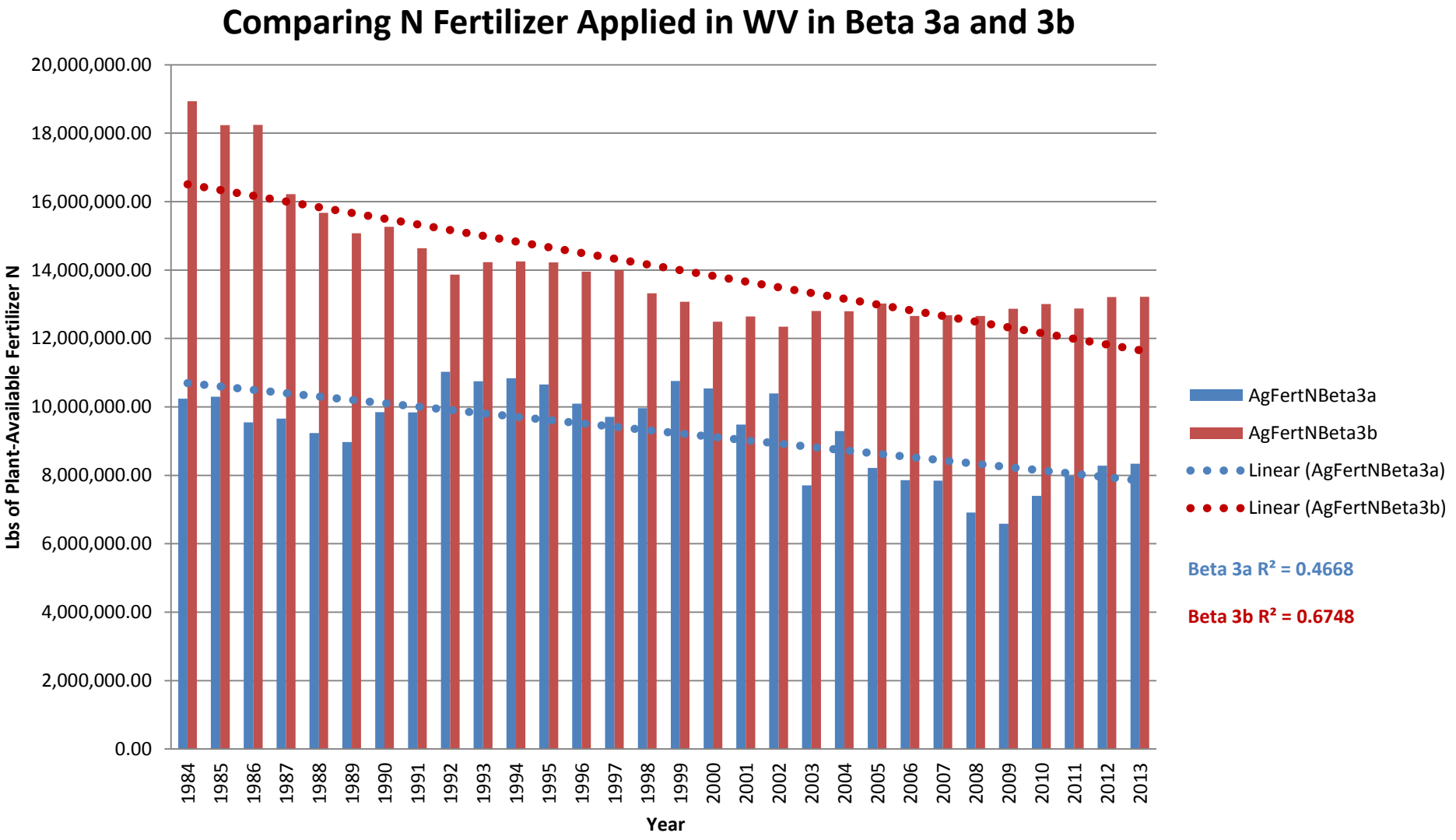

Comparing N Fertilizer Applied in PA in Beta 3a and 3b
250,000,000.00
200,000,000.00
150,000,000.00
100,000,000.00
50,000,000.00
0.00
Lbs of Plant-Available Fertilizer N
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
AgFertNBeta3a
AgFertNBeta3b
Linear (AgFertNBeta3a)
Linear (AgFertNBeta3b)
Beta 3a R² = 0.0000
Beta 3b R² = 0.3132


Comparing P Fertilizer Applied in PA in Beta 3a and 3b
70,000,000.00
60,000,000.00
50,000,000.00
40,000,000.00
30,000,000.00
20,000,000.00
10,000,000.00
0.00
Lbs of Plant-Available Fertilizer P
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
AgFertPBeta3a
AgFertPBeta3b
Linear (AgFertPBeta3a)
Linear (AgFertPBeta3b)
Beta 3a R² = 0.7758
Beta 3b R² = 0.0000


Comparing N Fertilizer Applied in VA in Beta 3a and 3b
160,000,000.00
140,000,000.00
120,000,000.00
100,000,000.00
80,000,000.00
60,000,000.00
40,000,000.00
20,000,000.00
0.00
Lbs of Plant-Available Fertilizer N
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
AgFertNBeta3a
AgFertNBeta3b
Linear (AgFertNBeta3a)
Linear (AgFertNBeta3b)
Beta 3a R² = 0.059
Beta 3b R² = 0.0001

Comparing P Fertilizer Applied in VA in Beta 3a and 3b




Comparing N Fertilizer Applied in WV in Beta 3a and 3b
Lbs of Plant-Available Fertilizer N
20,000,000.00
18,000,000.00
16,000,000.00
14,000,000.00
12,000,000.00
10,000,000.00
8,000,000.00
6,000,000.00
4,000,000.00
2,000,000.00
0.00
1984
1985
1986
1987
1988
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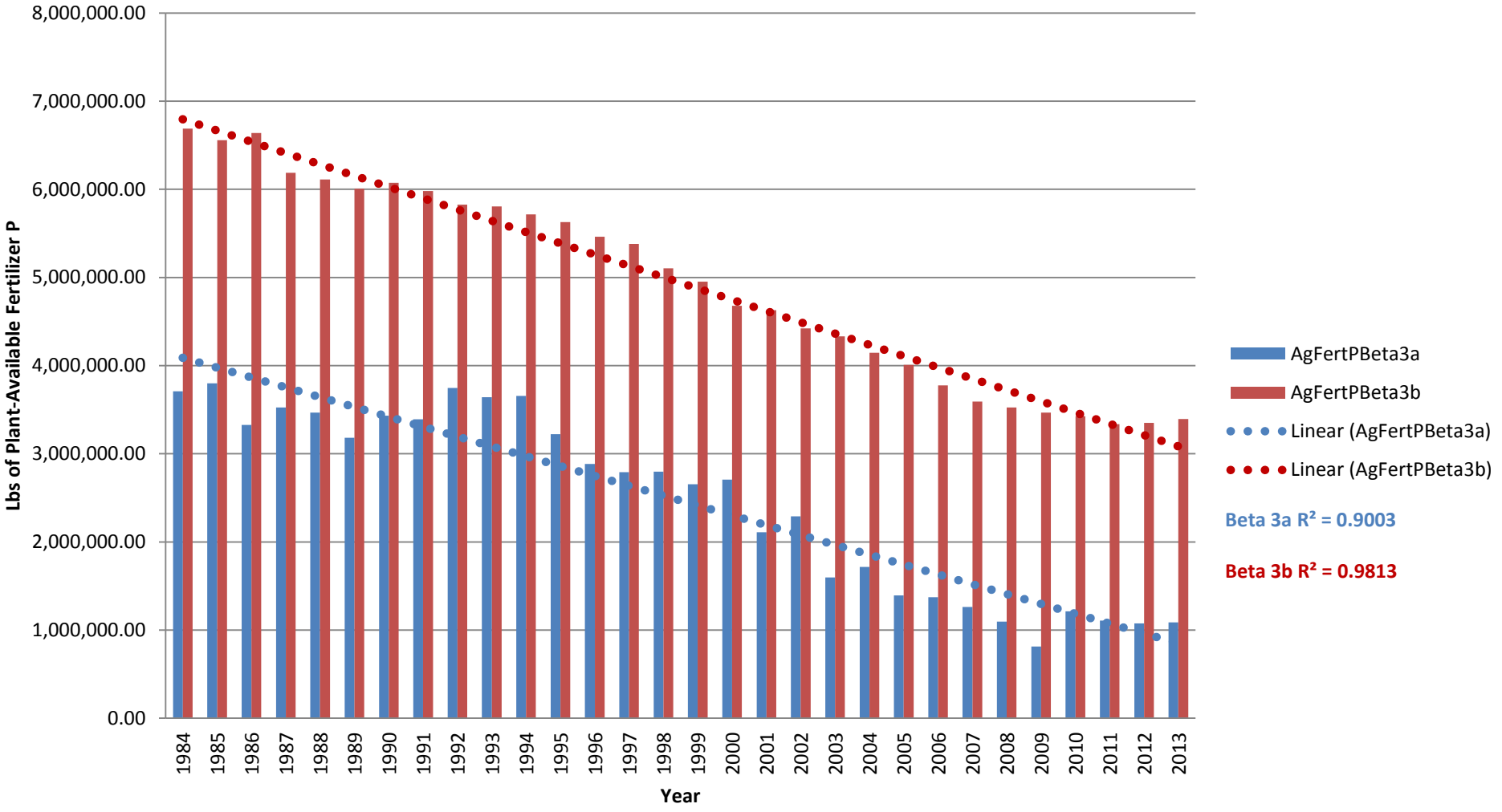
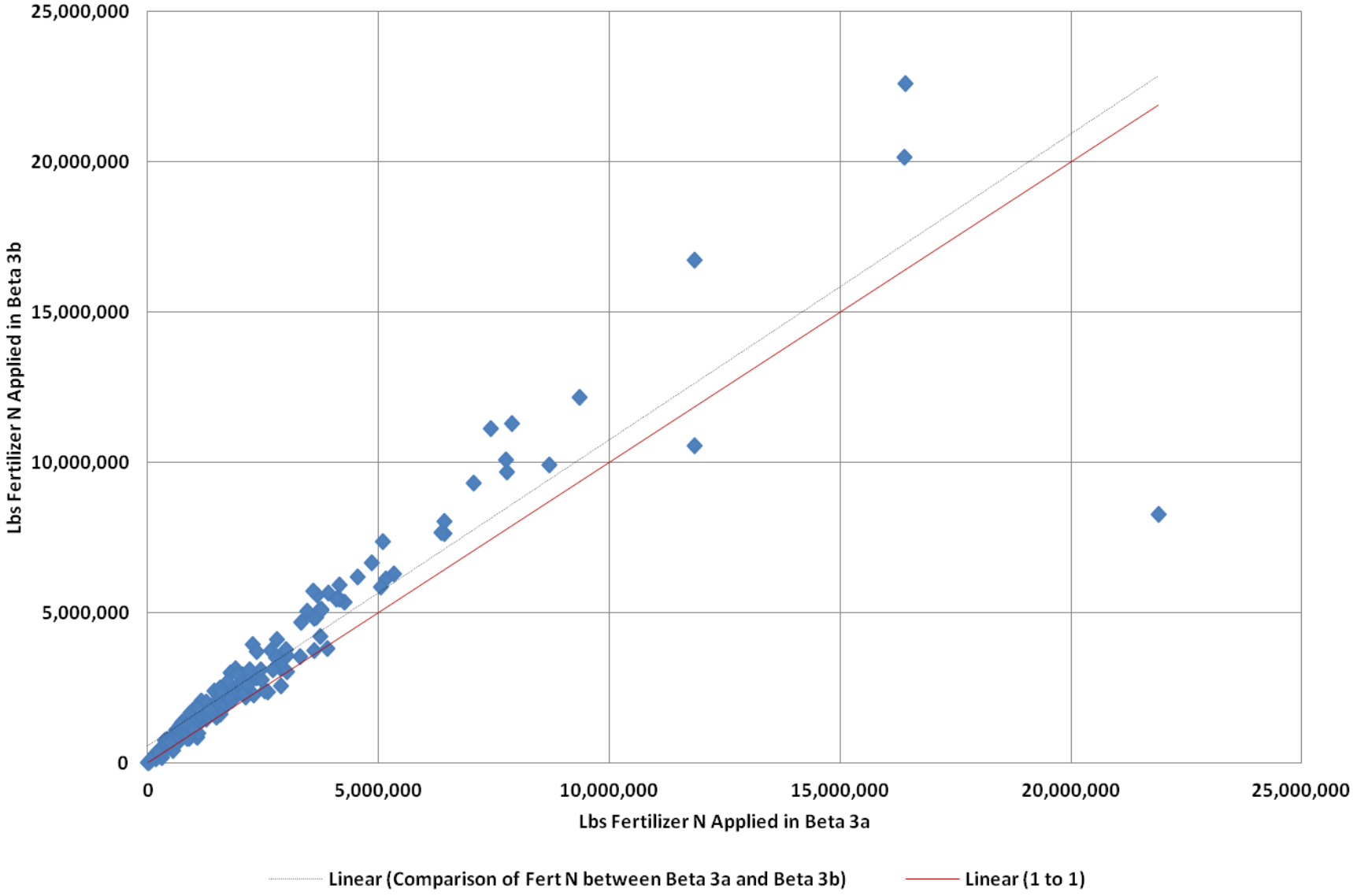
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
AgFertNBeta3a
AgFertNBeta3b
Linear (AgFertNBeta3a)
Linear (AgFertNBeta3b)
Beta 3a R² = 0.4668
Beta 3b R² = 0.6748

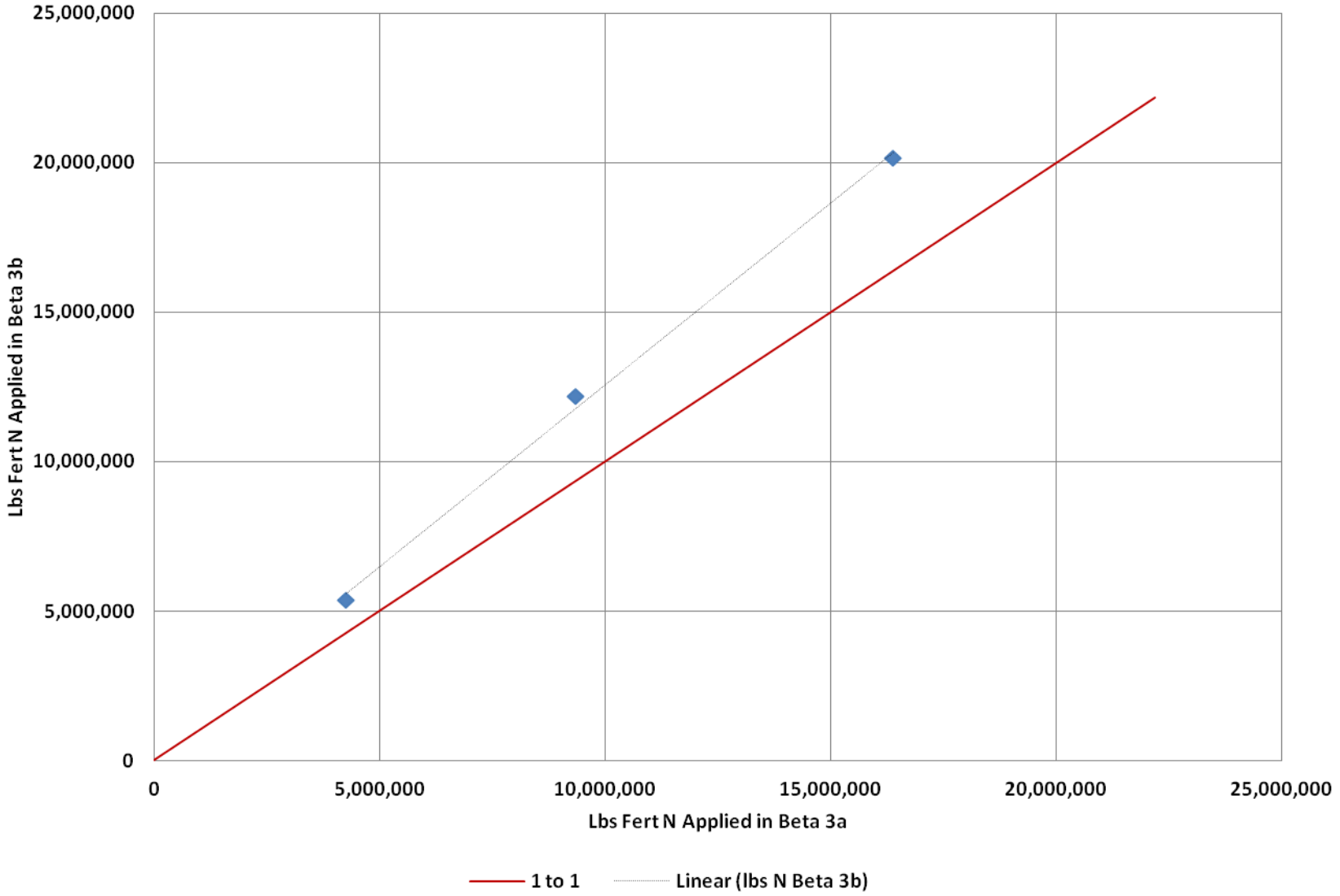
Comparing P Fertilizer Applied in WV in Beta 3a and 3b



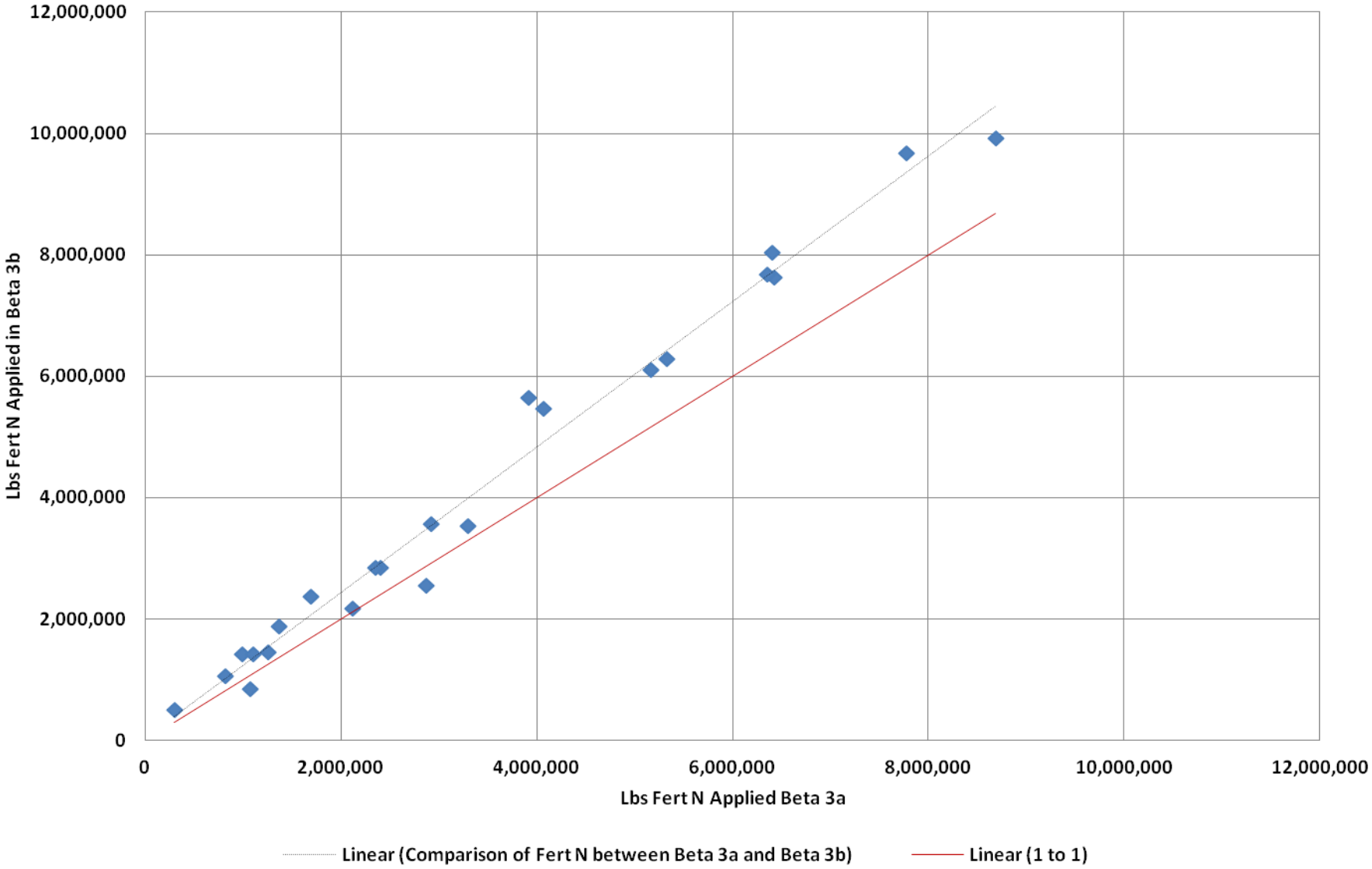
Comparison of Lbs Fertilizer N Applied by County between Beta 3a and 3b in 2012



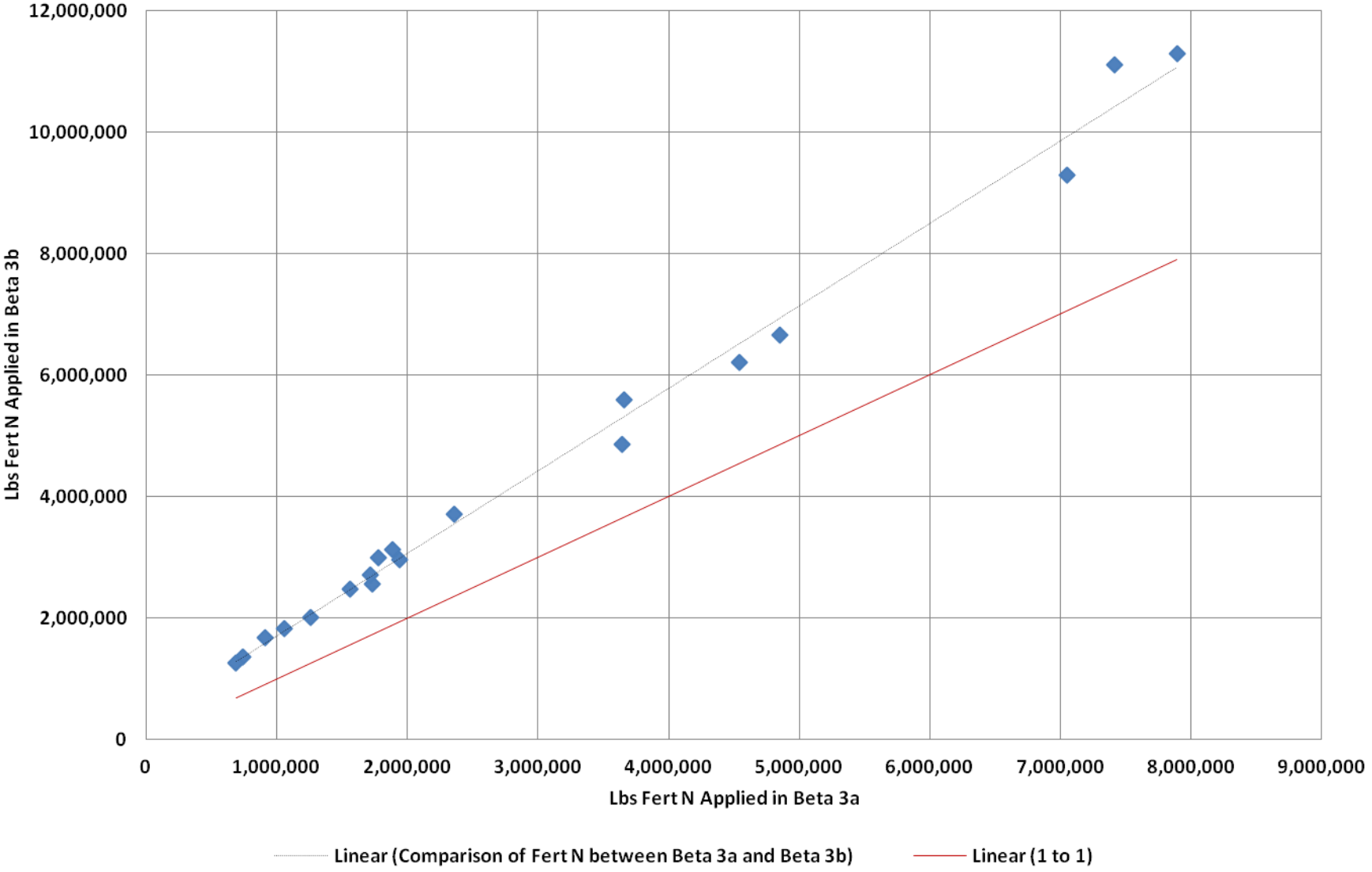
Comparison of Fert N Applied by DE County between Beta 3a and 3b in 2012



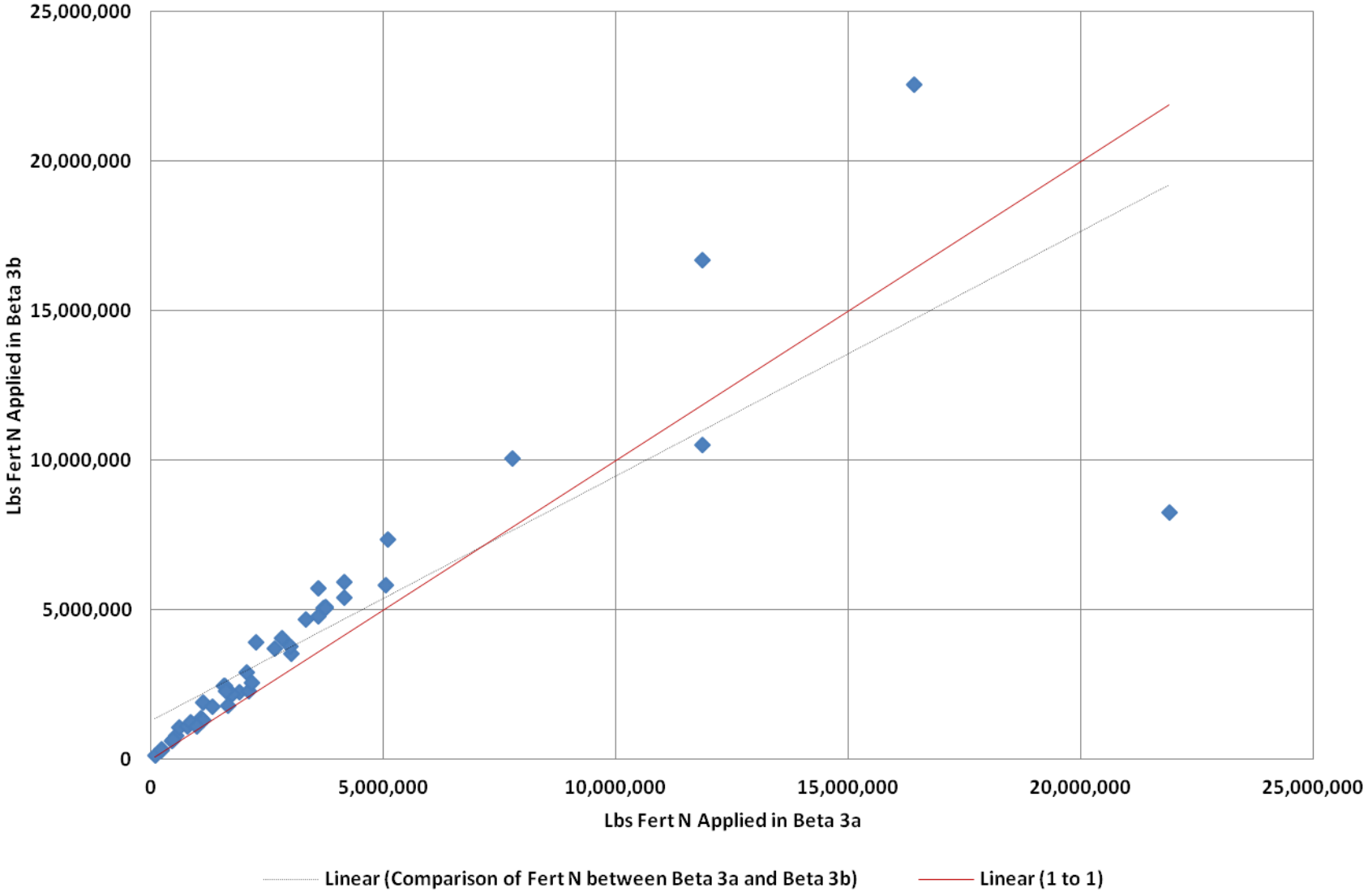
Comparison of Fert N Applied by MD County between Beta 3a and 3b in 2012



