Review of Fertilizer Spread Options for Phase 6

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Phase 6 Model Structure

Average Load + Δ Inputs * Sensitivity

*

Land Use Acres

*

BMPs

*

Land to Water

*

Stream Delivery

*

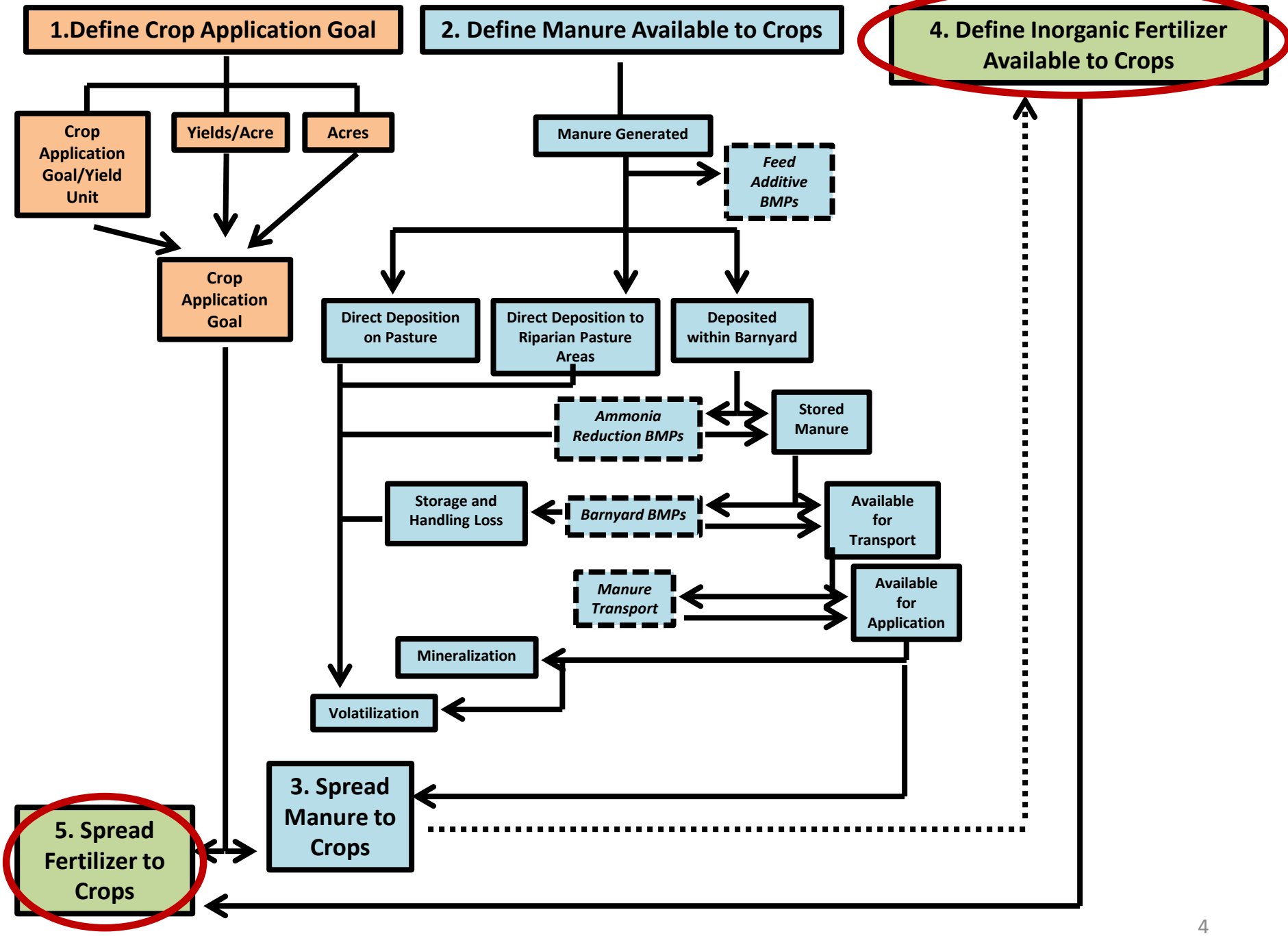
River Delivery

Direct Loads

Phase 6

Nutrient Spread Components in Beta 3 (All scenarios)

- 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**

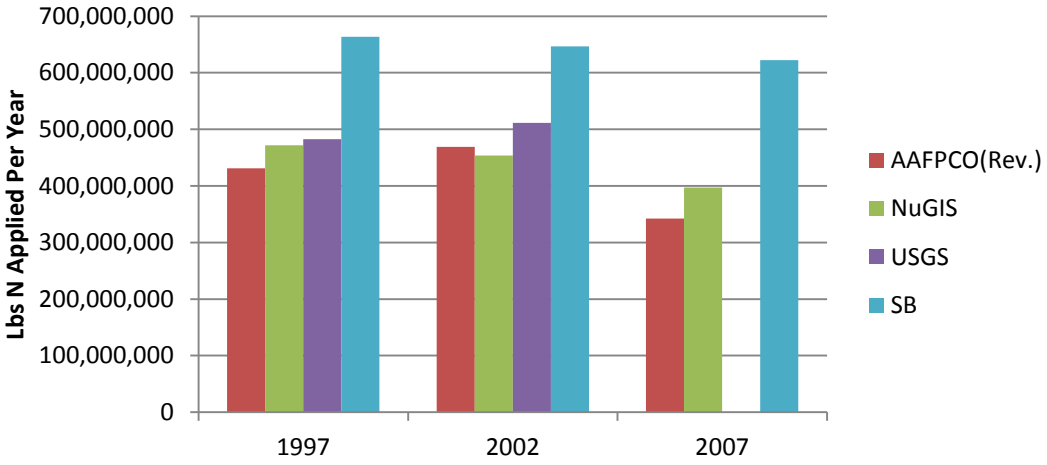

1.Define Crop Application Goal
2. Define Manure Available to Crops
4. Define Inorganic Fertilizer Available to Crops
Crop Application Goal/Yield Unit
Yields/Acre
Acres
Crop Application Goal
Manure Generated
Feed Additive BMPs
Direct Deposition on Pasture
Direct Deposition to Riparian Pasture Areas
Deposited 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 (Fertilizer Sales OR Beta 3a).
  - NO. Fertilizer should be applied to fulfill all unmet crop application goals in a county after manure is applied (Backfill OR Beta 3b).

How did we get here?
Comparing Across Methods