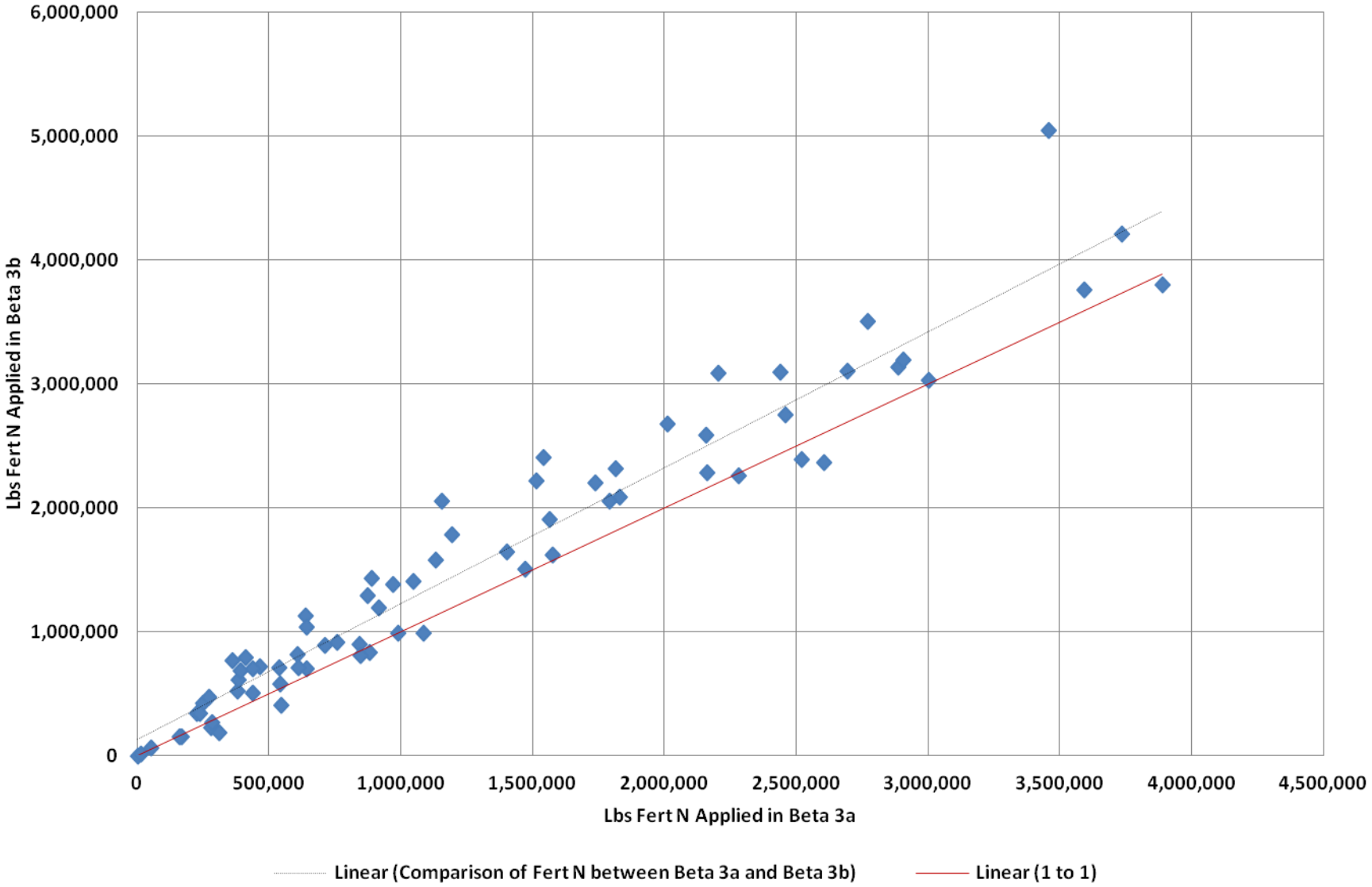
Comparison of Fert N Applied by NY County between Beta 3a and 3b in 2012



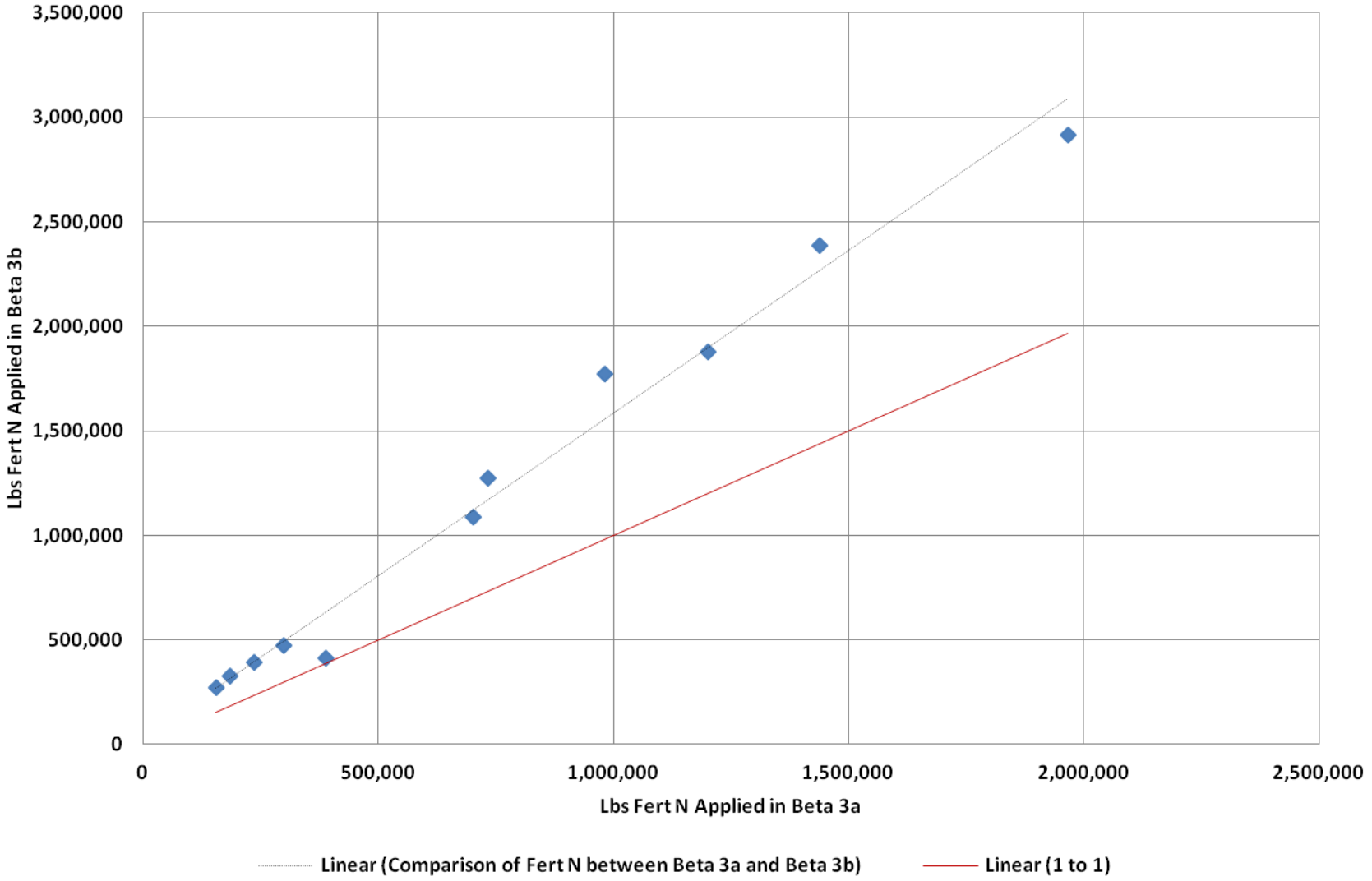
Comparison of Fert N Applied by PA County between Beta 3a and 3b in 2012



Comparison of Fert N Applied by VA County between Beta 3a and 3b in 2012

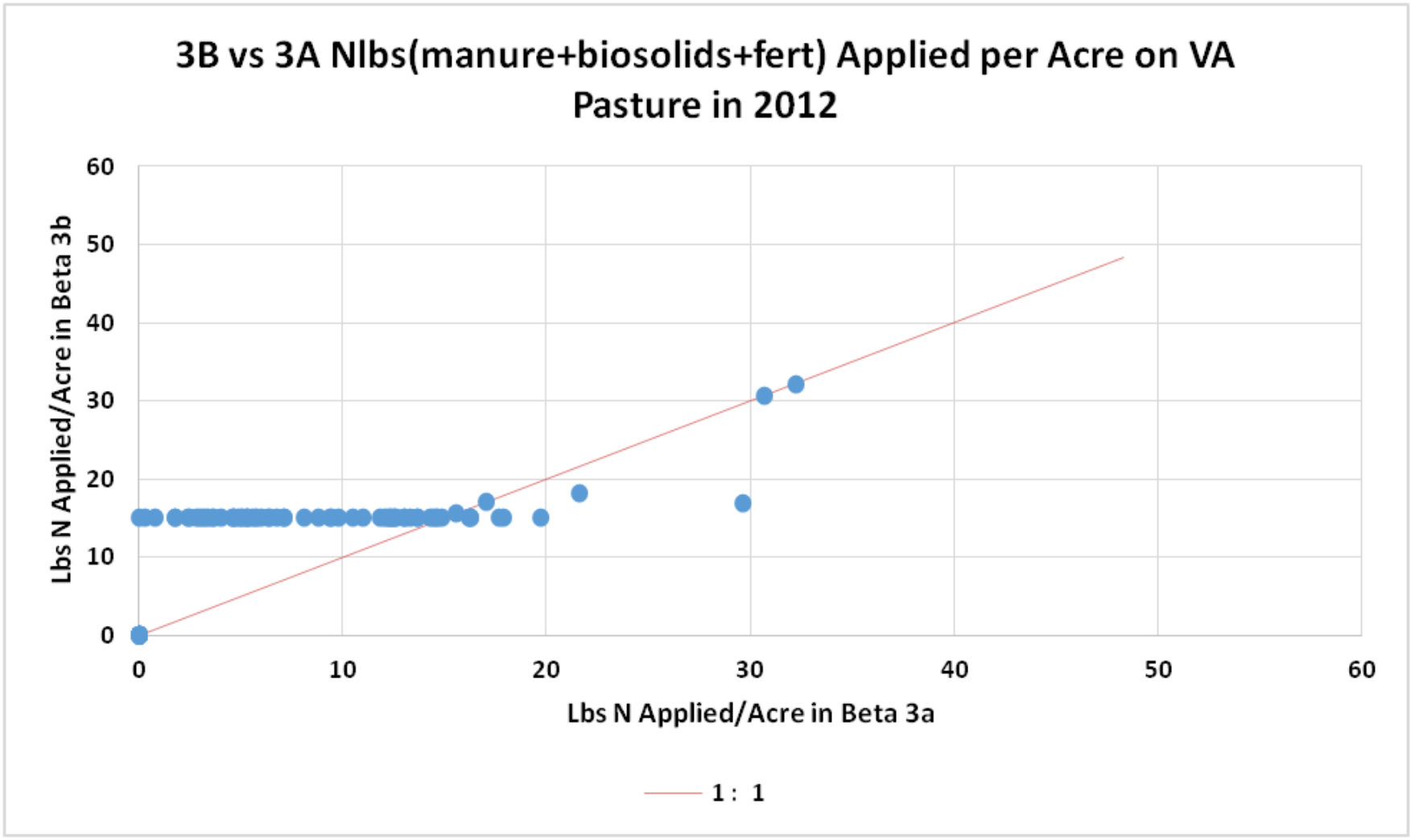


Comparison of Fert N Applied by WV County between Beta 3a and 3b in 2012

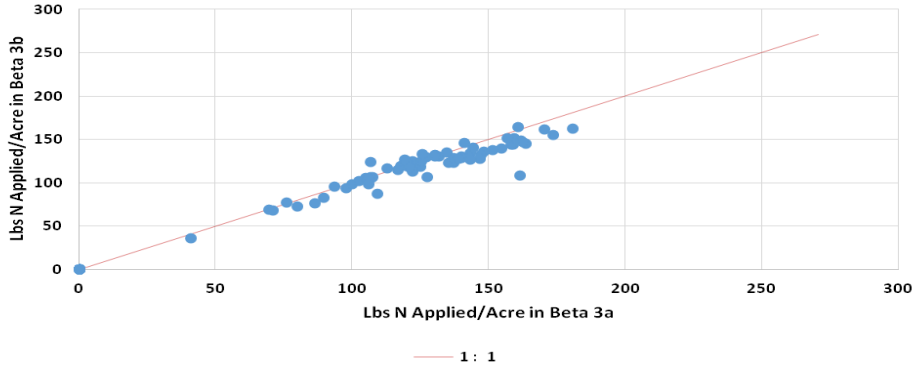


Why is there more N in Beta 3b?

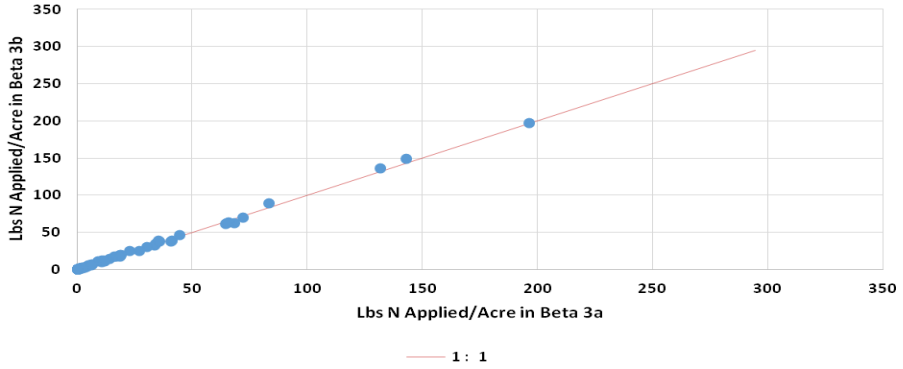
- Beta 3b assumes that every acre of crop, hay and pasture will receive at least the crop application goal.
- Beta 3a assumes there is only a finite amount of nitrogen fertilizer within the watershed.
- Beta 3a assumes that fertilizer applications are prioritized to commodity crops over leguminous crops, pasture and hay.
- Adjustments in availability of manure nitrogen could bring countywide applications closer.
- Only adjustments in Beta 3a application curves would bring legume applications closer.


3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Pasture in 2012
Lbs N Applied/Acre in Beta 3b
60
50
40
30
20
10
0
0
10
20
30
40
50
60
Lbs N Applied/Acre in Beta 3a
1 : 1

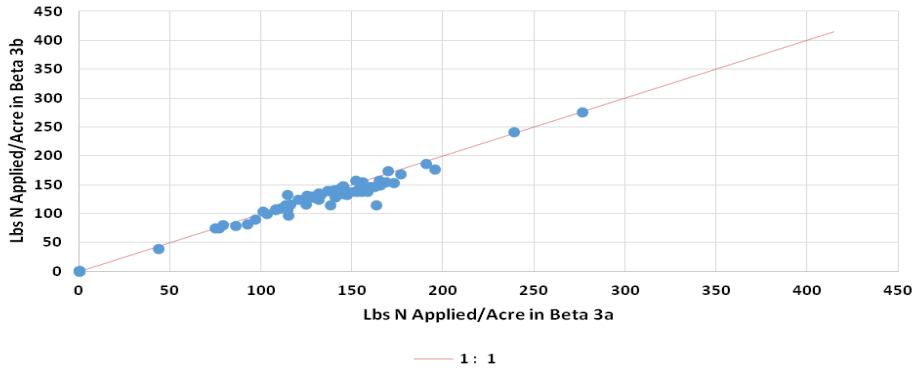
3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Grain Without Manure in 2012



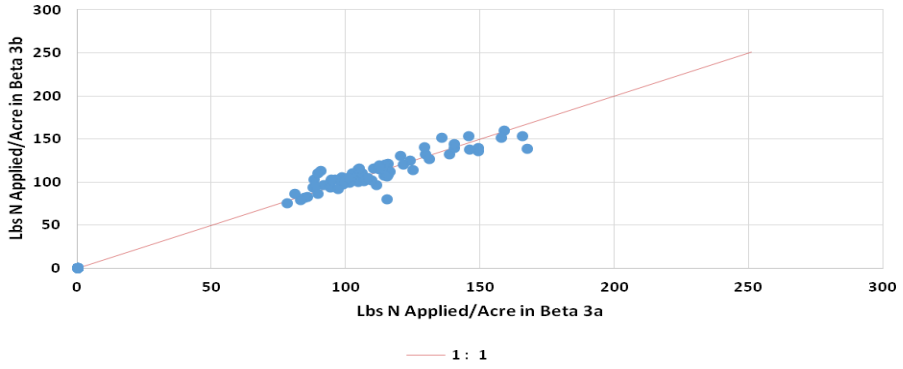
3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Other Agronomic Crops in 2012



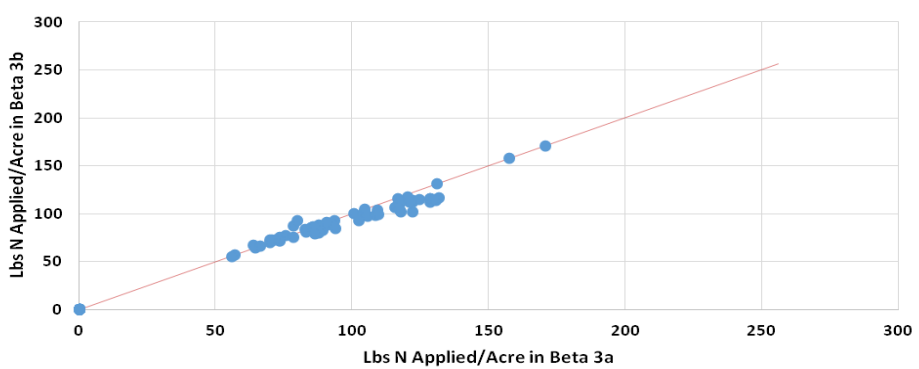
3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Grain With Manure in 2012



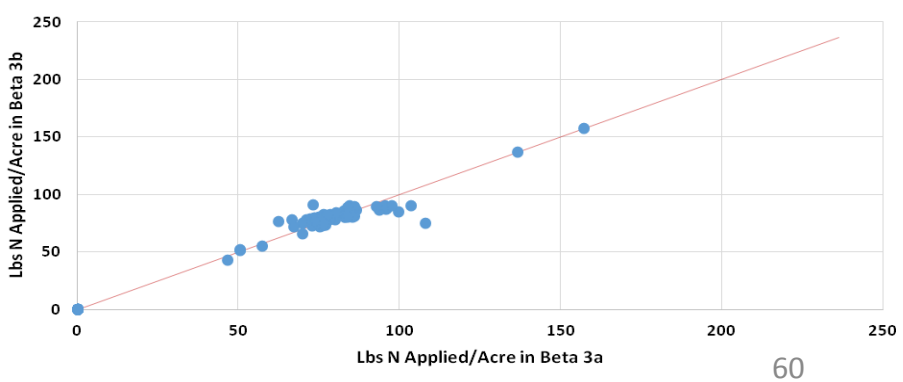
3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Specialty Crops High in 2012

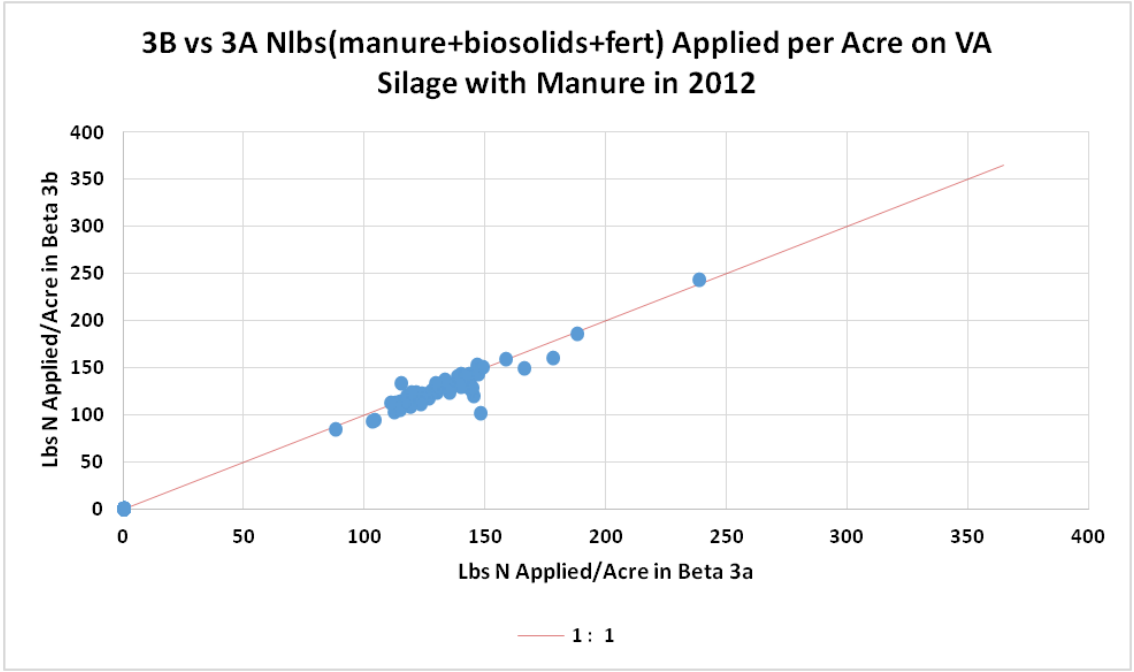


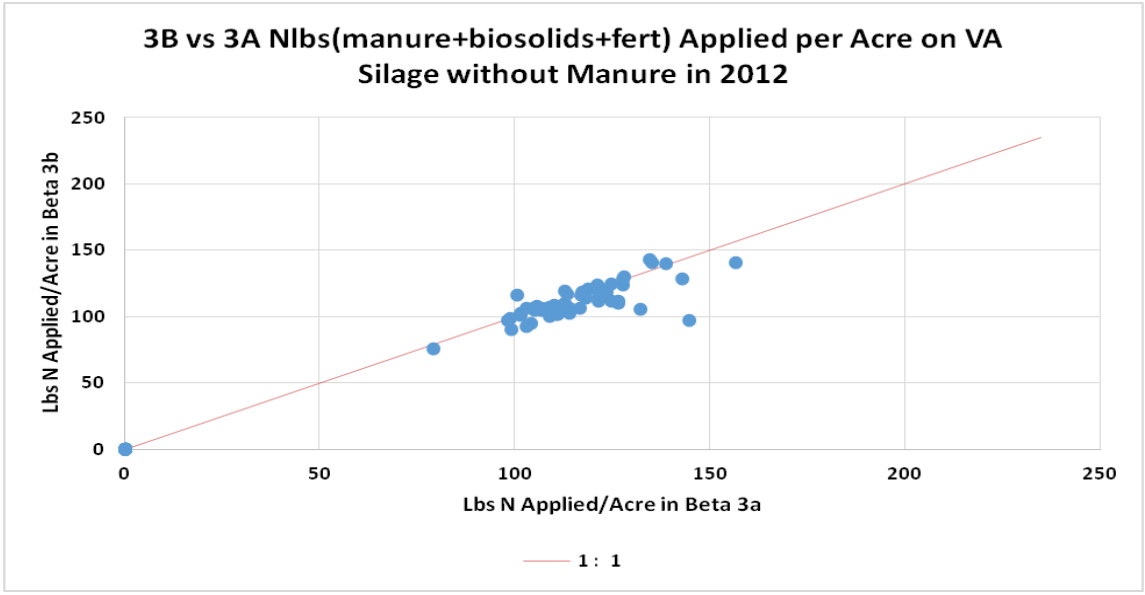
3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Small Grains and Grains in 2012

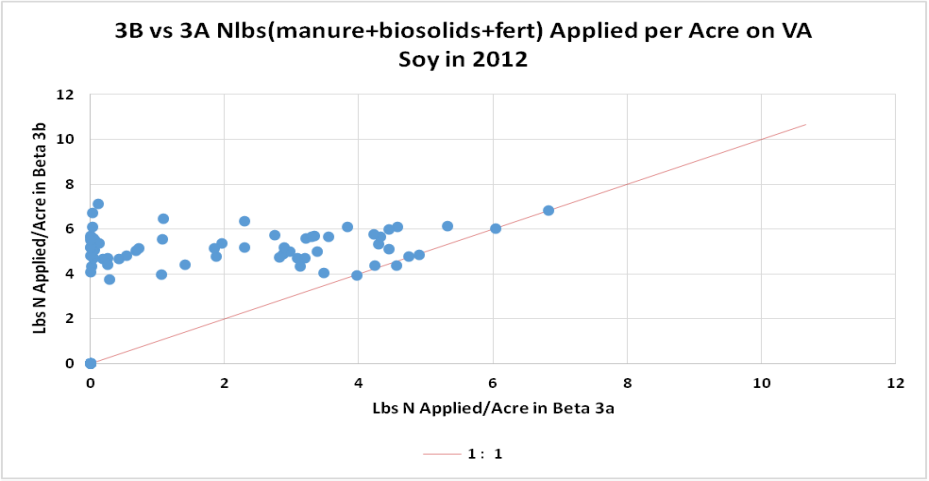


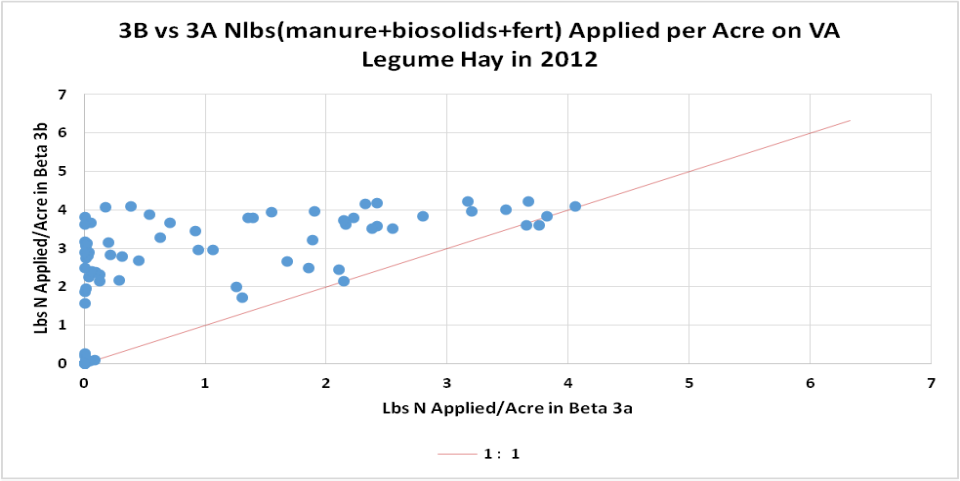
3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Specialty Crops Low in 2012

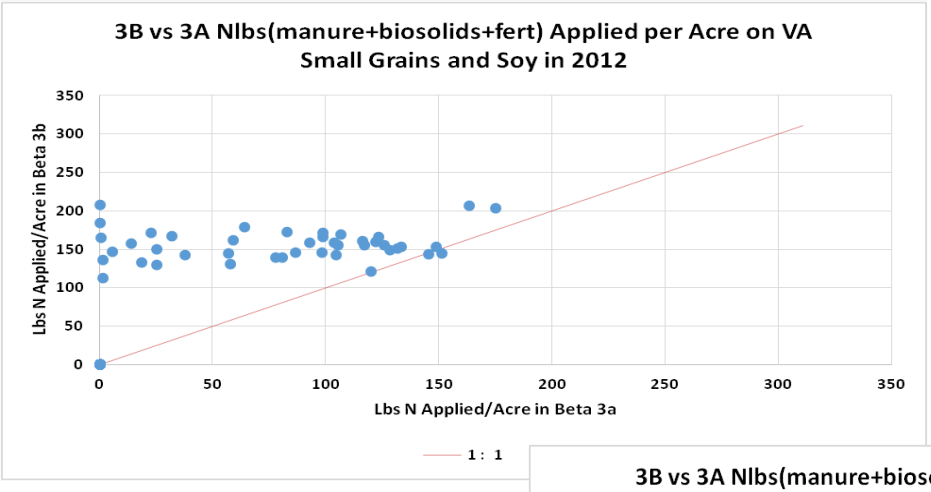


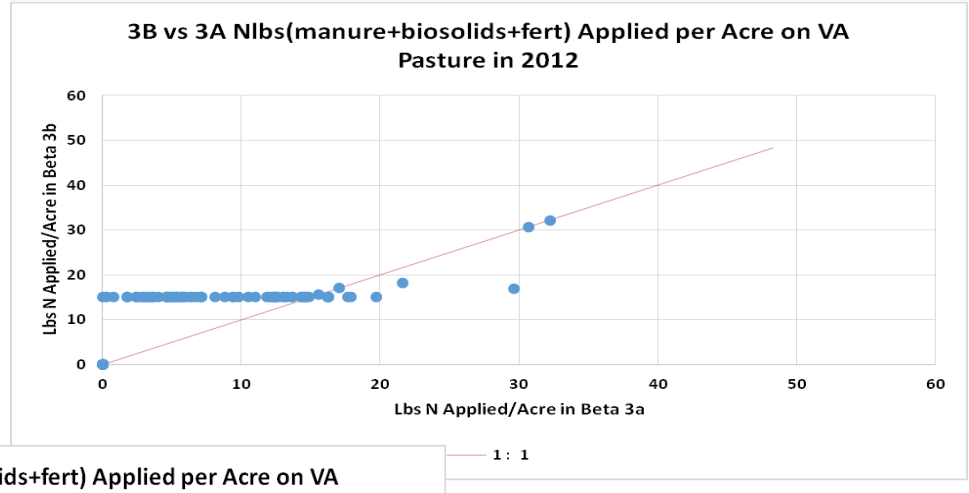

3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Silage with Manure in 2012
Lbs N Applied/Acre in Beta 3b
0
50
100
150
200
250
300
350
400
Lbs N Applied/Acre in Beta 3a
1 : 1

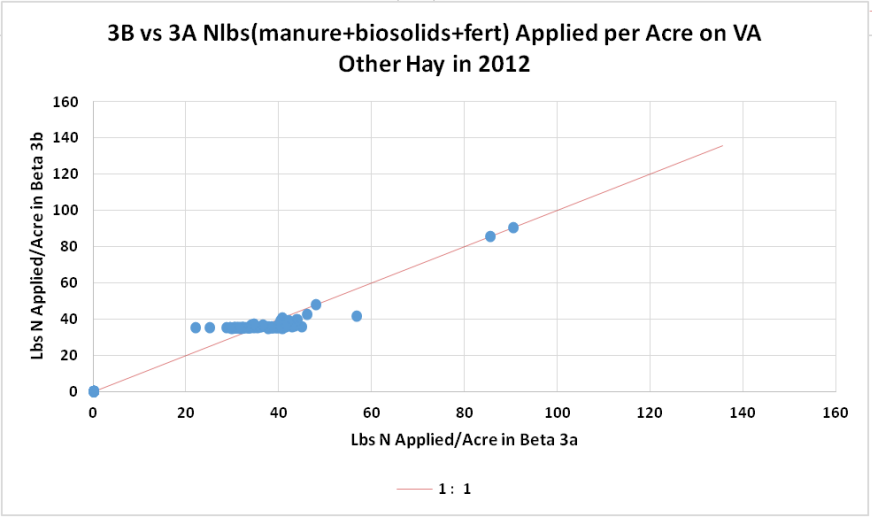

3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Silage without Manure in 2012
Lbs N Applied/Acre in Beta 3b
0
50
100
150
200
250
Lbs N Applied/Acre in Beta 3a
1 : 1


3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Soy in 2012
Lbs N Applied/Acre in Beta 3b
Lbs N Applied/Acre in Beta 3a
1 : 1

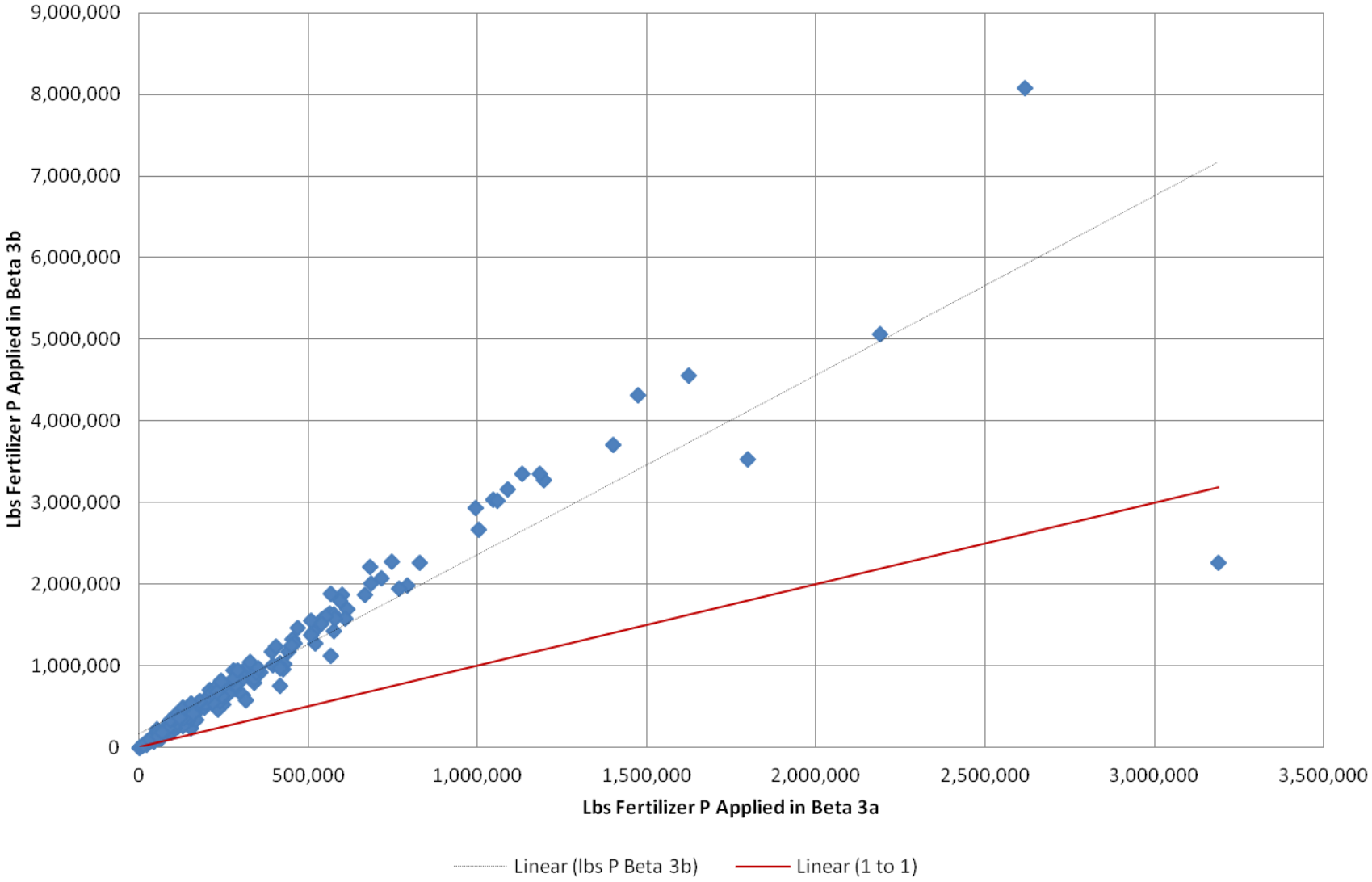

3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Legume Hay in 2012
Lbs N Applied/Acre in Beta 3b
Lbs N Applied/Acre in Beta 3a
1 : 1

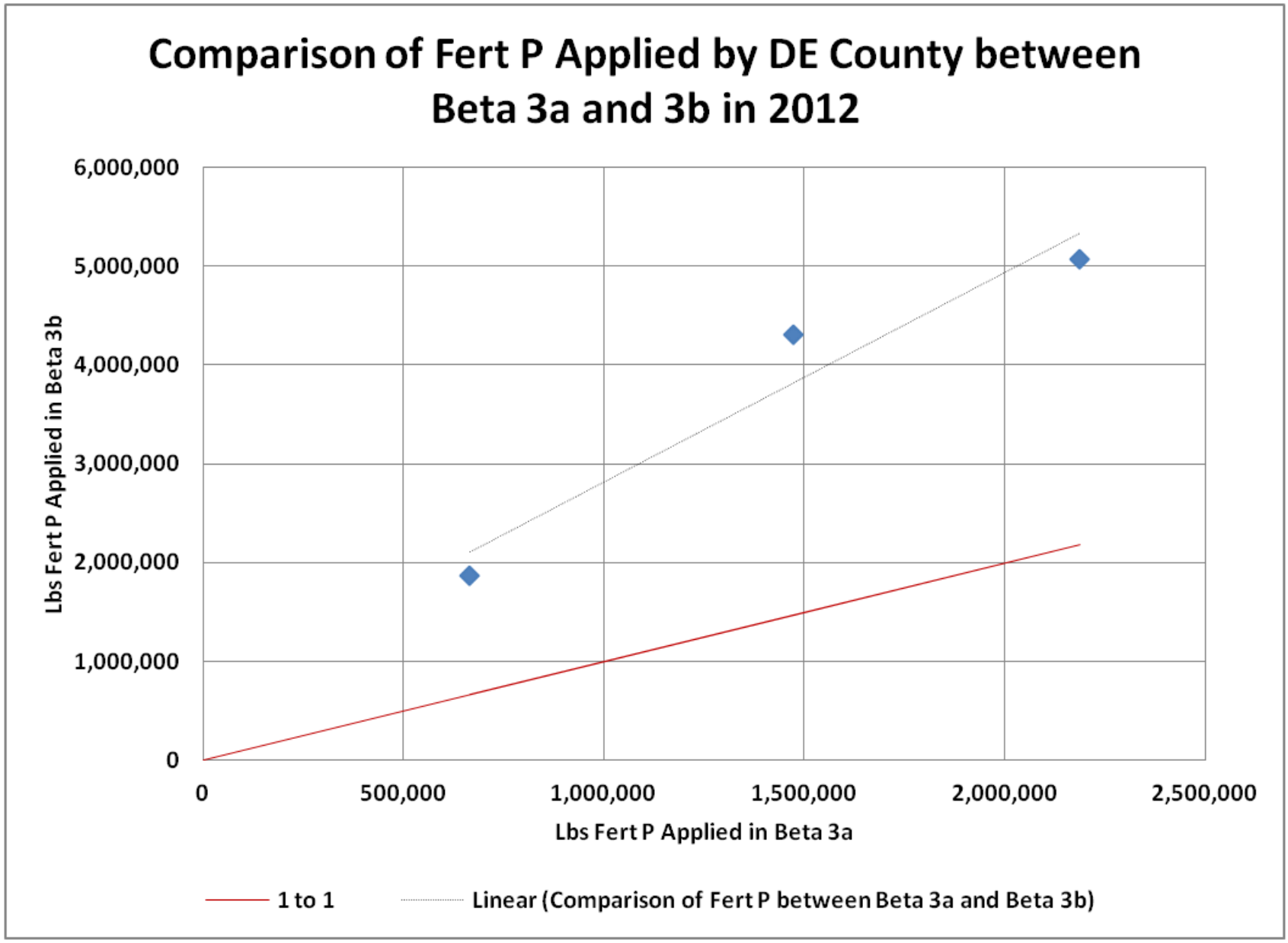

3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Small Grains and Soy in 2012
Lbs N Applied/Acre in Beta 3b
Lbs N Applied/Acre in Beta 3a
1 : 1

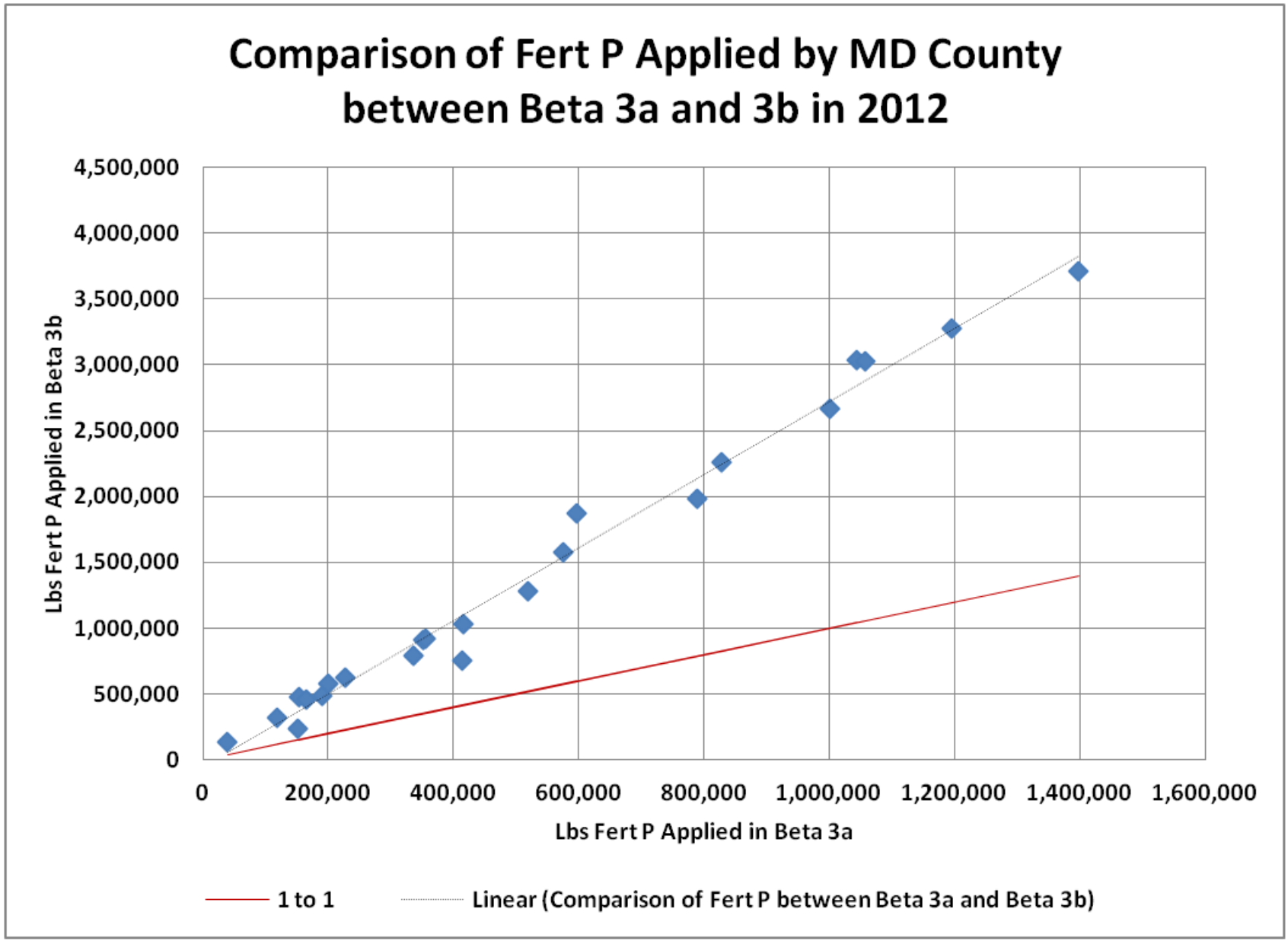

3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Pasture in 2012
Lbs N Applied/Acre in Beta 3b
Lbs N Applied/Acre in Beta 3a
1 : 1

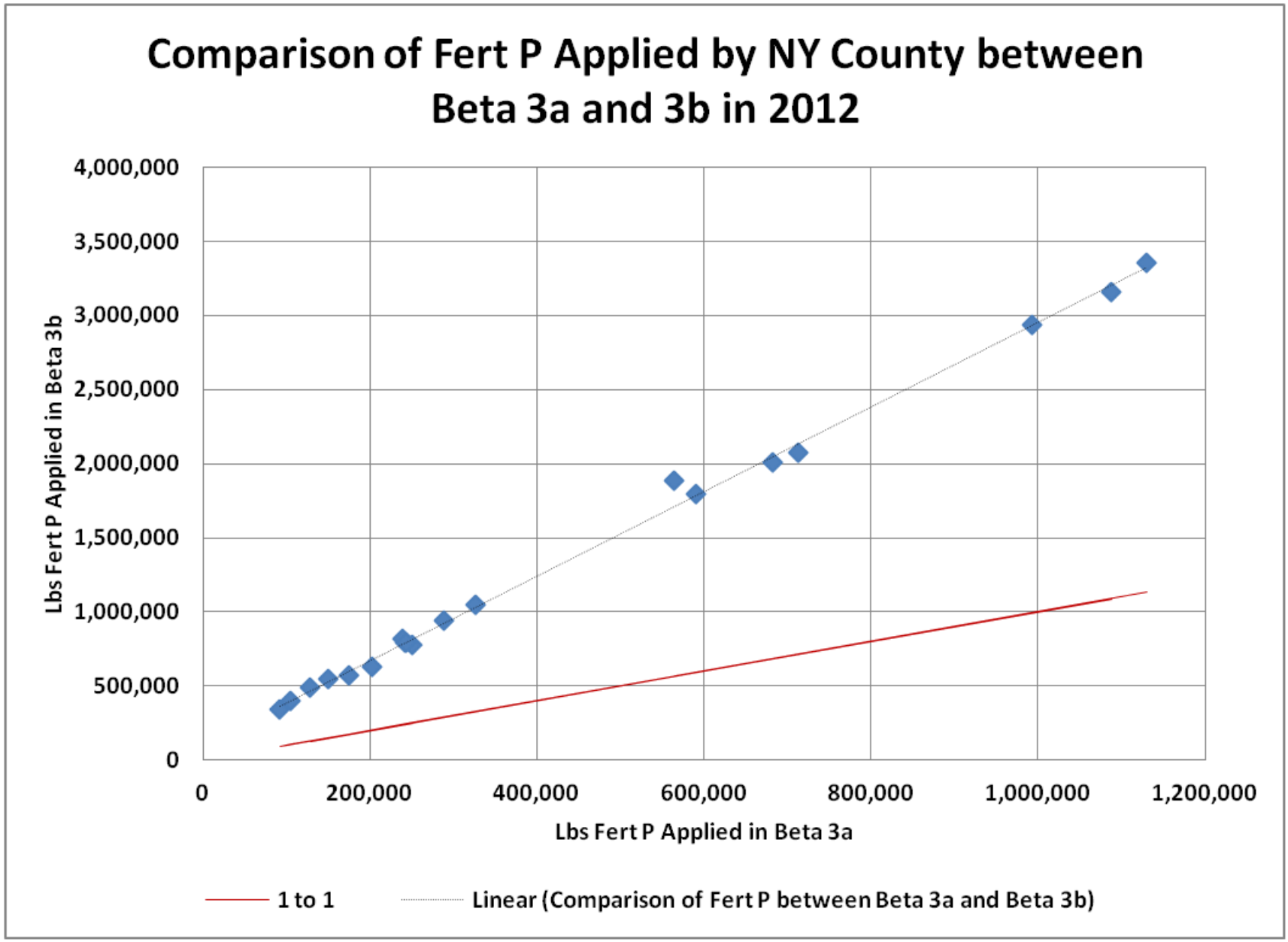

3B vs 3A Nlbs(manure+biosolids+fert) Applied per Acre on VA Other Hay in 2012
Lbs N Applied/Acre in Beta 3b
Lbs N Applied/Acre in Beta 3a
1 : 1

Comparison of Lbs Fertilizer P Applied by County between Beta 3a and 3b in 2012

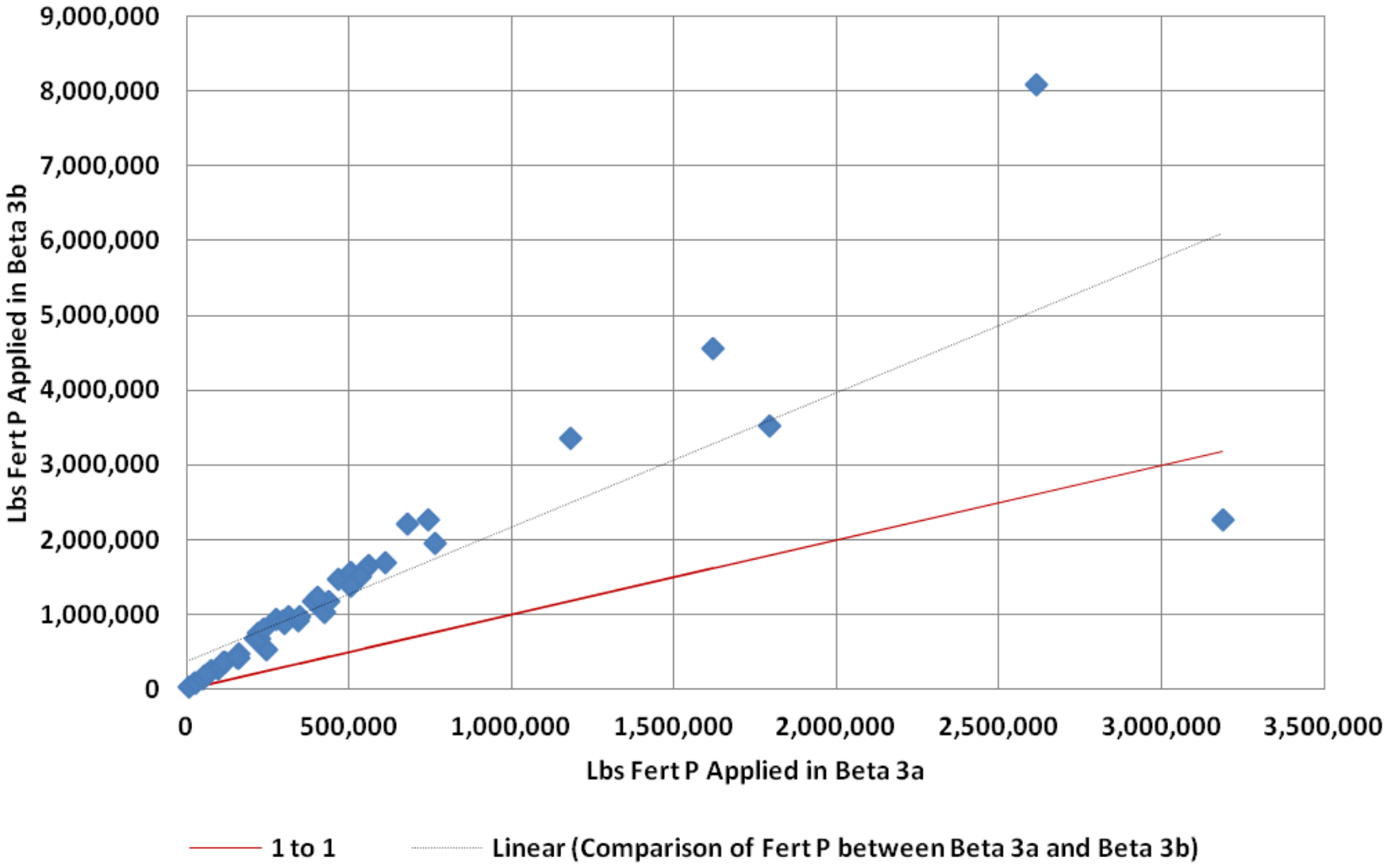


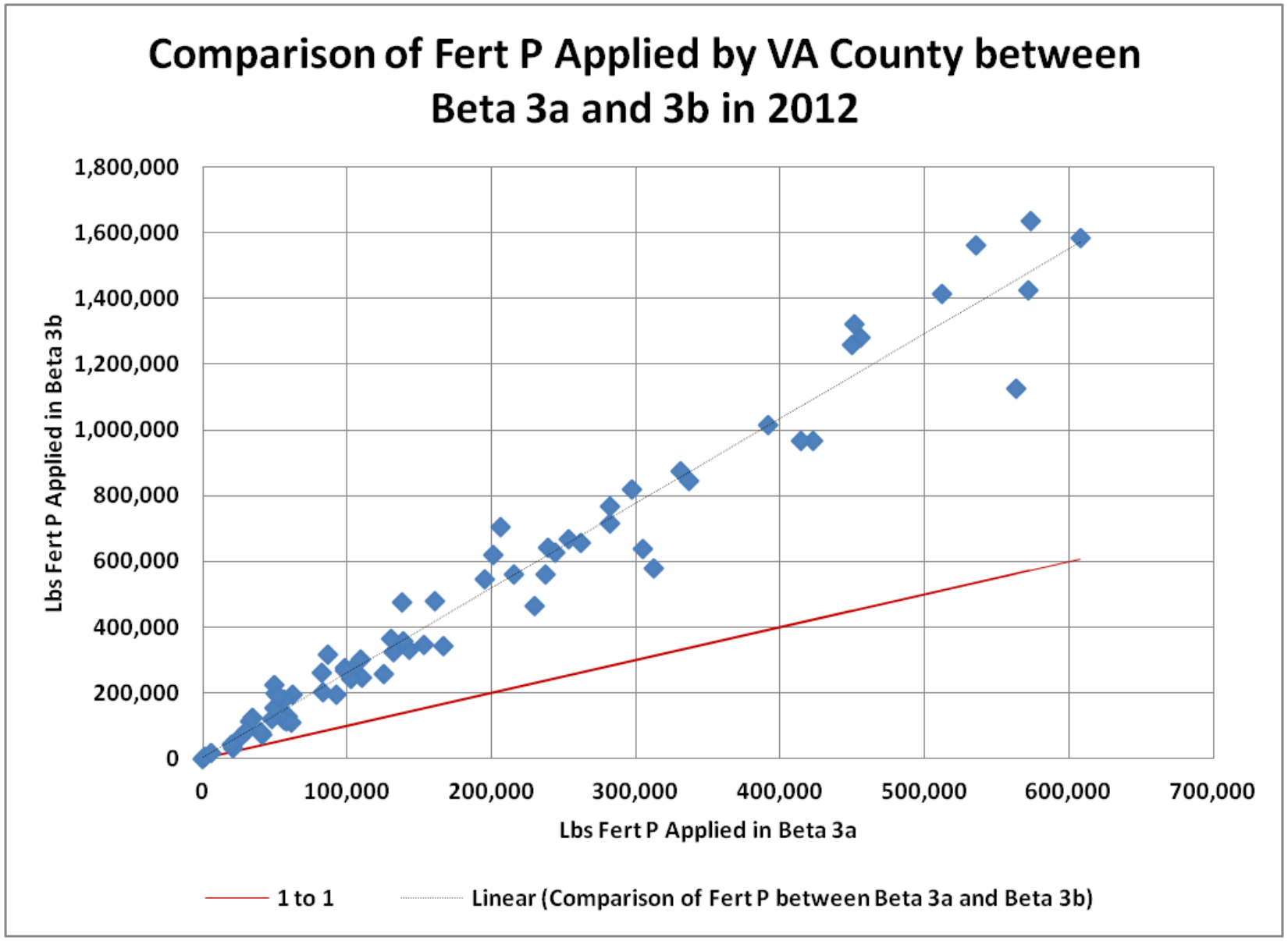

Comparison of Fert P Applied by DE County between Beta 3a and 3b in 2012
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
Lbs Fert P Applied in Beta 3b
0
500,000
1,000,000
1,500,000
2,000,000
2,500,000
Lbs Fert P Applied in Beta 3a
1 to 1
Linear (Comparison of Fert P between Beta 3a and Beta 3b)

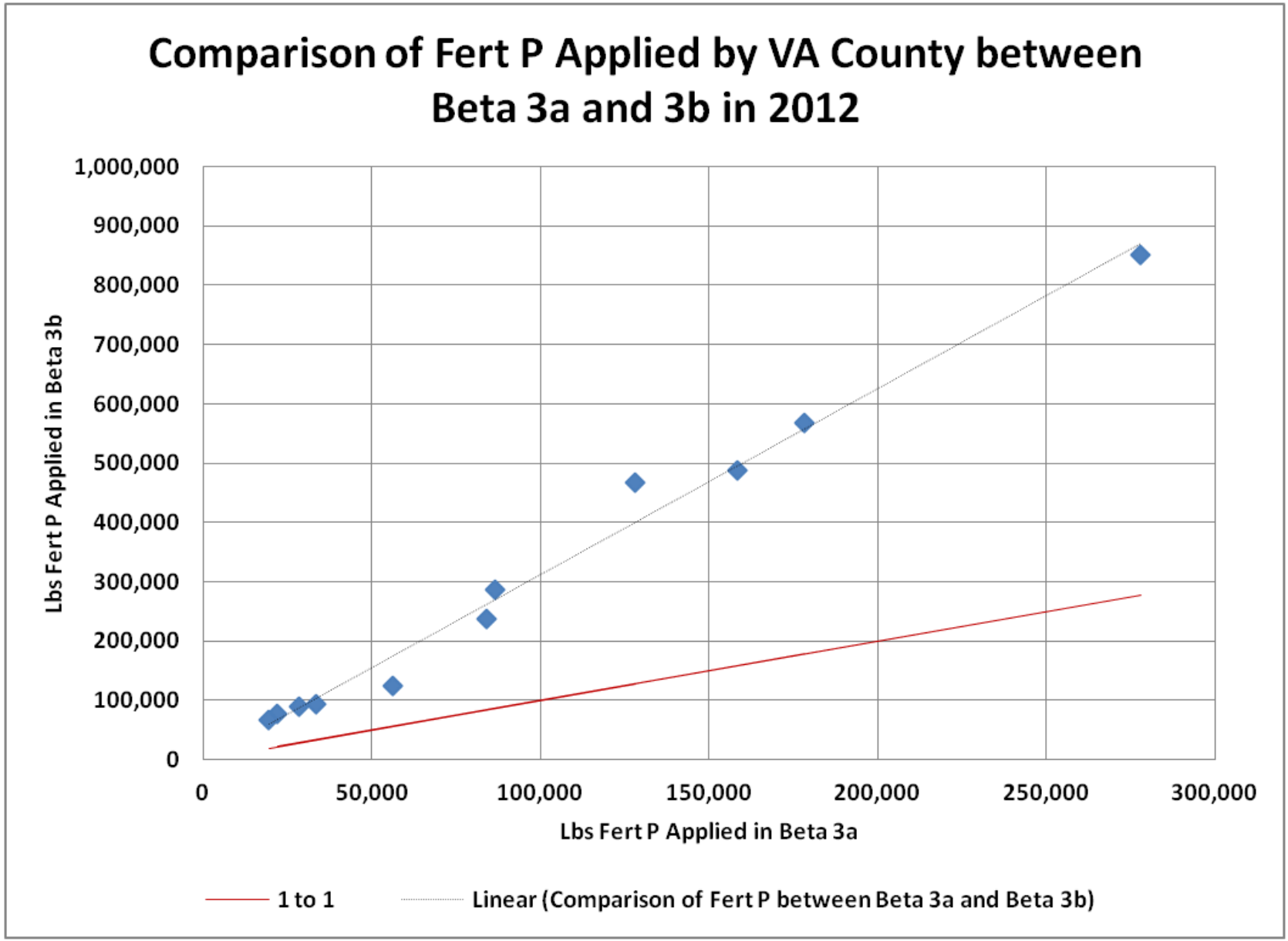

Comparison of Fert P Applied by MD County between Beta 3a and 3b in 2012
Lbs Fert P Applied in Beta 3b
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
0
200,000
400,000
600,000
800,000
1,000,000
1,200,000
1,400,000
1,600,000
Lbs Fert P Applied in Beta 3a
1 to 1
Linear (Comparison of Fert P between Beta 3a and Beta 3b)


Comparison of Fert P Applied by NY County between Beta 3a and 3b in 2012
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Lbs Fert P Applied in Beta 3b
0
200,000
400,000
600,000
800,000
1,000,000
1,200,000
Lbs Fert P Applied in Beta 3a
1 to 1
Linear (Comparison of Fert P between Beta 3a and Beta 3b)

Comparison of Fert P Applied by PA County between Beta 3a and 3b in 2012



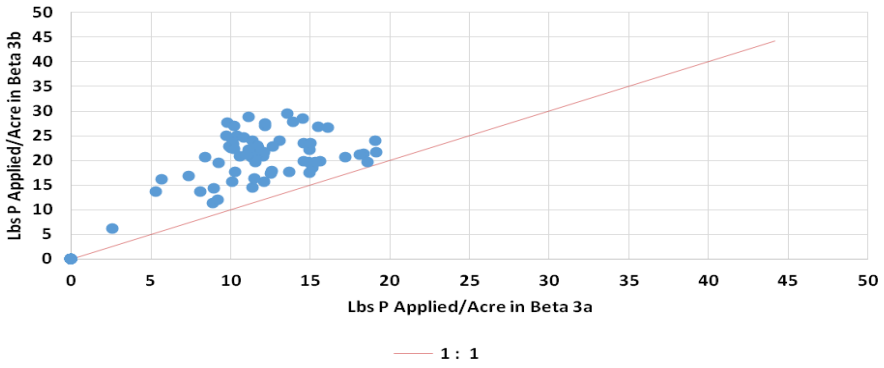

Comparison of Fert P Applied by VA County between Beta 3a and 3b in 2012
Lbs Fert P Applied in Beta 3b
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
0
100,000
200,000
300,000
400,000
500,000
600,000
700,000
Lbs Fert P Applied in Beta 3a
1 to 1
Linear (Comparison of Fert P between Beta 3a and Beta 3b)


Comparison of Fert P Applied by VA County between Beta 3a and 3b in 2012
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Lbs Fert P Applied in Beta 3b
0
50,000
100,000
150,000
200,000
250,000
300,000
Lbs Fert P Applied in Beta 3a
1 to 1
Linear (Comparison of Fert P between Beta 3a and Beta 3b)

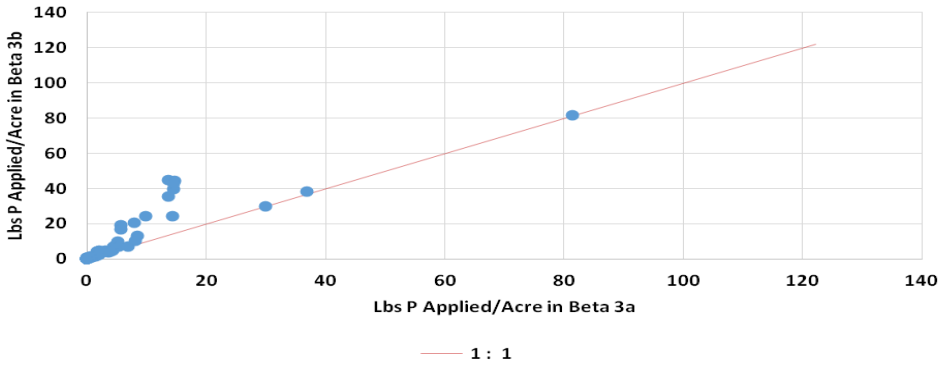
Why is there more P in Beta 3b?

- Beta 3b assumes that every acre of crop, hay and pasture will receive at least the crop application goal.
- Beta 3a assumes there is only a finite amount of phosphorus fertilizer within the watershed.
- Every acre of agricultural land in both beta versions are assumed to have non-nutrient management application goals for P per recommendation from NM Panel.
- If each acre under core nutrient management had an application goal equal to state-supplied goals, then P applications between two scenarios may be closer.
- Trend in P applications seen in fertilizer sales likely will NOT be easily duplicated using any other method because of increasing crop yields and commodity crop production.

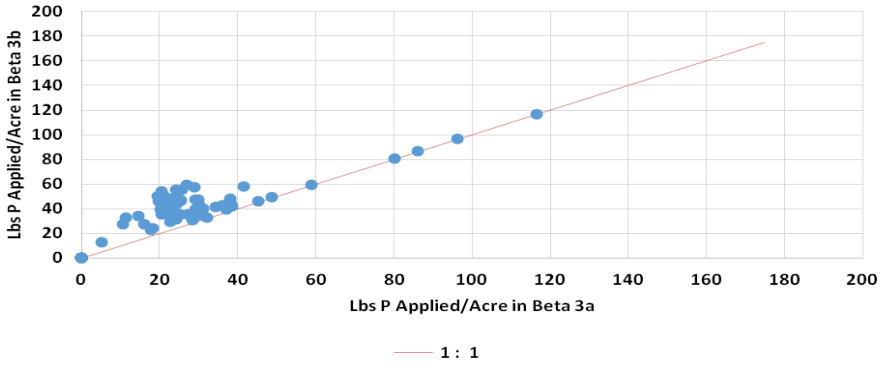
3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Grains without Manure 2012



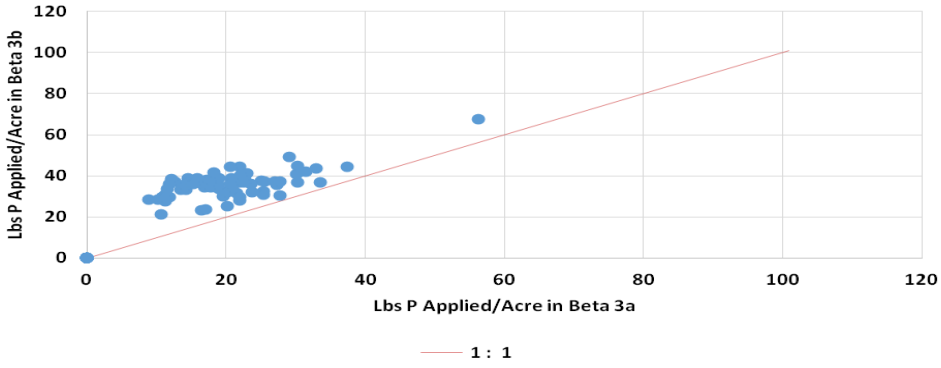
3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Other Agronomic Crops 2012



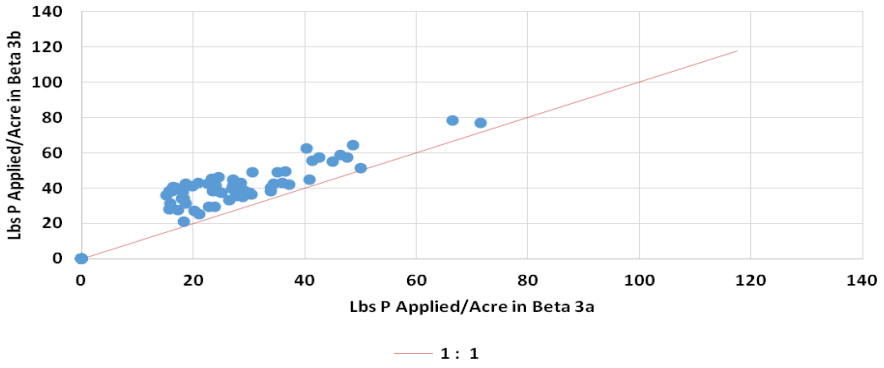
3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Grains with Manure 2012



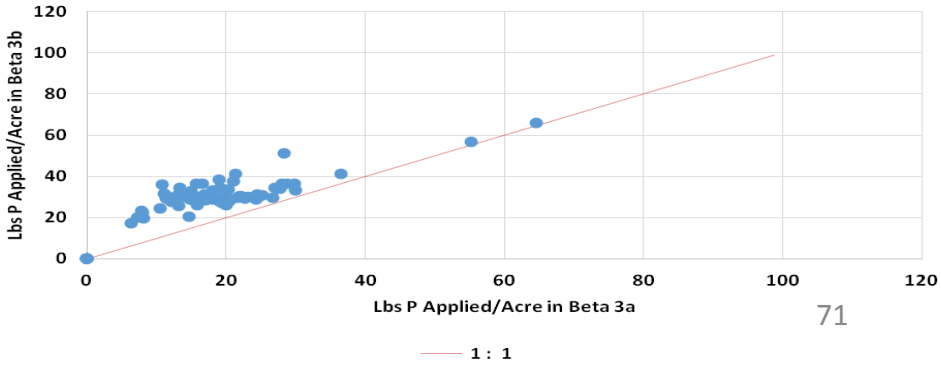
3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Specialty Crop High 2012

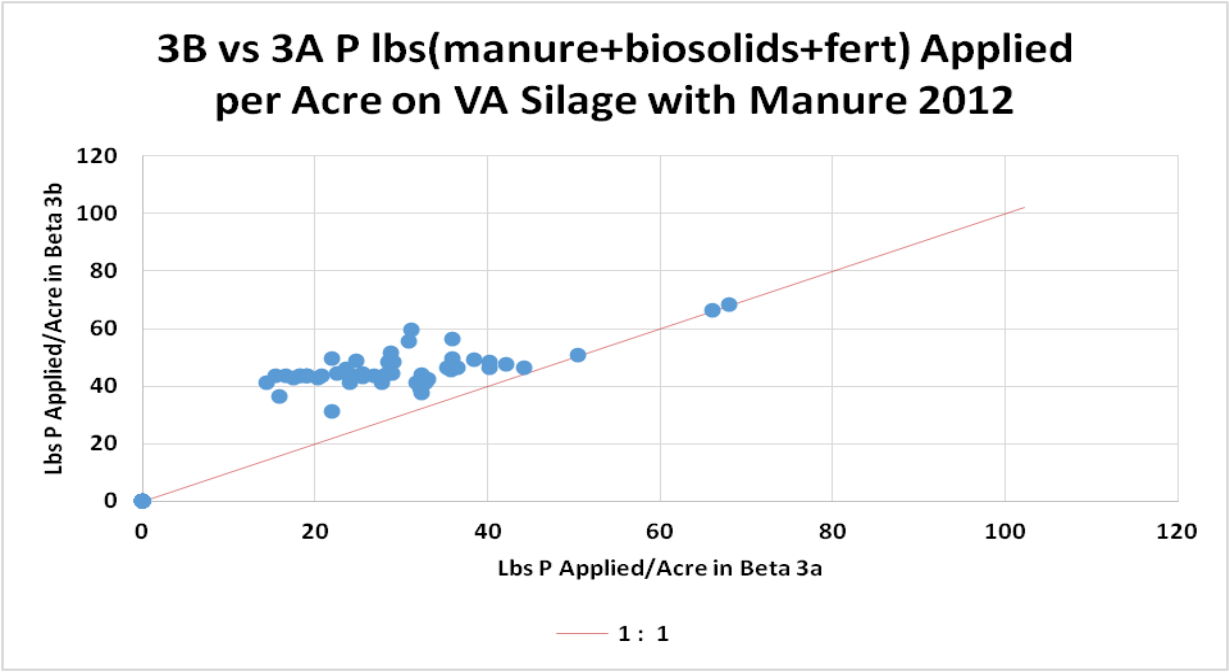


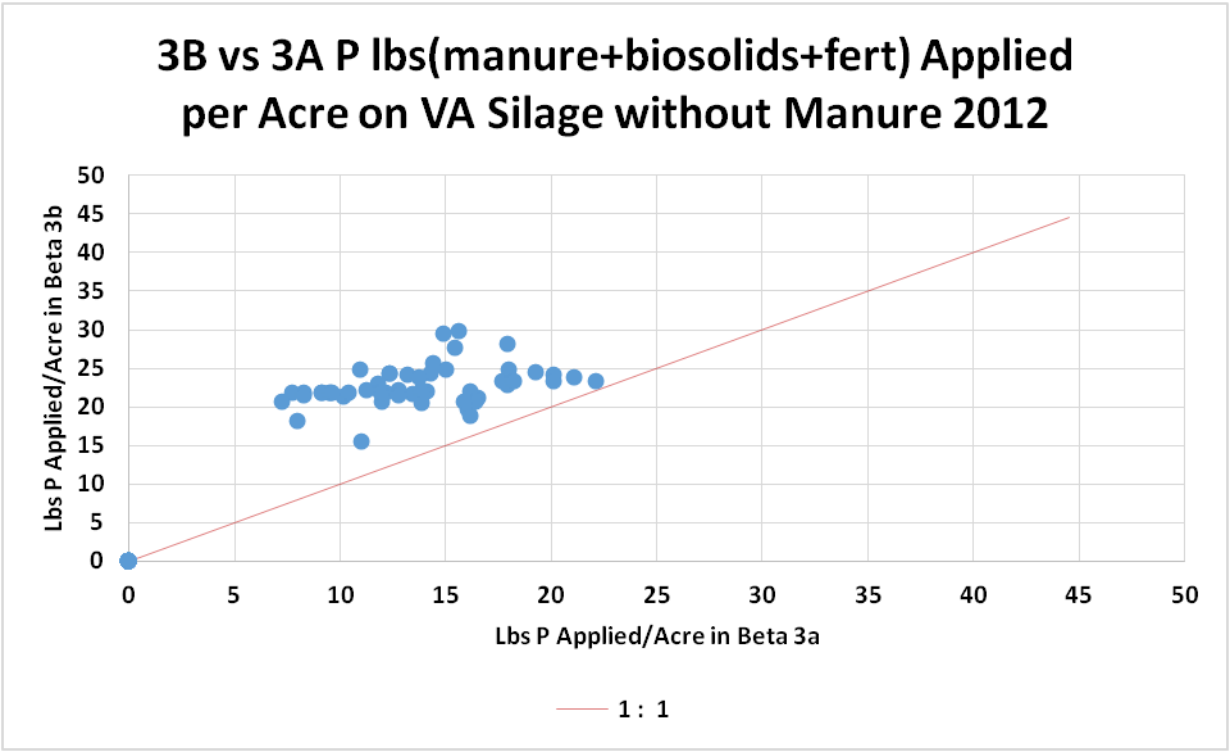
3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Small Grains and Grains 2012

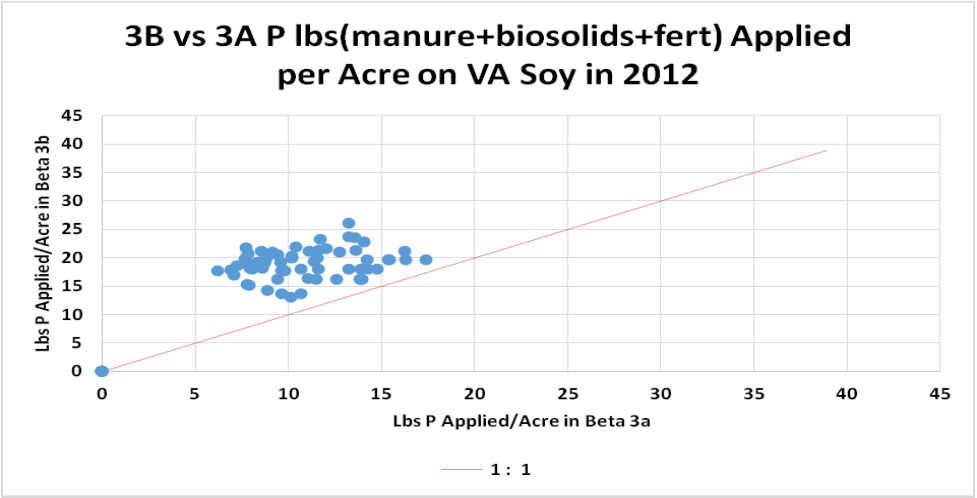


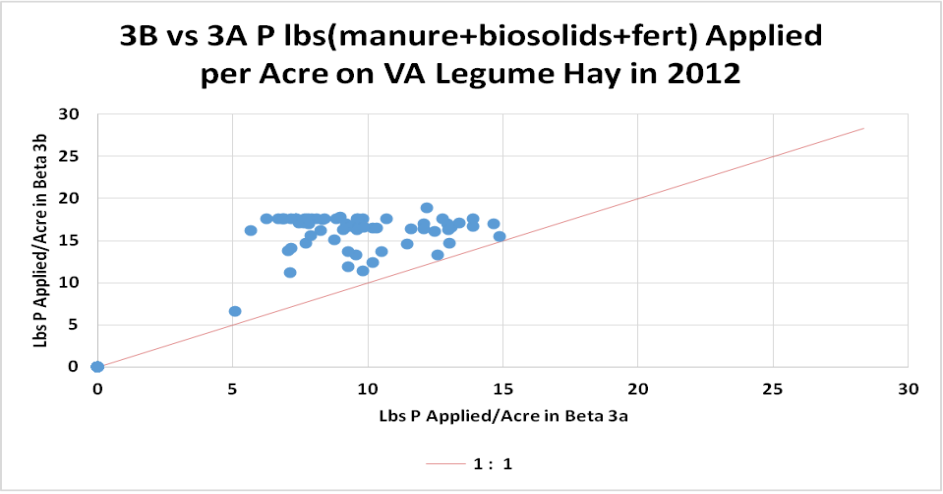
3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Specialty Crop Low 2012

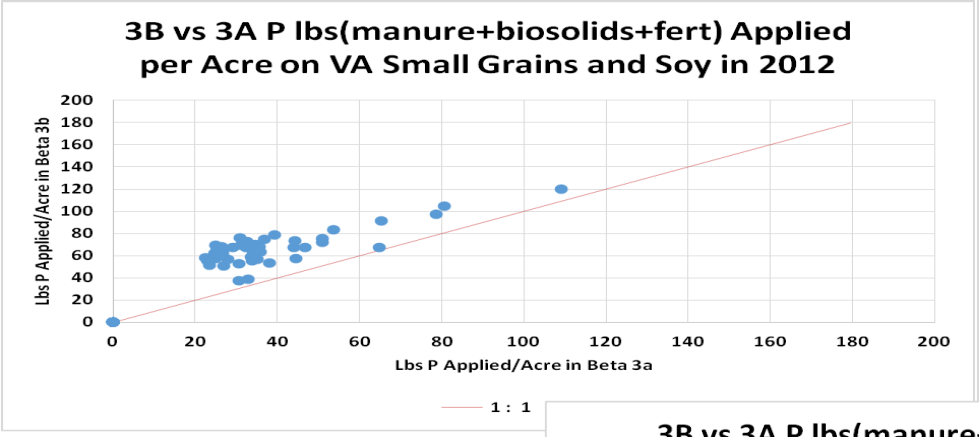


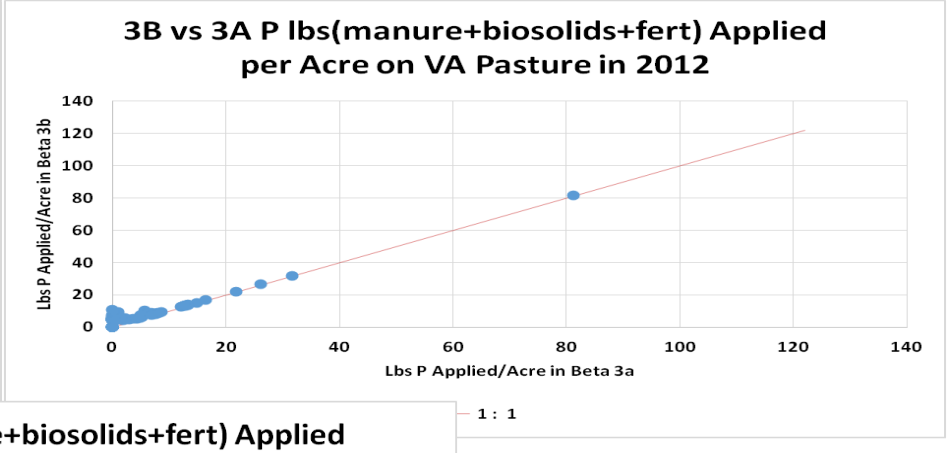

3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Silage with Manure 2012
Lbs P Applied/Acre in Beta 3b
0
20
40
60
80
100
120
Lbs P Applied/Acre in Beta 3a
1 : 1

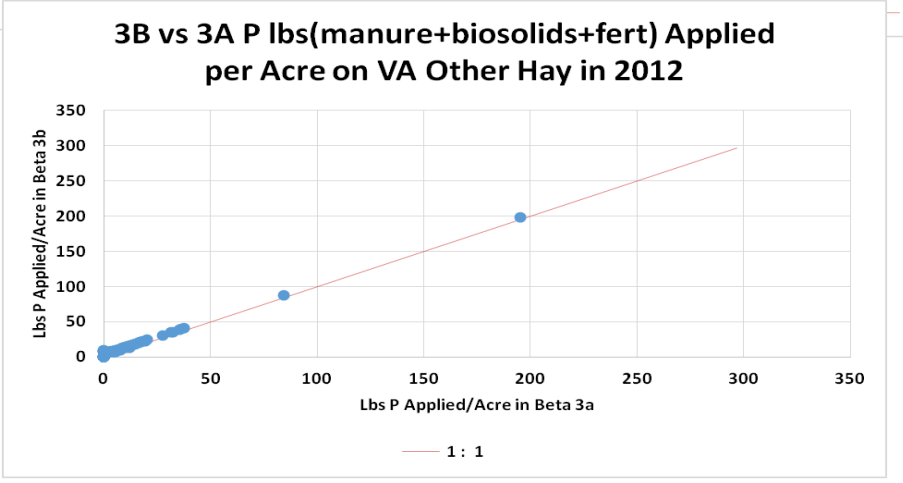

3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Silage without Manure 2012
Lbs P Applied/Acre in Beta 3b
0
5
10
15
20
25
30
35
40
45
50
Lbs P Applied/Acre in Beta 3a
1 : 1


3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Soy in 2012
Lbs P Applied/Acre in Beta 3b
Lbs P Applied/Acre in Beta 3a
1 : 1


3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Legume Hay in 2012
Lbs P Applied/Acre in Beta 3b
Lbs P Applied/Acre in Beta 3a
1 : 1

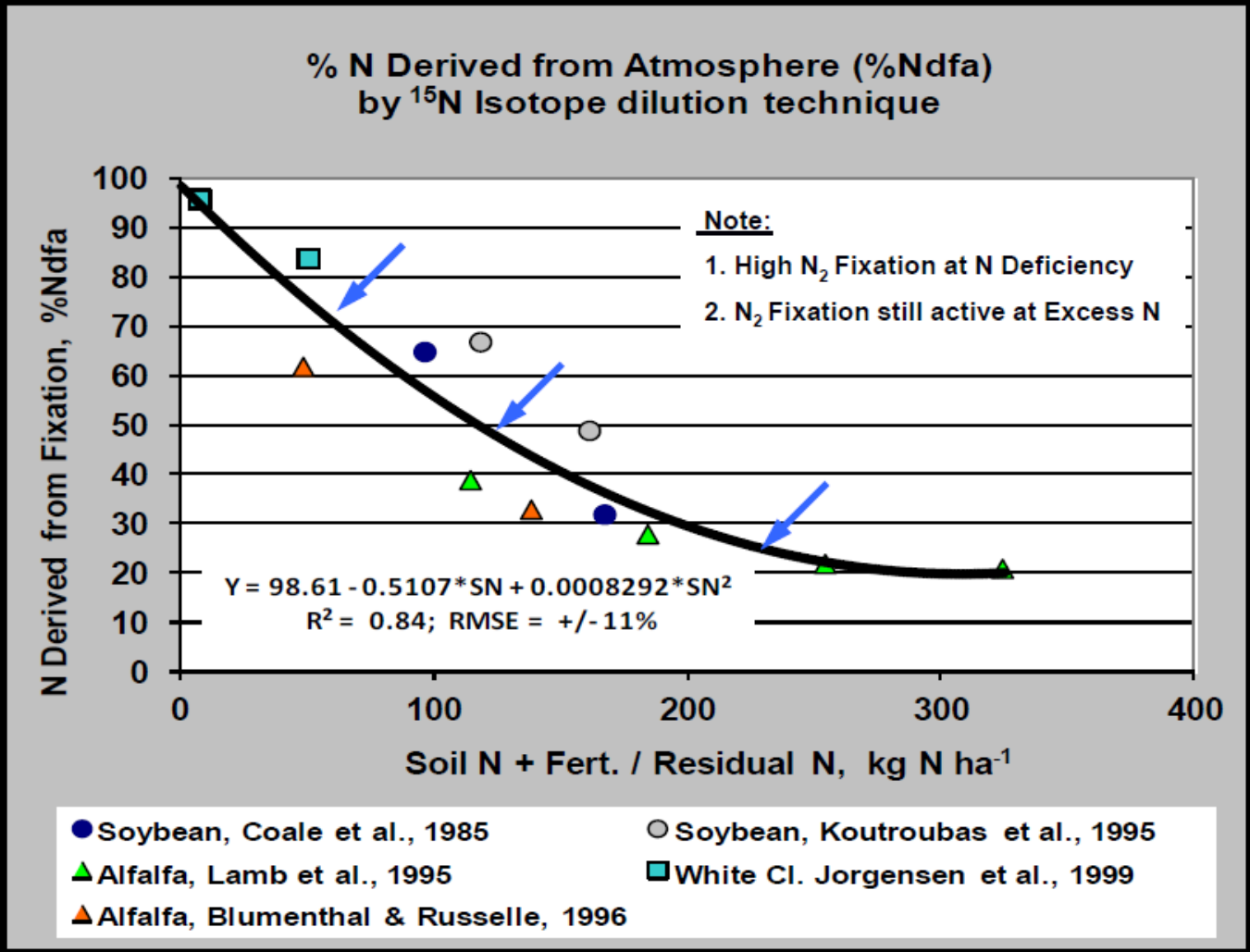

3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Small Grains and Soy in 2012
Lbs P Applied/Acre in Beta 3b
Lbs P Applied/Acre in Beta 3a
1 : 1


3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Pasture in 2012
Lbs P Applied/Acre in Beta 3b
Lbs P Applied/Acre in Beta 3a
1 : 1


3B vs 3A P lbs(manure+biosolids+fert) Applied per Acre on VA Other Hay in 2012
Lbs P Applied/Acre in Beta 3b
Lbs P Applied/Acre in Beta 3a
1 : 1

Legume Fixation

Estimating N_2 Fixation: Percent of Crop N Yield from N_2 Fixation and Influence of Soil N



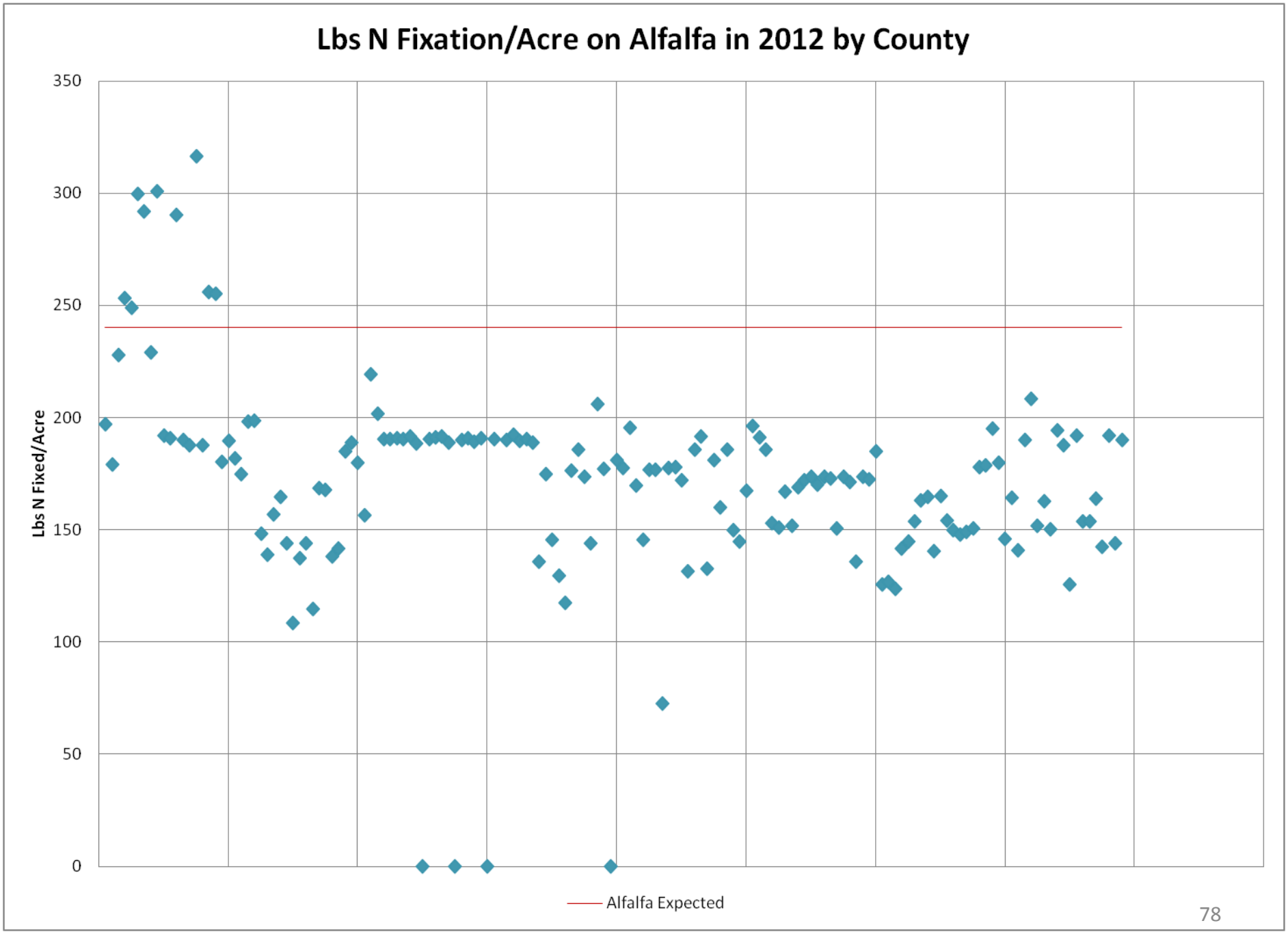
Slide adopted from Meisinger, 2016; source – Meisinger, Randall, 1991

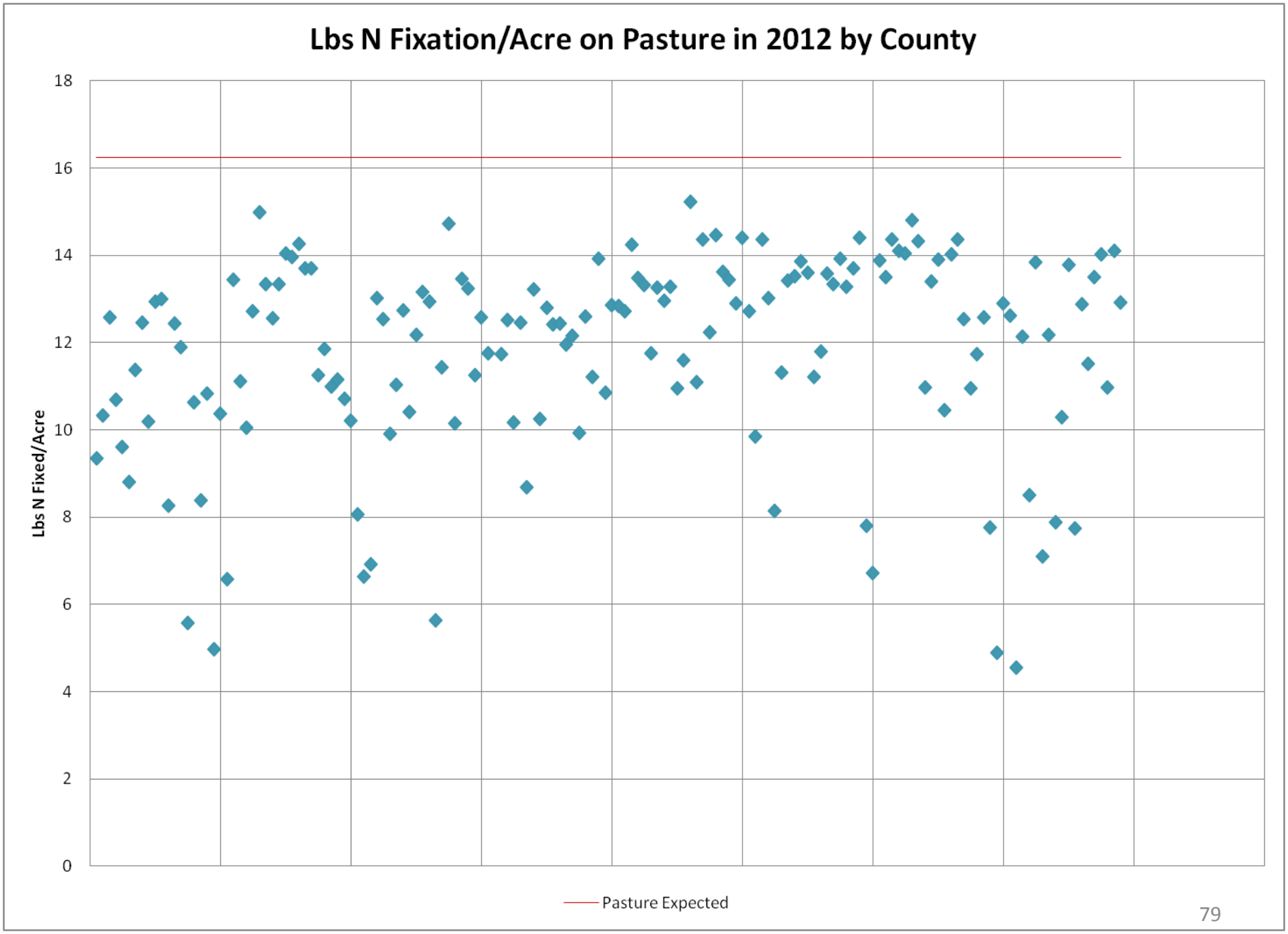
What do we need to calculate Legume Fixation?

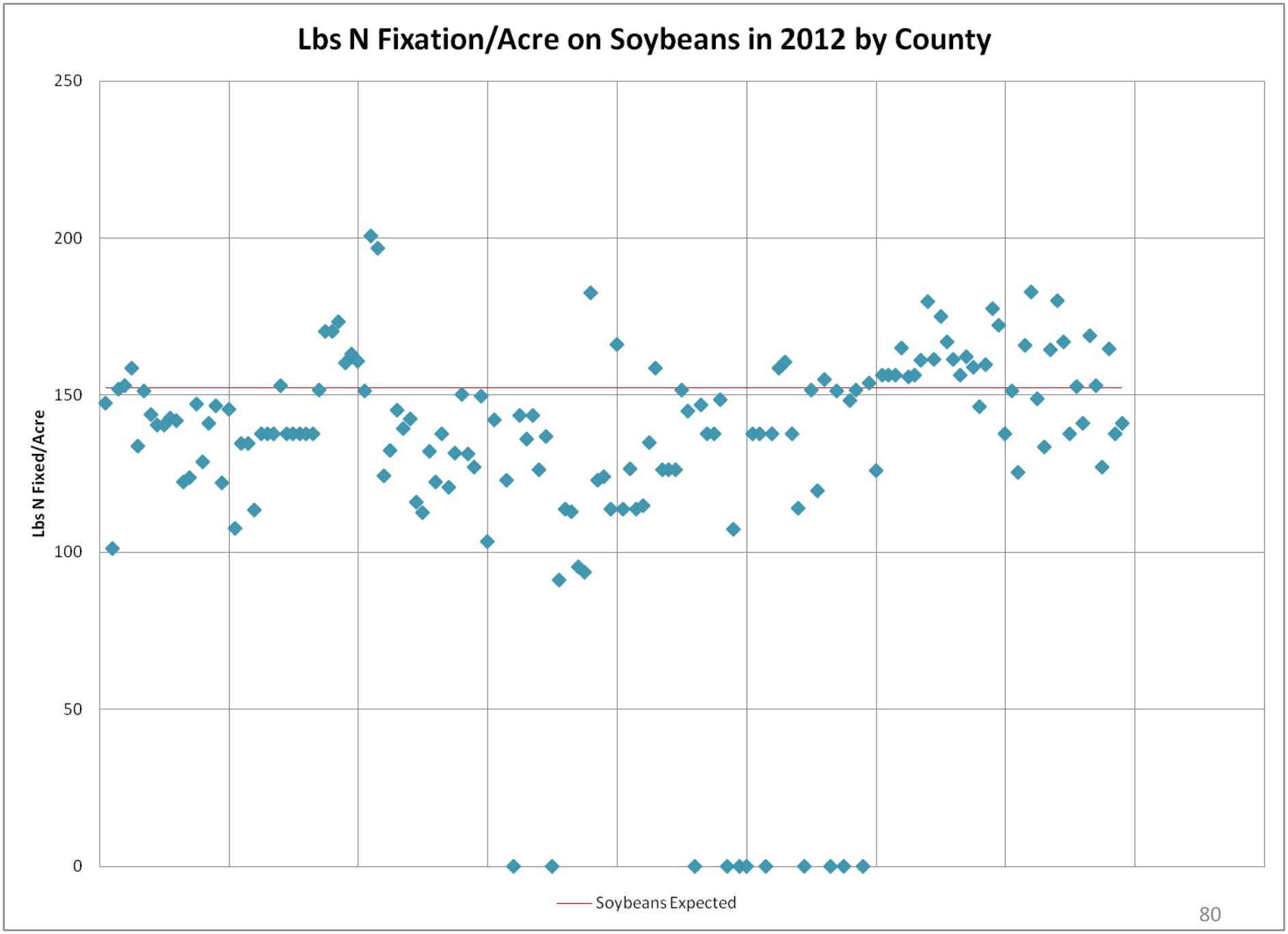
- Crop Removal
- Estimated contribution of PAN from soil
  - Assumed to be 45 lbs PAN/acre based upon an assumption of 1.5% organic matter and Meisinger, Randall, 1991 equation
- Estimated applications of PAN from manure and inorganic fertilizer
- % N Fixation based upon Meisinger, Randall 1991 regression

Legume Fixation with 0 applications of PAN from manure and fertilizer

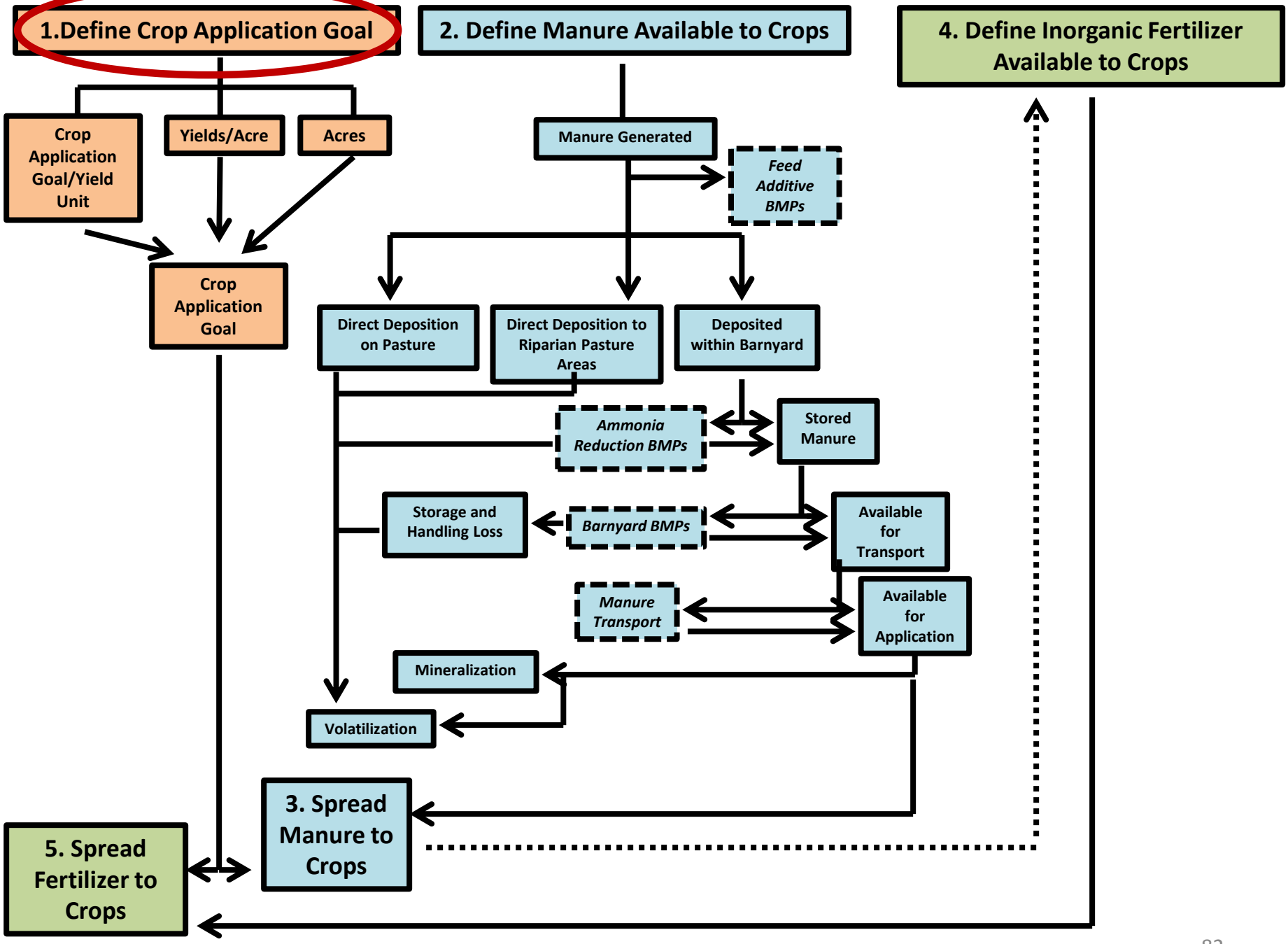
Crop Name	Avg Lbs N Fixed/Acre
Alfalfa Hay Harvested Area	240
Alfalfa seed Harvested Area	158
Birdsfoot trefoil seed Harvested Area	88
Cropland used only for pasture or grazing Area	16
Dry edible beans, excluding limas Harvested Area	69
Green Lima Beans Harvested Area	106
Haylage or greenchop from alfalfa or alfalfa mixtures Harvested Area	81
Other haylage, grass silage, and greenchop Harvested Area	16
Pastureland and rangeland other than cropland and woodland pastured Area	16
Peanuts for nuts Harvested Area	141
Peas, Chinese (sugar and Snow) Harvested Area	106
Peas, Green (excluding southern) Harvested Area	106
Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	106
Red clover seed Harvested Area	110
Snap Beans Harvested Area	106
Soybeans for beans Harvested Area	152
Vetch seed Harvested Area	195


Lbs N Fixation/Acre on Alfalfa in 2012 by County
Lbs N Fixed/Acre
350
300
250
200
150
100
50
0
Alfalfa Expected


Lbs N Fixation/Acre on Pasture in 2012 by County
Lbs N Fixed/Acre
18
16
14
12
10
8
6
4
2
0
Pasture Expected


Lbs N Fixation/Acre on Soybeans in 2012 by County
250
200
150
100
50
0
Lbs N Fixed/Acre
Soybeans Expected

What about EVERYTHING else???


1.Define Crop Application Goal
2. Define Manure Available to Crops
4. Define Inorganic Fertilizer Available to Crops
Crop Application Goal/Yield Unit
Yields/Acre
Acres
Crop Application Goal
Manure Generated
Feed Additive BMPs
Direct Deposition on Pasture
Direct Deposition to Riparian Pasture Areas
Deposited within Barnyard
Ammonia Reduction BMPs
Stored Manure
Storage and Handling Loss
Barnyard BMPs
Available for Transport
Manure Transport
Available for Application
Mineralization
Volatilization
3. Spread Manure to Crops
5. Spread Fertilizer to Crops

Crop Application Goal

- States provided the following for each crop:
  - Total N and P application goals per acre or yield unit
    - Example: 0.92 lb of N/bushel of corn for grain yield
  - Fraction of total application goal which should be met by applications in each month
    - Example: 0.4 of yearly total N on corn for grain should be applied in April
  - Indication of which applications are eligible to be met by only inorganic fertilizer, or by any kind of nutrient in each month
    - Example: April applications are eligible to be met by inorganic and organic fertilizer. June applications are eligible to be met by only inorganic fertilizer.

Crop Application Goal on Major Crops

Crop	DoubleCrop	Nutrient	Yield Unit	DE_1	MD_1	NY_1	PA_1	VA_1	WV_1
Alfalfa Hay Harvested Area	N	TN	dry tons	1	1	1	1	1	1
Alfalfa Hay Harvested Area	N	TP	dry tons	5	5	5	6	5	5
Corn for Grain Harvested Area	N	TN	bushels	0.92	0.92	0.92	0.92	0.92	0.92
Corn for Grain Harvested Area	N	TP	bushels	0.12	0.12	0.12	0.12	0.12	0.12
Corn for Grain Harvested Area	Y	TN	bushels	0.92	0.92	0.92	0.92	0.92	0.92
Corn for Grain Harvested Area	Y	TP	bushels	0.12	0.12	0.12	0.12	0.12	0.12
Wheat for Grain Harvested Area	N	TP	bushels	0.31	0.31	0.31	0.31	0.31	0.31
Wheat for Grain Harvested Area	N	TN	bushels	1.25	1.25	1	1	1.25	1.25
Wheat for Grain Harvested Area	Y	TP	bushels	0.465	0.465	0.465	0.465	0.465	0.465
Wheat for Grain Harvested Area	Y	TN	bushels	1.25	1.25	1	1	1.25	1.25
Pastureland and rangeland other than cropland and woodland pastured Area	N	TN	acres	15	15	15	15	15	15
Pastureland and rangeland other than cropland and woodland pastured Area	N	TP	acres	4	4	4	4	4	4
Soybeans for beans Harvested Area	N	TN	bushels	0.12	0.12	0.12	0.12	0.12	0.12
Soybeans for beans Harvested Area	N	TP	bushels	0.33	0.33	0.33	0.33	0.33	0.33
Soybeans for beans Harvested Area	Y	TN	bushels	0	0	0	0	0	0
Soybeans for beans Harvested Area	Y	TP	bushels	0	0	0	0	0	0

- Data provided by states after consultation with nutrient management program staff.

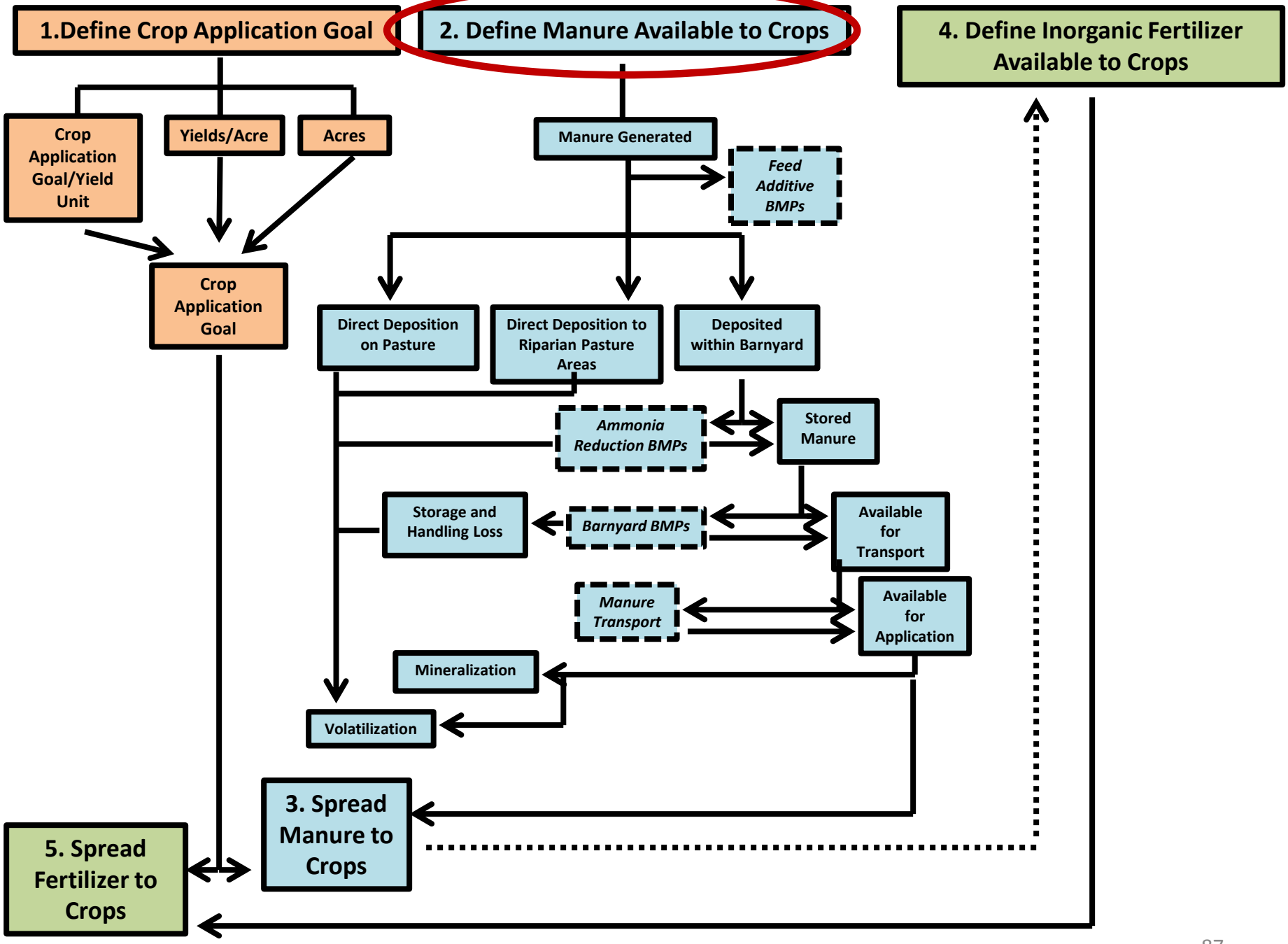
Non-Nutrient Management Application Goal Multipliers

Land Use	Non NM N Multiplier	Non NM P Multiplier
Full Season Soybeans	1.2	1.5
Grain with Manure	1.3	3
Grain without Manure	1.2	1.5
Legume Hay	1.2	1
Silage with Manure	1.4	3
Silage without Manure	1.2	1.5
Small Grains and Grains	1.2	1.5
Small Grains and Soybeans	1.2	1.5
Specialty Crop High	1.3	2
Specialty Crop Low	1.2	2
Other Agronomic Crops	1.1	1.5
Other Hay	1	1
Pasture	1	1

- Data provided by Nutrient Management Panel.
- Acres of core NM do NOT currently qualify for reduced P applications.

Incorporating Yields into Crop Application Goals

- Crop Application Goal Equation:
  - *Lbs of N/Year = State-Supplied Lbs of N/Application Goal Yield Unit/Year X Yield/Year X 1.1*
- Application goals are yield-based for the following major crops:
  - Alfalfa Hay; Barley; Buckwheat; Corn for Grain; Corn for Silage; Oats for Grain; Rye for Grain; Sorghum for Grain; Sorghum for Silage; Soybeans for Beans; and Wheat for Grain
- Application goals are per acre for all other crops, and do not vary across the years.
- Yearly yields provided by NASS for major crops.
- AMS elected to multiply yearly yield by 1.1 assuming farmers are optimistic, and average yields are often under-estimated.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Yields/Acre
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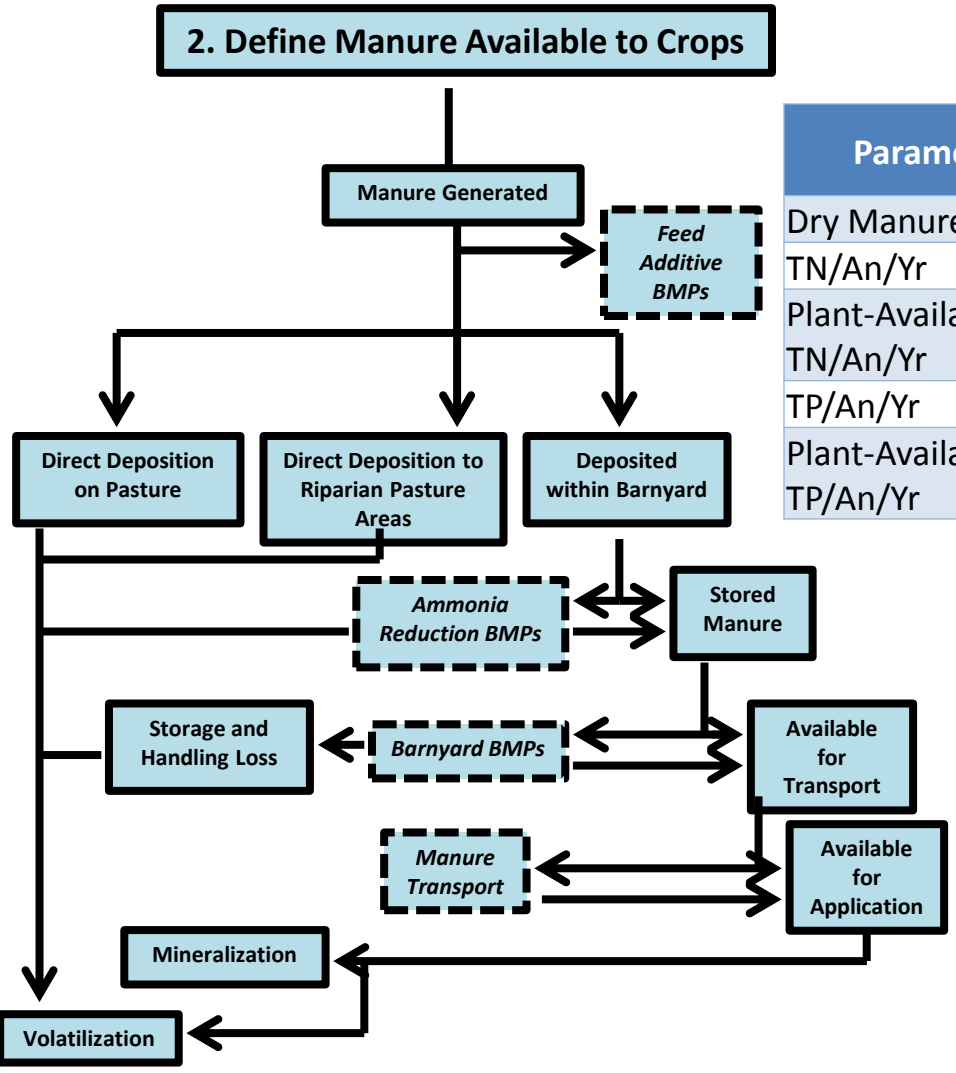
Crop Application Goal
Direct Deposition on Pasture
Direct Deposition to Riparian Pasture Areas
Deposited within Barnyard
Ammonia Reduction BMPs
Stored Manure
Storage and Handling Loss
Barnyard BMPs
Available for Transport
Manure Transport
Available for Application
Mineralization
Volatilization
3. Spread Manure to Crops
5. Spread Fertilizer to Crops

Example Manure Calculation for Dairy



Parameter	Lbs Generated	Lbs Applied to Crops	% Reduction in Example
Dry Manure/An/Yr	4,404.33	738.14	-83%
TN/An/Yr	185.96	20.88	-89%
Plant-Available TN/An/Yr	113.89	11.70	-90%
TP/An/Yr	29.79	3.74	-87%
Plant-Available TP/An/Yr	29.79	3.74	-87%

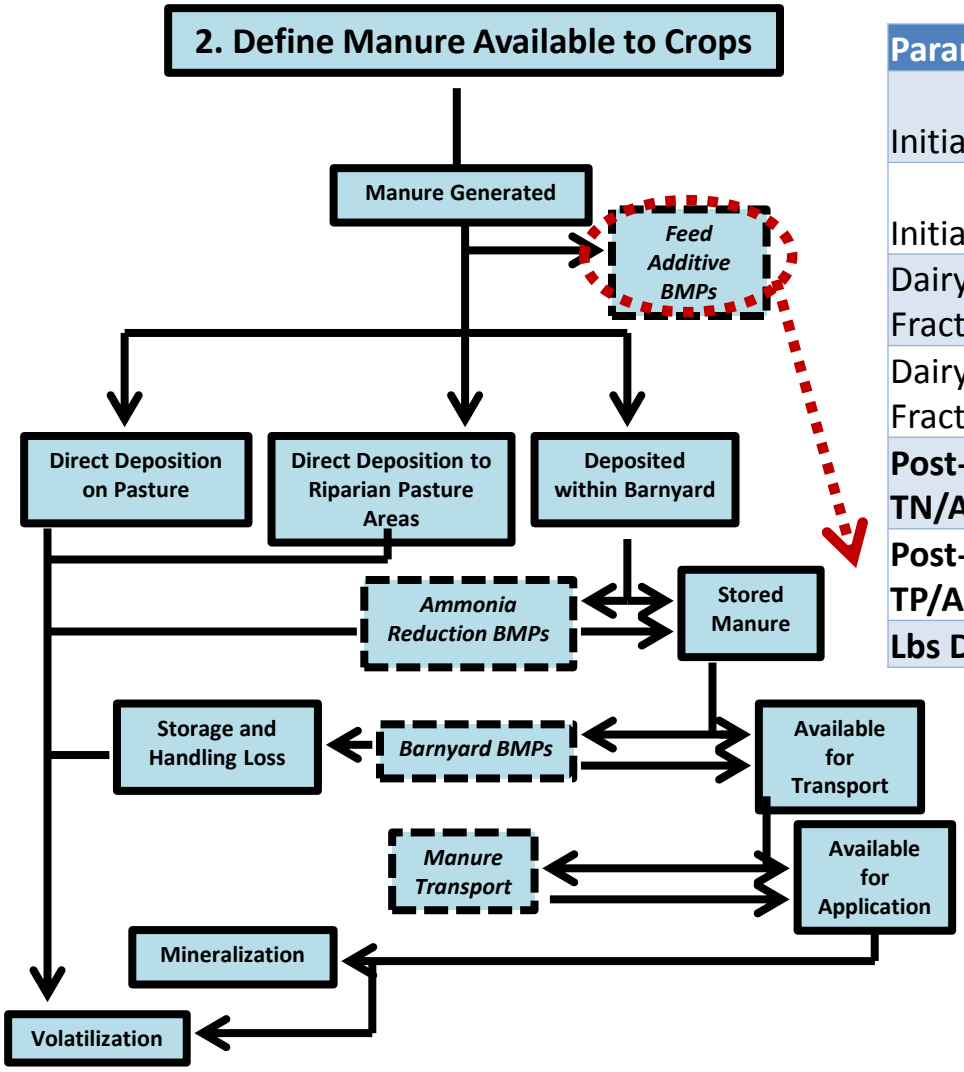
- Example includes 0.5 T of dry manure transport for this dairy animal.
- Values for ALL processes on the left impact this result.
  - BMP efficiencies
  - Confinement fractions
  - Volatilization assumptions
  - Storage and Handling Loss assumptions
  - Mineralization Assumptions

Example Manure Calculation for Dairy

Parameter	Lbs	Source
Dry Manure/An/Yr	**4,404.33**	ASAE 2005
TN/Lb Dry Manure	0.04	ASAE 2005
TP/Lb Dry Manure	0.01	ASAE 2005
TN/An/Yr	**185.96**	Calculated from ASAE 2005
TP/An/Yr	**29.79**	Calculated from ASAE 2005

- Manure generation data comes from ASAE, 2005 or from PLS.
- Values are calculated on dry weight basis.

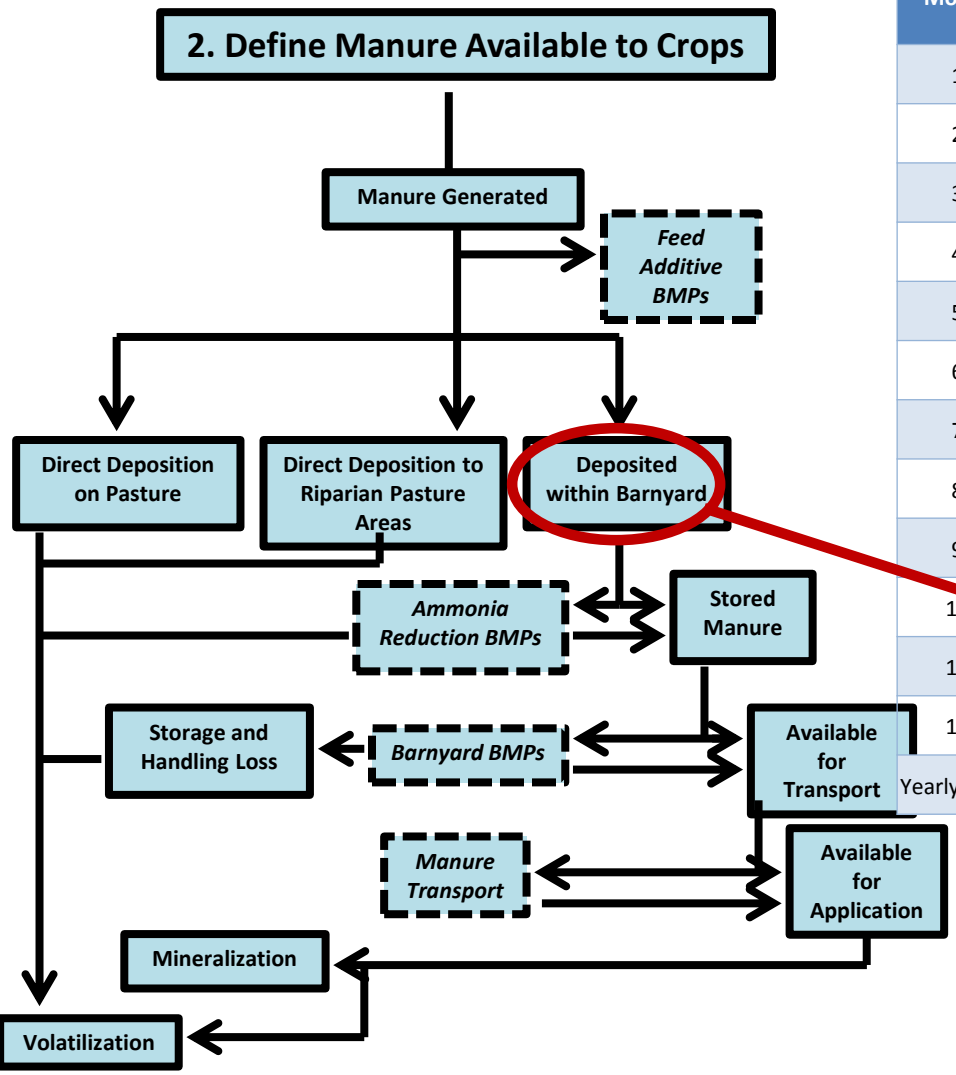
Example Manure Calculation for Dairy



Parameter	Units	Source
Initial Lbs TN/An/Yr	185.96	Calculated from ASAE 2005
Initial Lbs TP/An/Yr	29.79	Calculated from ASAE 2005
Dairy Precision Feed Fraction N Reduction	0.24	CBP BMP
Dairy Precision Feed Fraction P Reduction	0.25	CBP BMP
Post-Feed Additive Lbs TN/An/Yr	**141.33**	CBP Calculation
Post-Feed Additive Lbs TP/An/Yr	**22.34**	CBP Calculation
Lbs Dry Manure/An/Yr	**4,404.33**	ASAE 2005

- Feed Additive BMPs are submitted by states, and can reduce nutrient concentrations within manure.

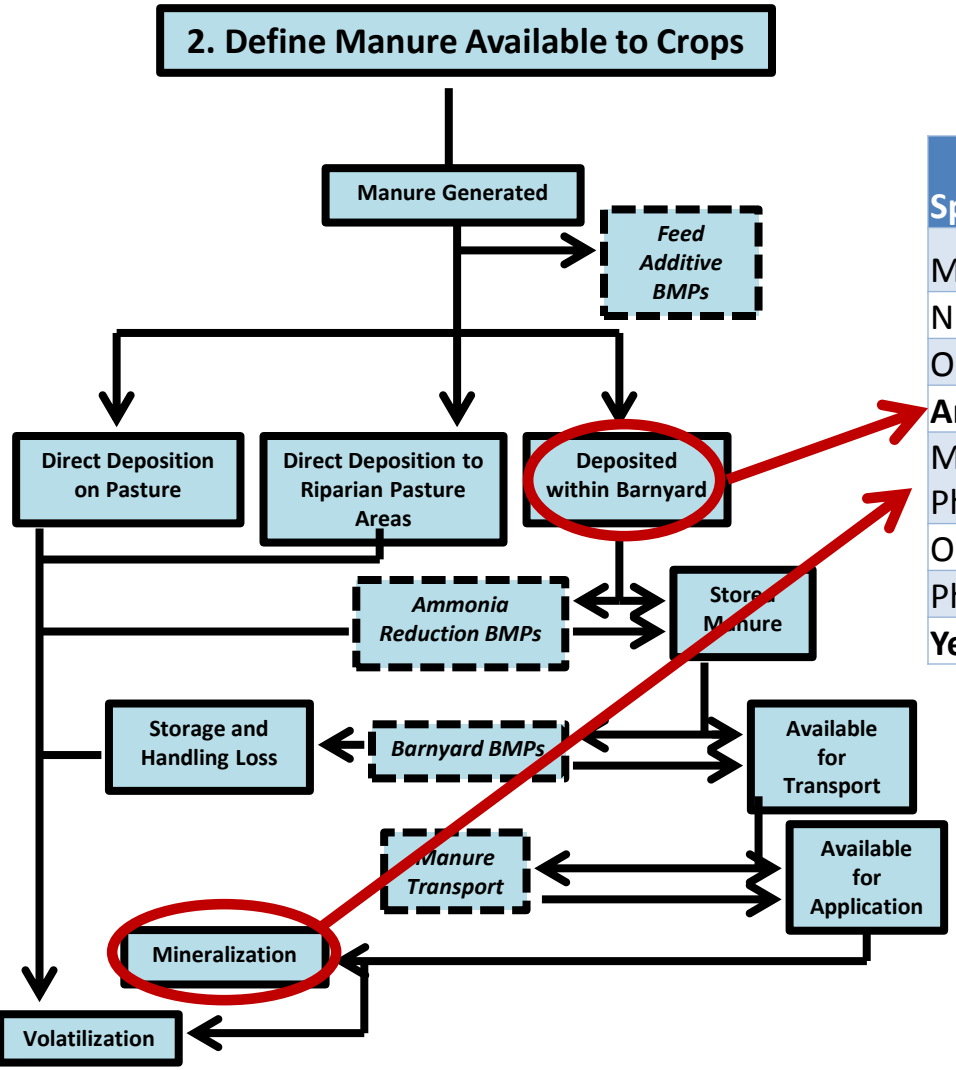
Example Manure Calculation for Dairy



Month	Total Lbs N/An	Total Lbs P/An	Total Lbs Dry Manure/An	Fraction Confinement	Confined Lbs N/An	Confined Lbs P/An	Confined Dry Lbs Manure/An
1	11.78	1.86	367.03	0.76	8.95	1.42	278.94
2	11.78	1.86	367.03	0.76	8.95	1.42	278.94
3	11.78	1.86	367.03	0.62	7.30	1.15	227.56
4	11.78	1.86	367.03	0.55	6.48	1.02	201.87
5	11.78	1.86	367.03	0.53	6.24	0.99	194.52
6	11.78	1.86	367.03	0.51	6.01	0.95	187.18
7	11.78	1.86	367.03	0.50	5.89	0.93	183.51
8	11.78	1.86	367.03	0.50	5.89	0.93	183.51
9	11.78	1.86	367.03	0.50	5.89	0.93	183.51
10	11.78	1.86	367.03	0.50	5.89	0.93	183.51
11	11.78	1.86	367.03	0.55	6.48	1.02	201.87
12	11.78	1.86	367.03	0.71	8.36	1.32	260.59
Yearly Total	141.33	22.34	4,404.33	NA	**82.32**	**13.01**	**2,565.52**

- Yearly manure is broken out into monthly manure, and separated between pasture (direct deposit or access area deposit) and barnyard (or confined).
- States provided fractions for time spent in each of the three areas.

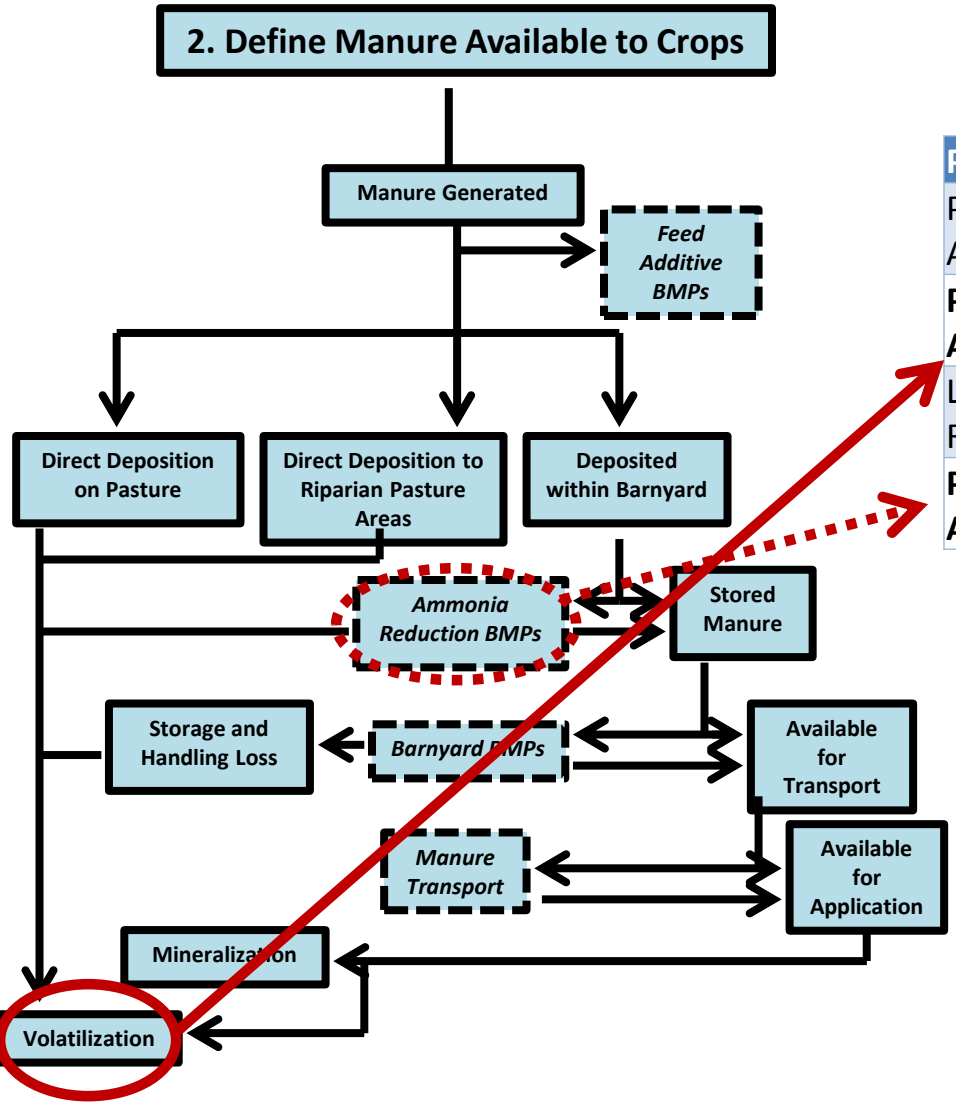
Example Manure Calculation for Dairy



Species	Lbs N Species/An /Yr	Lbs P Species/An /Yr
Mineralized Nitrogen	35.98	NA
Nitrate Nitrogen	0.00	NA
Organic Nitrogen	31.90	NA
Ammonia Nitrogen	**14.44**	NA
Mineralized Phosphorus	NA	0.42
Organic Phosphorus	NA	0.00
Phosphate	NA	12.60
Yearly Total Elemental	**82.32**	**13.01**

- At this point, the TN and TP can be broken into species to account for volatilization and future mineralization.

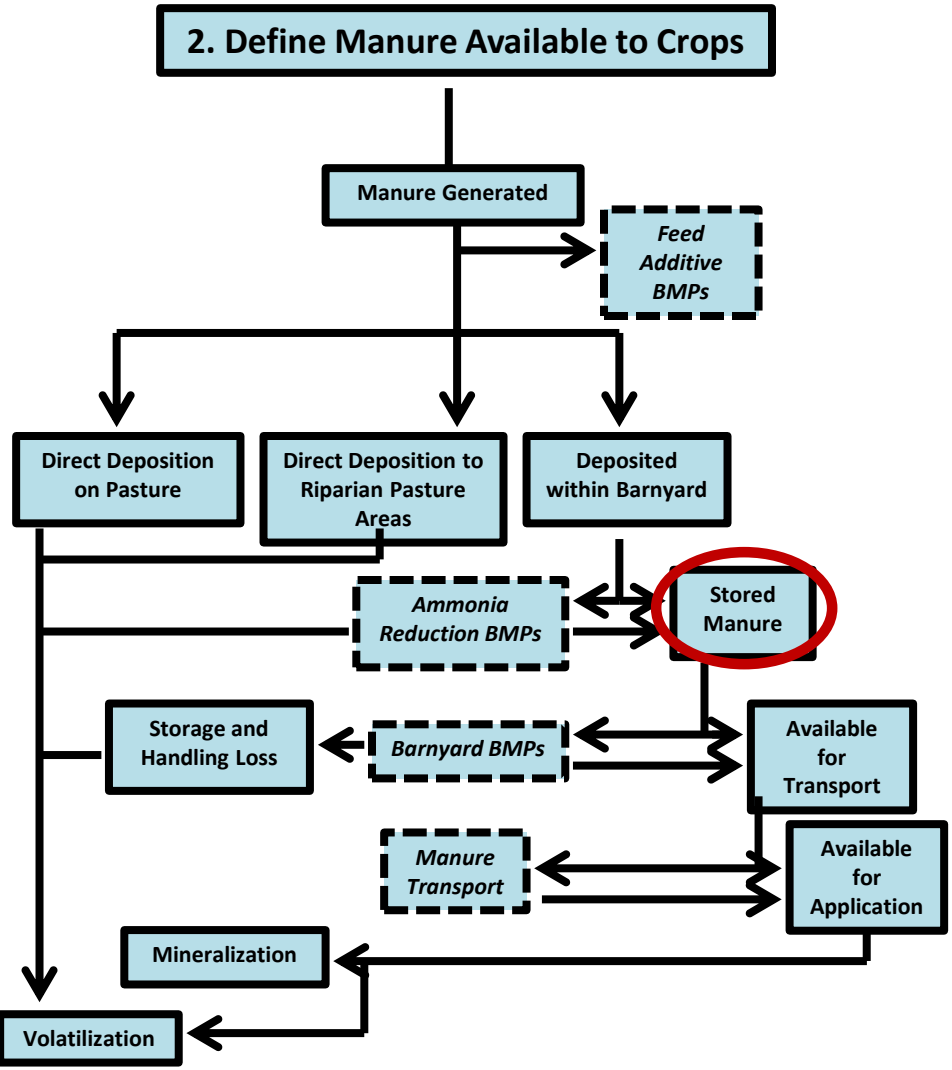
Example Manure Calculation for Dairy



Parameter	Units
Pre-Volatilization Lbs Ammonia N	14.44
Post-Volatilization Lbs Ammonia N	**5.06**
Lagoon Cover Volatilization Reduction Fraction	0.15
Post-Lagoon Cover Lbs Ammonia N	**7.22**

- A fraction of ammonia N is volatilized from the barnyard manure.
- Ammonia reduction BMPs are submitted by states, and can conserve ammonia N in the barnyard manure.

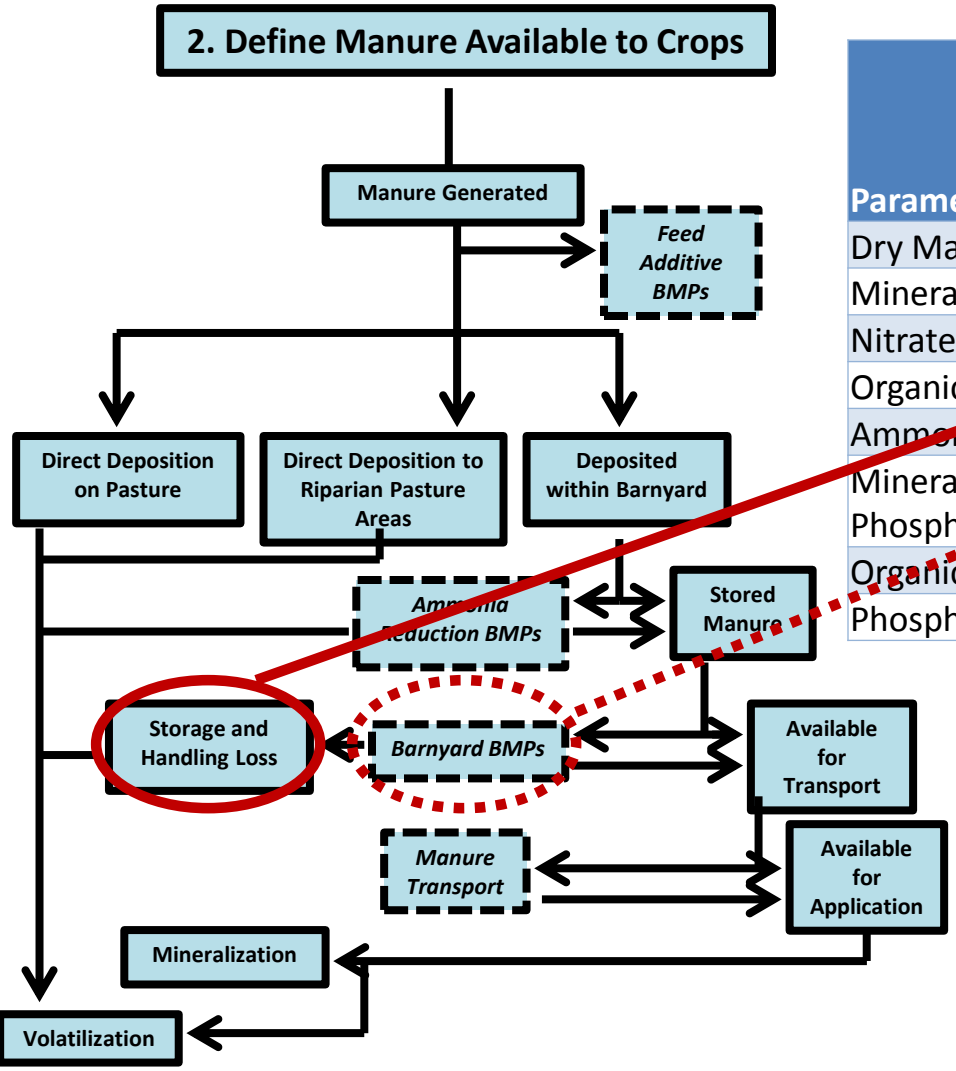
Example Manure Calculation for Dairy



Parameter	Lbs/An/Yr
Dry Manure	2,565.52
Mineralized Nitrogen	35.98
Nitrate Nitrogen	0.00
Organic Nitrogen	31.90
Ammonia Nitrogen	7.22
Mineralized Phosphorus	0.42
Organic Phosphorus	0.00
Phosphate	12.60

- After volatilization and ammonia reduction BMPs, SB prepares to assess how much manure and nutrients within the barnyard are lost or transported prior to application to crops.

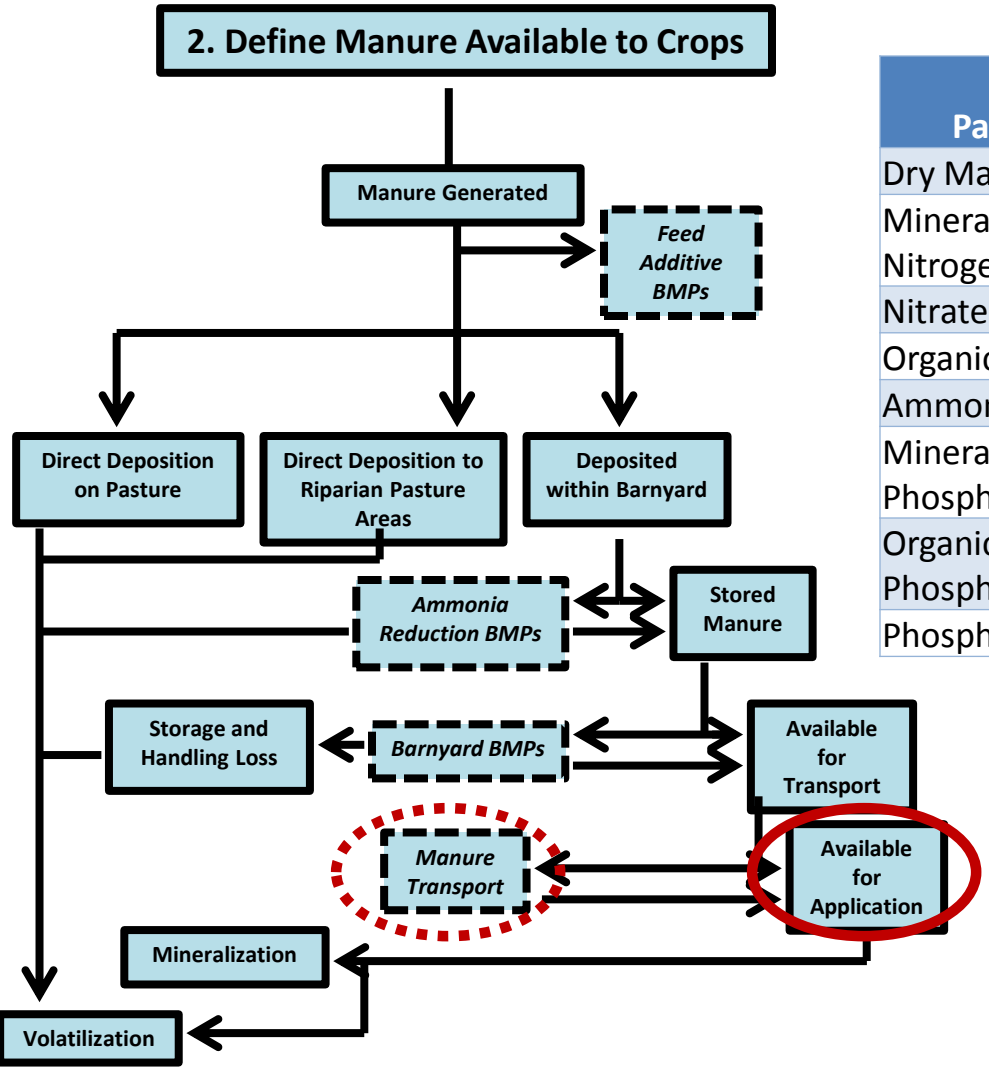
Example Manure Calculation for Dairy



Parameter	Lbs/An/Yr (Pre-Storage and Handling Loss)	Lbs/An/Yr (Post-Storage and Handling Loss)	Lbs/An/Yr (Post-AWMS)
Dry Manure	2,565.52	1,418.73	1,738.14
Mineralized Nitrogen	35.98	19.89	24.37
Nitrate Nitrogen	0.00	0.00	0.00
Organic Nitrogen	31.90	17.64	21.61
Ammonia Nitrogen	7.22	3.99	4.89
Mineralized Phosphorus	0.42	0.23	0.28
Organic Phosphorus	0.00	0.00	0.00
Phosphate	12.60	6.97	8.53

- Storage and handling loss values were taken from *USDA-NRCS, 2003. Costs Associated with Development and Implementation of Comprehensive Nutrient Management Plans. June, 2003.*
- AWMS BMPs are submitted by states, and can conserve manure within the barnyard.

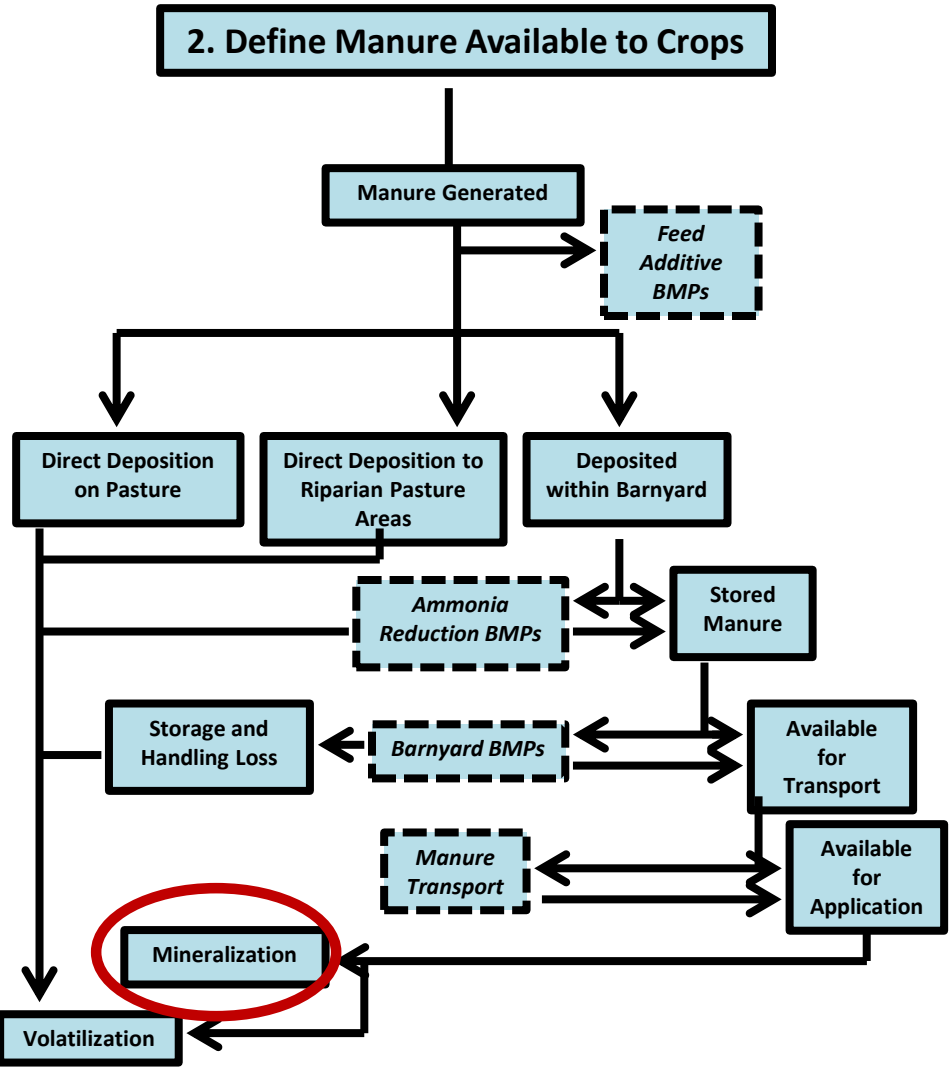
Example Manure Calculation for Dairy



Parameter	Lbs/Yr (Post-AWMS)	Lbs/Yr (Post 0.5 T Manure Transport)
Dry Manure	1738.14	738.14
Mineralized Nitrogen	24.37	10.35
Nitrate Nitrogen	0.00	0.00
Organic Nitrogen	21.61	9.18
Ammonia Nitrogen	4.89	2.08
Mineralized Phosphorus	0.28	0.12
Organic Phosphorus	0.00	0.00
Phosphate	8.53	3.62

- States submit manure transport by animal type and county.
- Manure may be transported into and out of counties, changing the associated nutrients available for application.

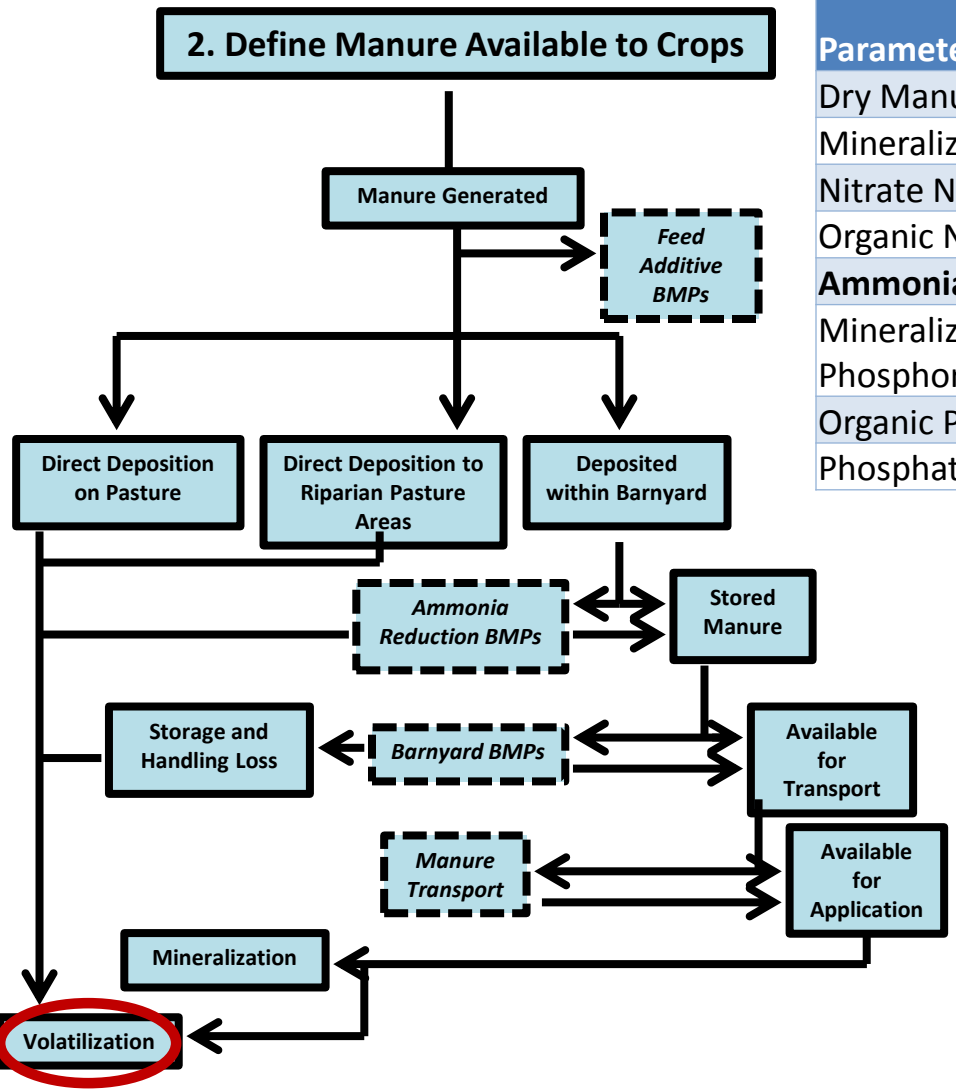
Example Manure Calculation for Dairy



- Mineralization factors provided by Maryland's Nutrient Management Manual 2011 and Mid-Atlantic Water Program's Nutrient Management Handbook, 2013.

- 3-year mineralization factors chosen to represent 2000s, single-year for 1980s, and interpolated for 1990s.

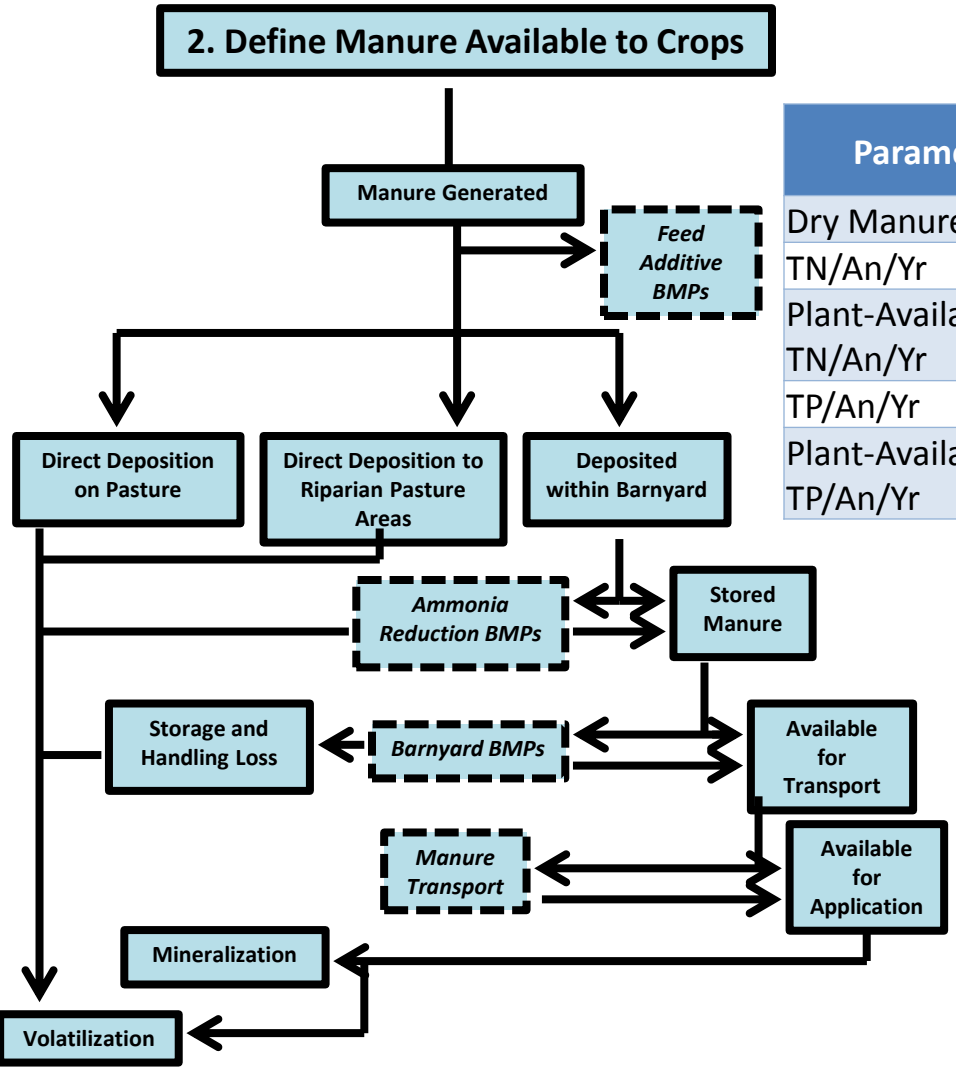
Example Manure Calculation for Dairy



Parameter	Lbs/Yr (Pre-In-Field Vol)	Lbs/Yr (Post In-Field Vol)
Dry Manure	738.14	738.14
Mineralized Nitrogen	10.35	10.35
Nitrate Nitrogen	0.00	0.00
Organic Nitrogen	9.18	9.18
Ammonia Nitrogen	**2.08**	**1.35**
Mineralized Phosphorus	0.12	0.12
Organic Phosphorus	0.00	0.00
Phosphate	3.62	3.62

- In-field volatilization losses were assumed to equal no incorporation within 72 hours, and values were taken from Maryland Nutrient Management Manual and Penn State Nutrient Management Guide.
- Only Mineralized N and Ammonia N are available for plants.
- This means that eliminating in-field volatilization would result in a 5.9% increase in plant-available N from dairy manure.

Example Manure Calculation for Dairy



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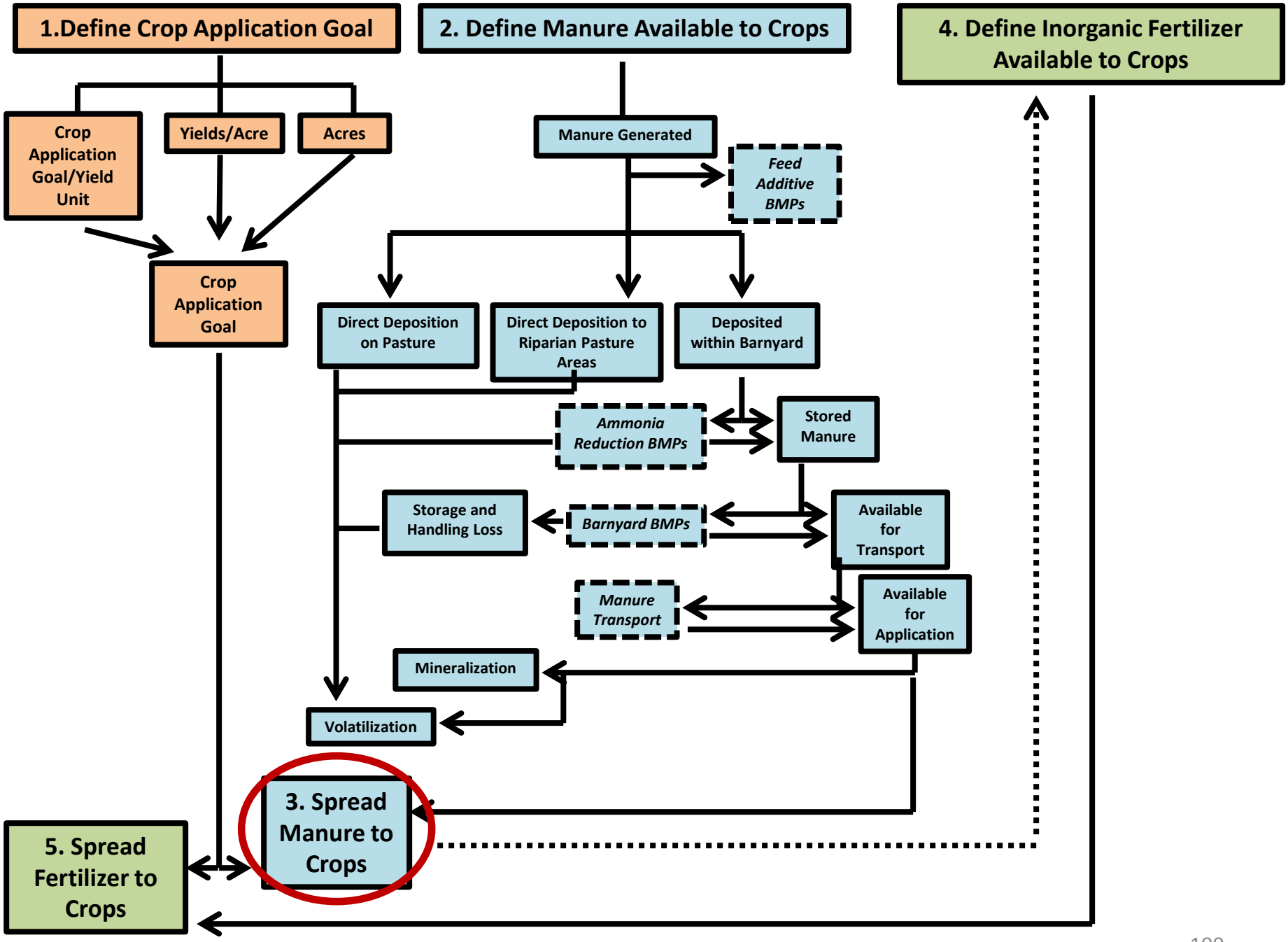
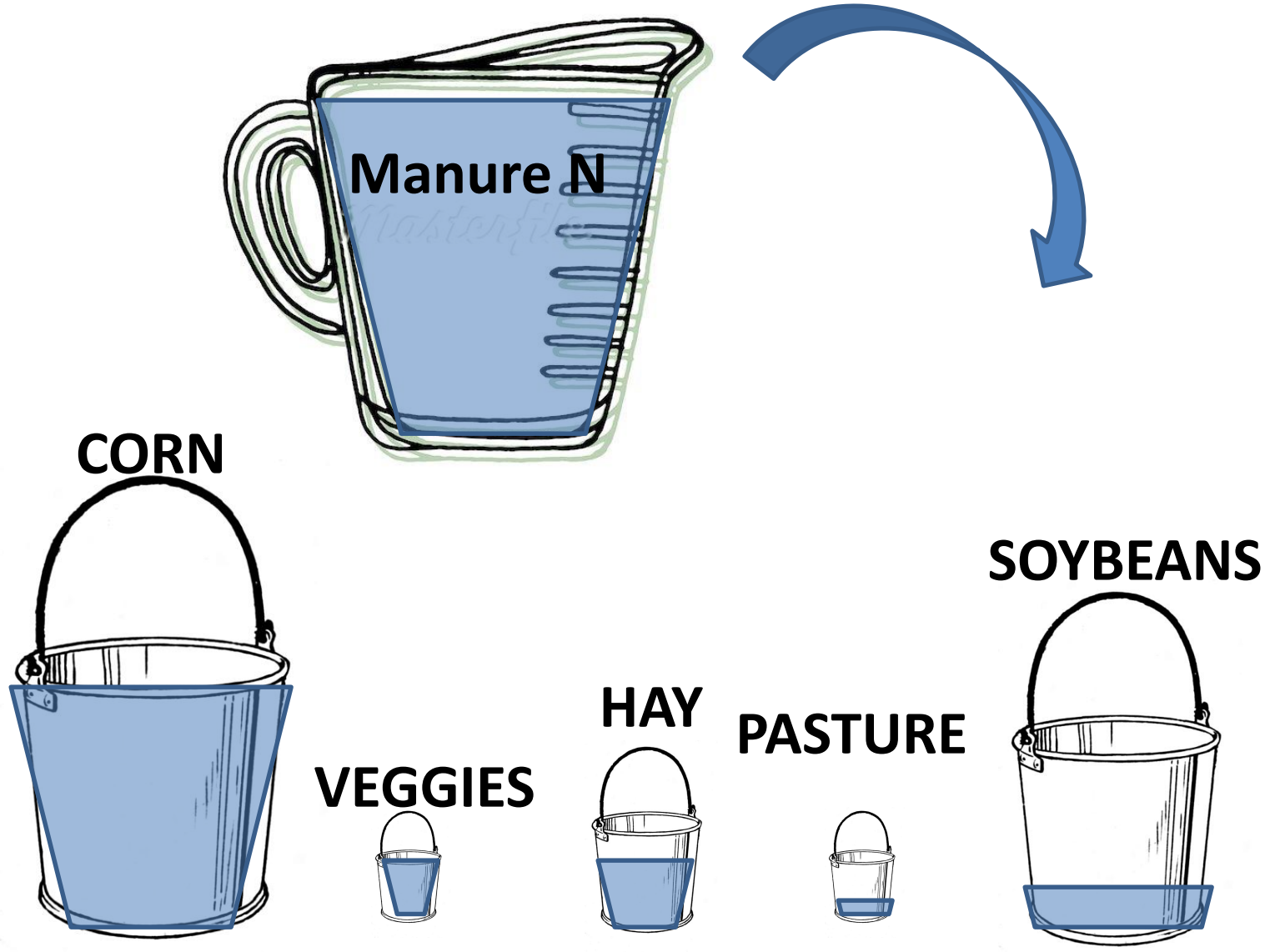
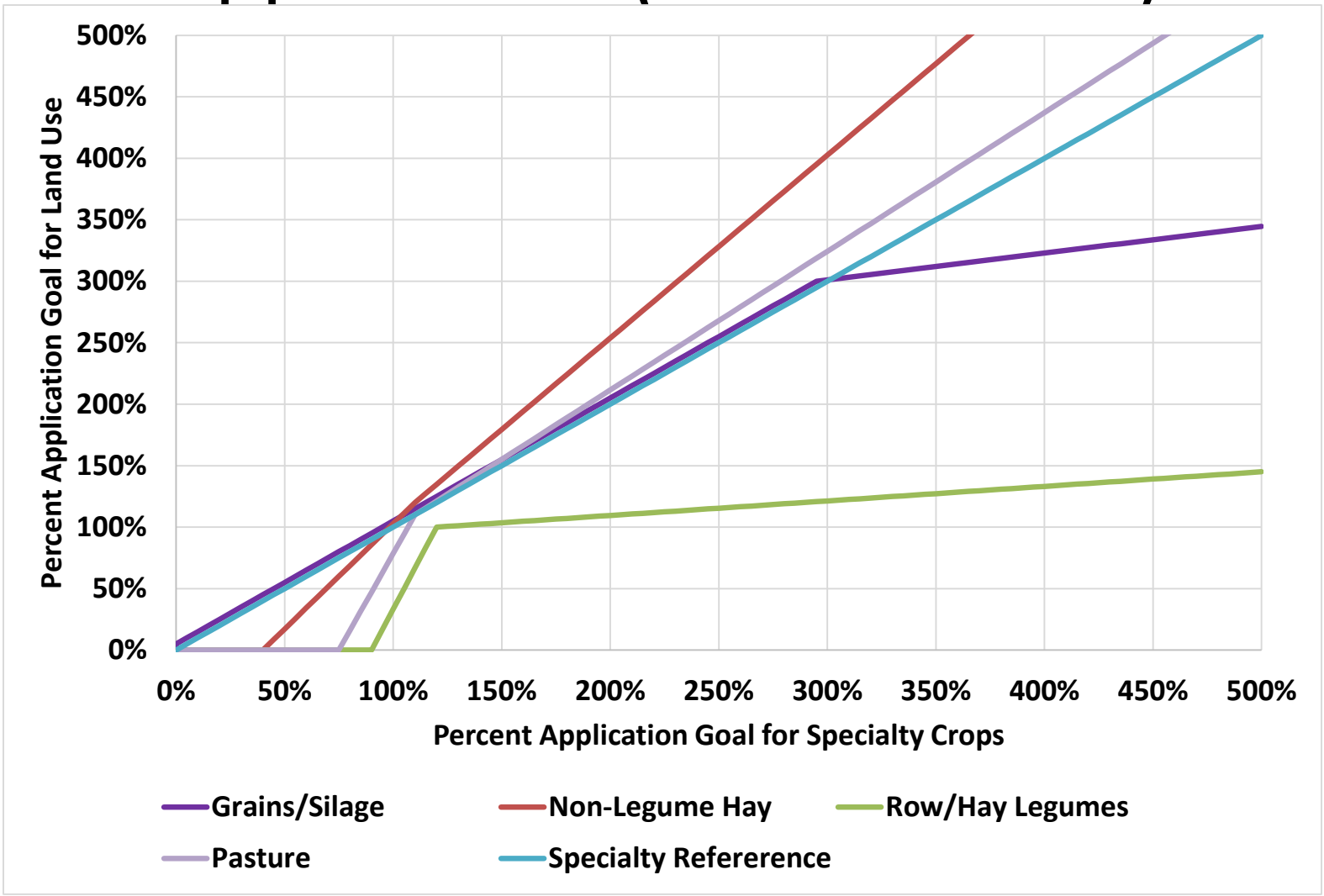
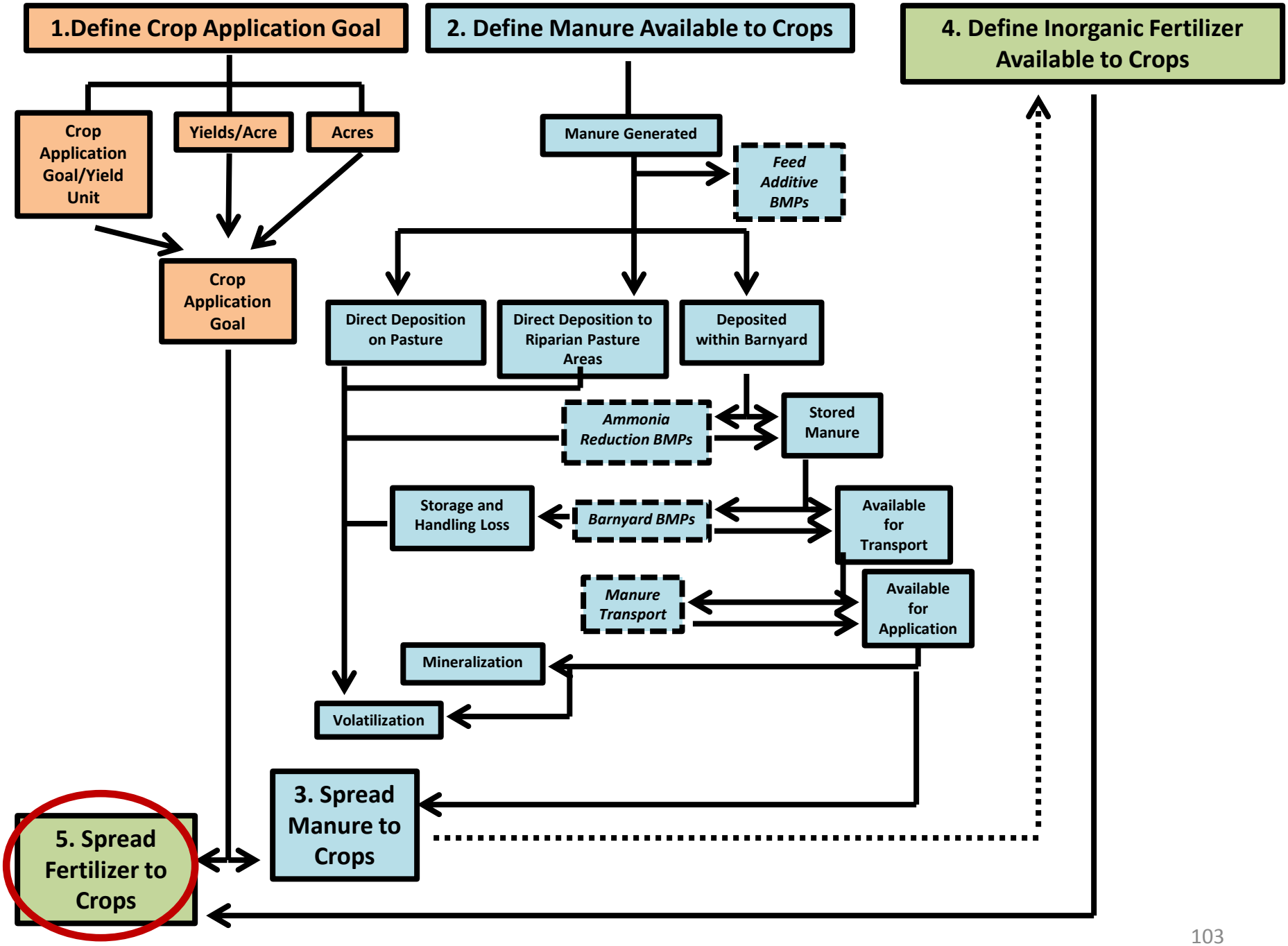

1.Define Crop Application Goal
2. Define Manure Available to Crops
4. Define Inorganic Fertilizer Available to Crops
Crop Application Goal/Yield Unit
Yields/Acre
Acres
Crop Application Goal
Manure Generated
Feed Additive BMPs
Direct Deposition on Pasture
Direct Deposition to Riparian Pasture Areas
Deposited within Barnyard
Ammonia Reduction BMPs
Stored Manure
Storage and Handling Loss
Barnyard BMPs
Available for Transport
Manure Transport
Available for Application
Mineralization
Volatilization
3. Spread Manure to Crops
5. Spread Fertilizer to Crops

Filling the Buckets of Organic Application Goal



Manure: Prioritizing Manure Nitrogen Applications (and Biosolids)

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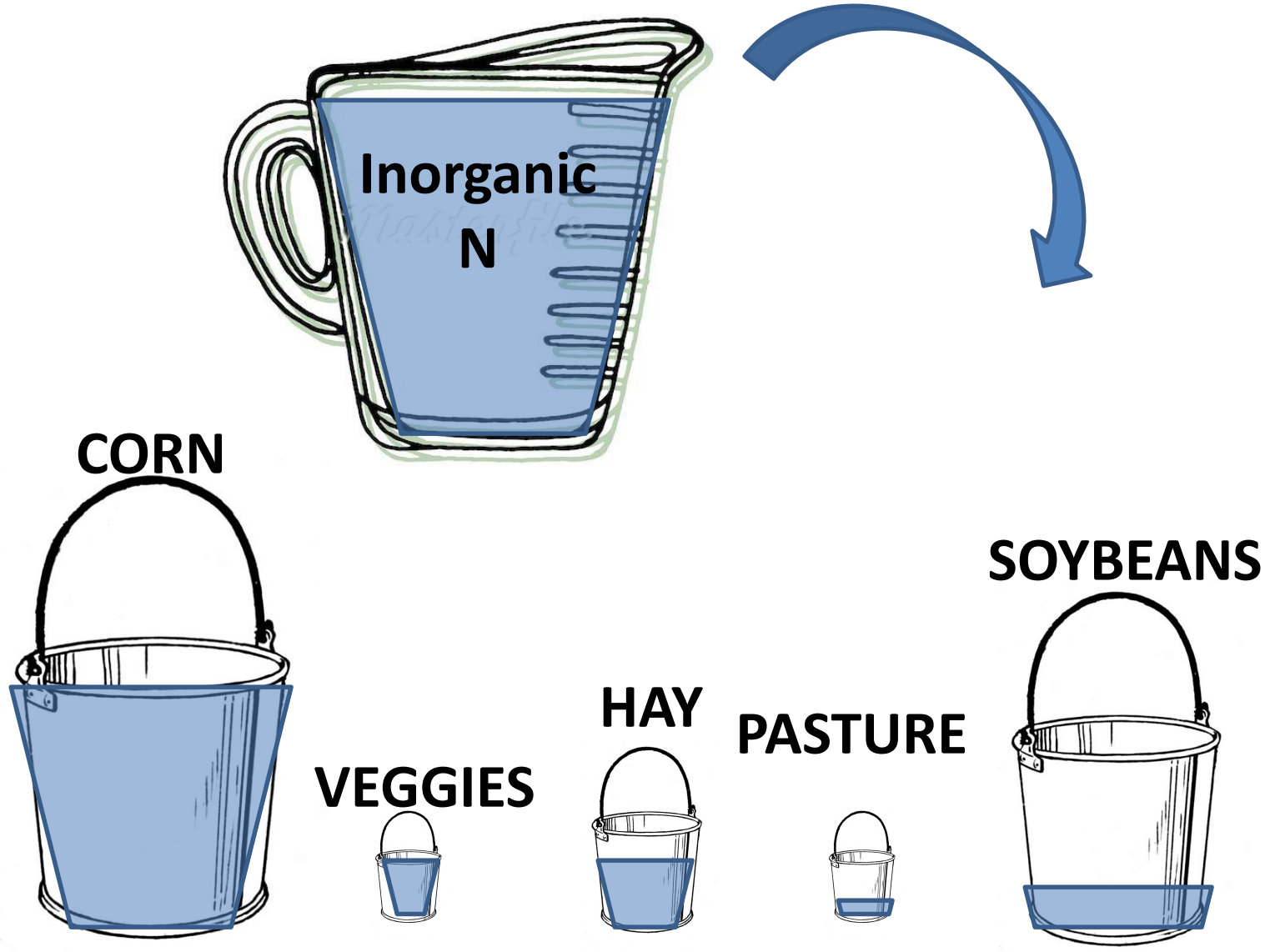
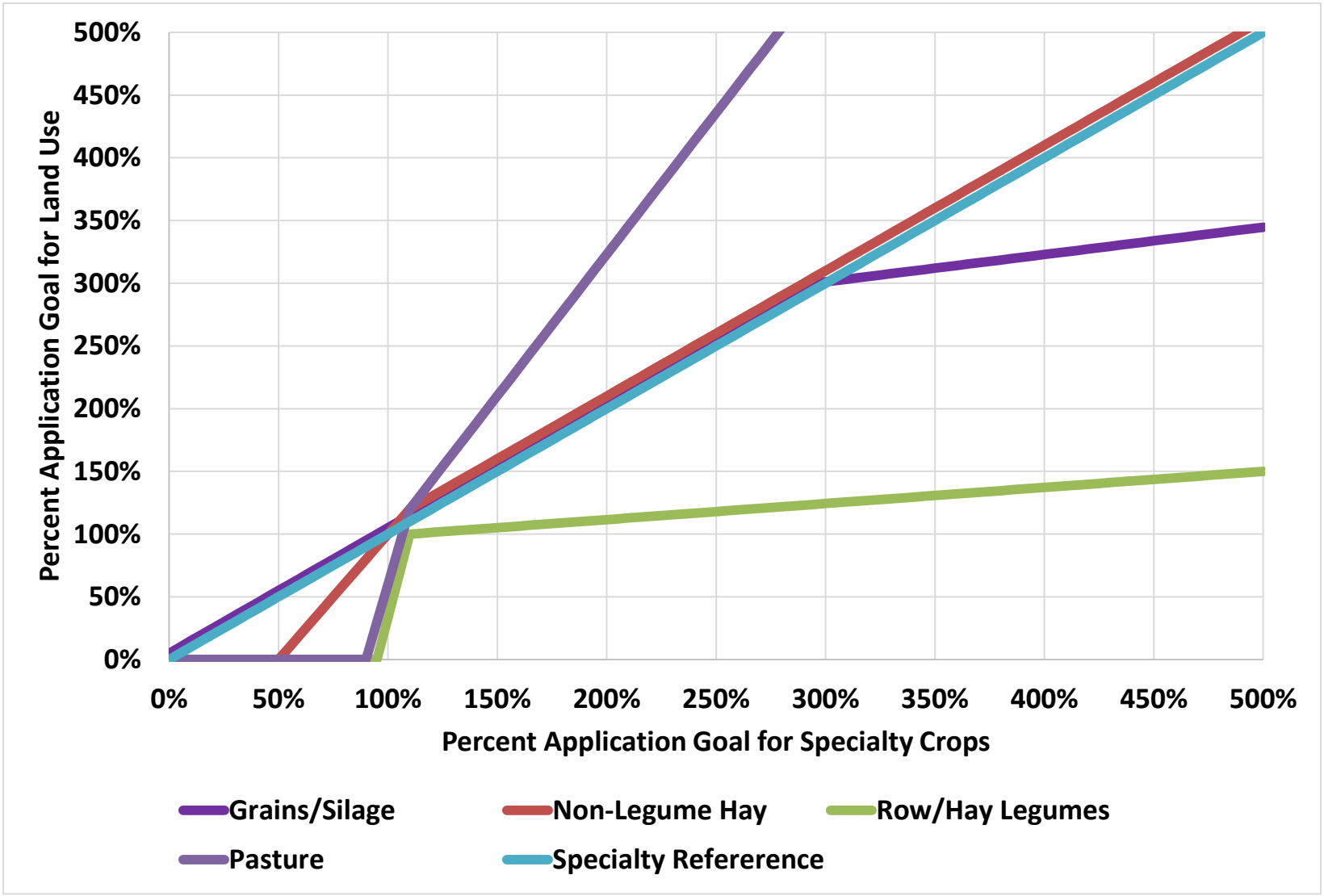
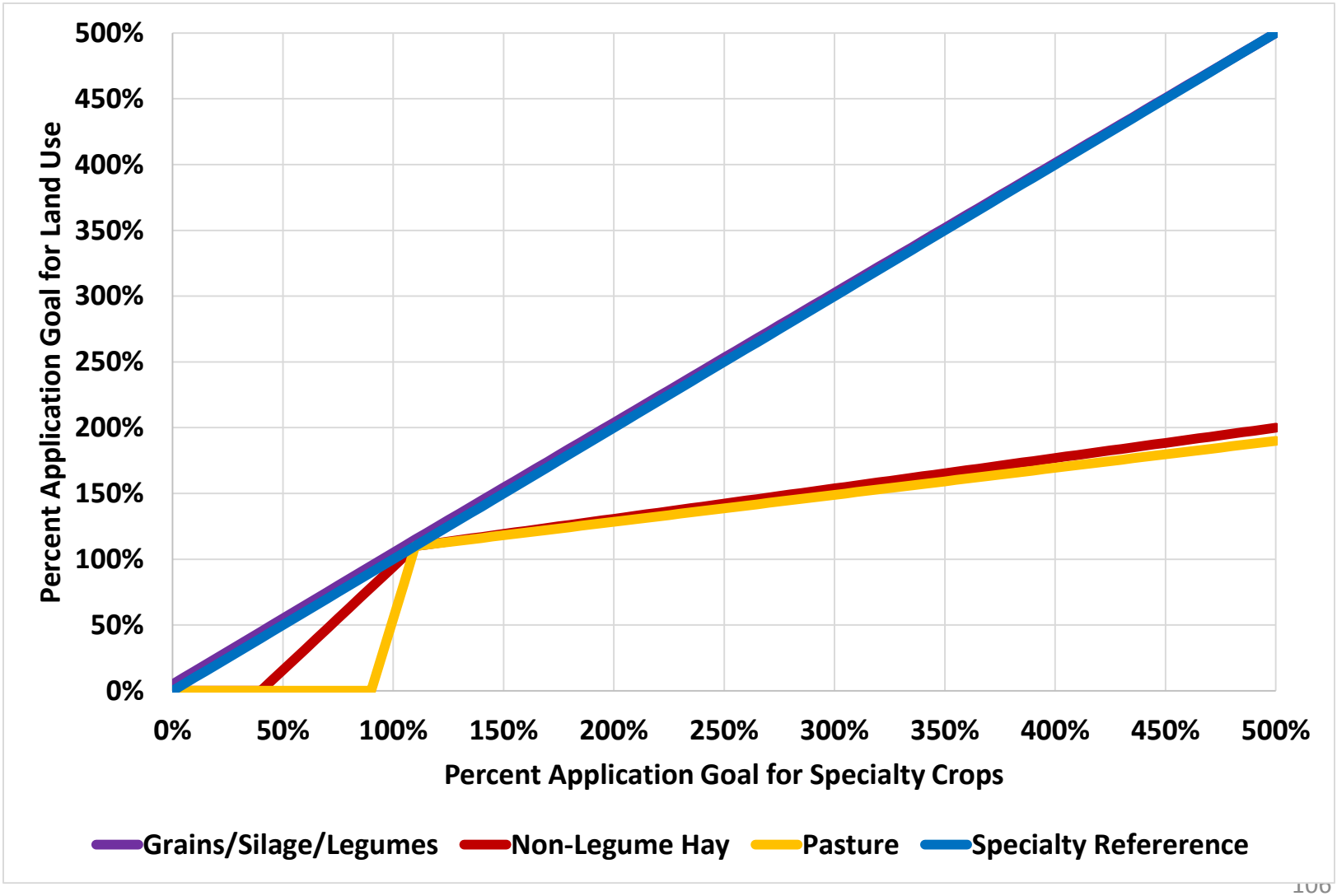
Filling the Buckets of Inorganic Crop Application Goal



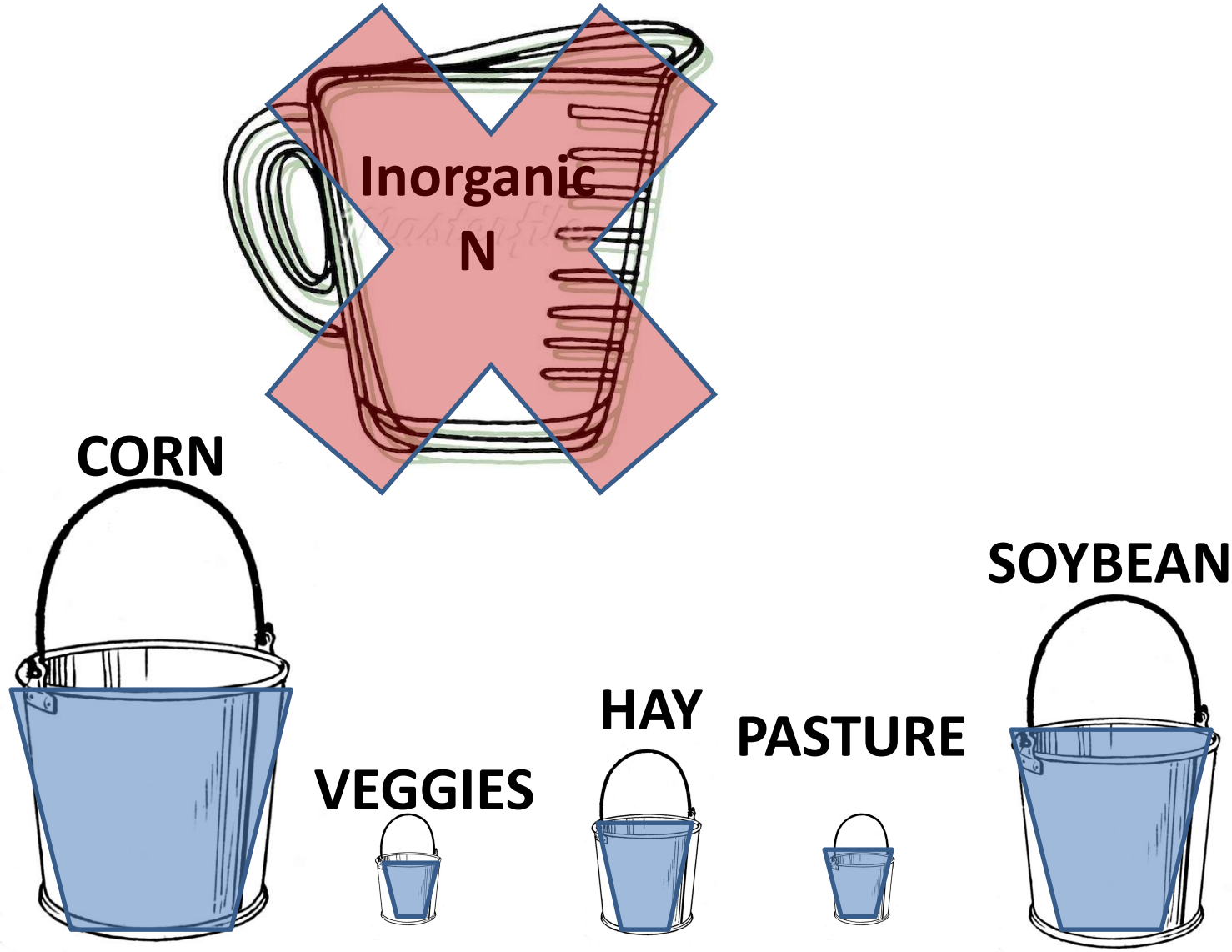
Inorganic: Prioritizing Inorganic Nitrogen Applications (Beta 3a)



Inorganic: Prioritizing Inorganic Phosphorus Applications (Beta 3a)



Filling the Buckets of Inorganic Crop Application Goal (Beta 3b)



Background Introductory Slides

Partnership Feedback on Modeling

- **Water Quality Goal Implementation Team**
  - Need more **transparent and easier** to understand decision-support tools to enable successful engagement of local partners

- **Scientific and Technical Advisory Committee**
  - Multiple Models
  - Phosphorus
  - Complex Reservoir Dynamics
  - Fine-scale processes

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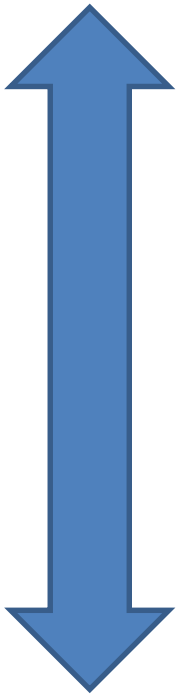
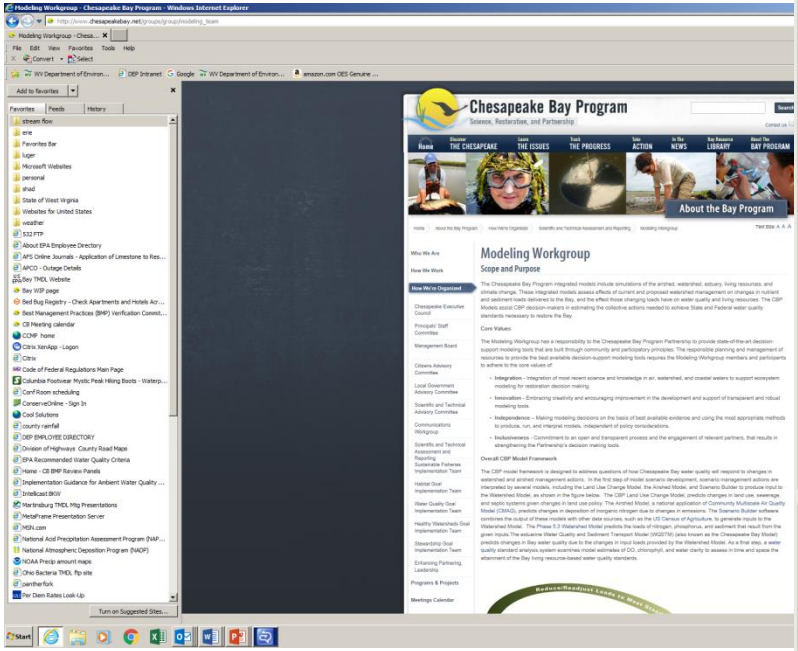
Keep it Simple!!



Include Everything!!!

Documentatic



Members | Meetings | Workgroups & Task Groups | Projects & Resources | Publications

Phase 6 Beta 2 Draft Documentation - June 2016

The Phase 6 Beta 2 Watershed Model is available for partnership review. The purpose of making the draft documentation available to the Partnership is to provide the Partnership with a written record of the results of the many partnership decisions that have been made in the Management Board, the Modeling Workgroup, the Water Quality Goal Implementation Team, and the WQGIT's many workgroups.

Documentation

Documentation pdf and excel files can be found here:
ftp://ftp.chesapeakebay.net/Modeling/Phase6/Ph6Calibration_Beta2/20160401/Documentation/

Calibration Plots

Graphics showing the calibration to individual stations and aggregate statistics are found here: ftp://ftp.chesapeakebay.net/Modeling/gbhatt/Phase_6_Beta_2/

Inputs

Inputs for Beta 2 were produced in April and do not reflect the latest versions of the nutrient spread and other partnership decisions that will be included in Beta 2. Inputs used in Beta 2 are available here: ftp://ftp.chesapeakebay.net/Modeling/Phase6/Ph6Calibration_Beta2/20160401/inputs/. A more conveniently summarized version of the the Beta 2 inputs can be found in excel files at this ftp site: ftp://ftp.chesapeakebay.net/Modeling/Phase6/Ph6Calibration_Beta2/20160401/inputs/ScenarioBuilder/

Load Outputs

The 'AllLoads' excel files are the annual average loads in raw format and can be found at this FTP site: ftp://ftp.chesapeakebay.net/Modeling/Phase6/Ph6Calibration_Beta2/20160401/

Phase 6 Beta 1 - January 2016

The Phase 6 Beta 1 Watershed Model is available for partnership review. Draft documentation files are available in the series of attached documents below. Calibration plots are available on the CBP FTP site by constituent, or in a single file (hyperlinks below). Information and data regarding Scenario Builder inputs can also be accessed from another linked FTP below.

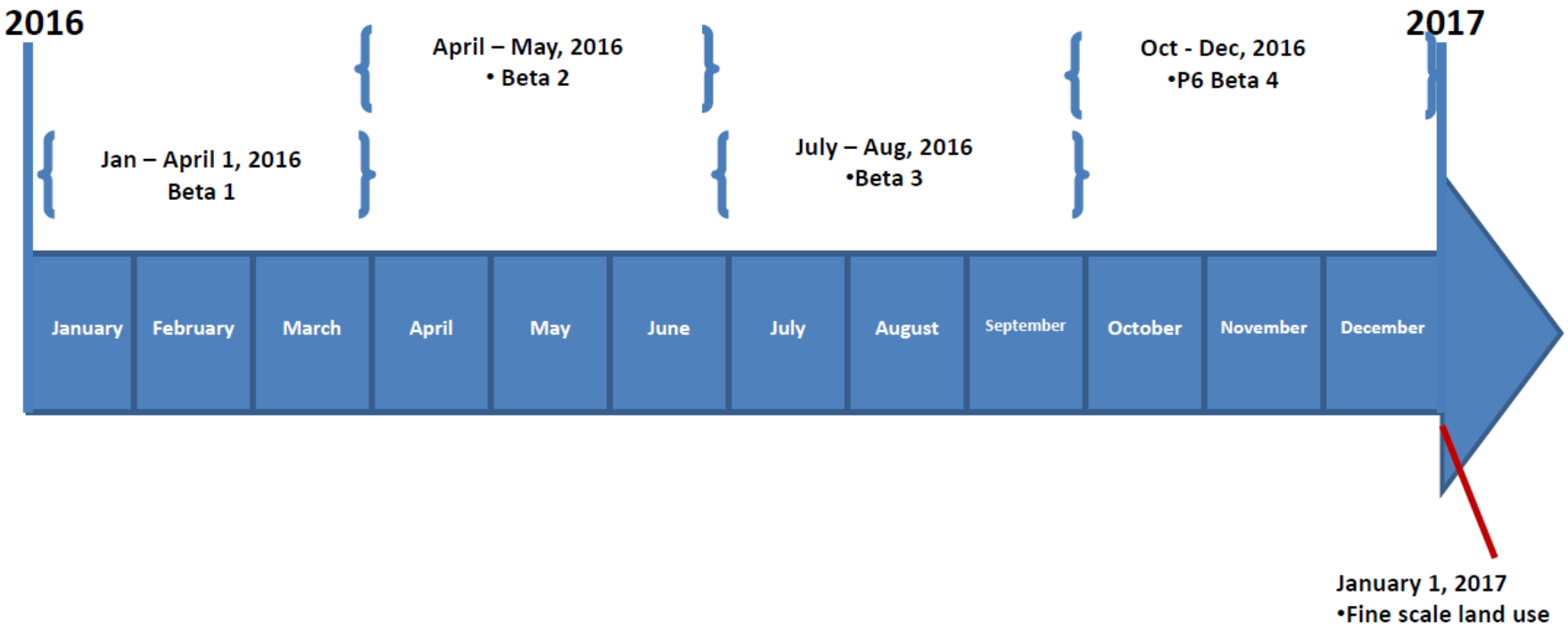
Calibration Plots, by Constituent: ftp://ftp.chesapeakebay.net/Modeling/gbhatt/Phase_6_Beta_1/20151231_Calibration_Graphics/

All Calibration Plots (large file size): http://ftp.chesapeakebay.net/Modeling/gbhatt/Phase_6_Beta_1/20151231_Calibration_Graphics/Calibration%20Graphics%20Binder%2020151231.pdf

Scenario Builder Inputs: ftp://ftp.chesapeakebay.net/Modeling/Phase6

- See MWG Webpage
- http://www.chesapeakebay.net/groups/group/modeling_team
- Will be periodically updated
- Webinars here too

2016 Phase 6 Model Review Timeline



Reviews

- STAC Reviews
  - Scenario Builder / Nutrient Inputs (summer)
  - Watershed Model (fall)
  - Estuarine WQSTM (winter)
- Partnership Review
  - Started with 2012 WQGIT F2F and BBBM workshop
  - Continual work in MWG, WQGIT, and all WQGIT WGs
  - Prototypes and Beta versions
  - Beta 4 will have all changes except for land use
  - Final model review April – May 2017
  - WQSTM being reviewed by MWG during this period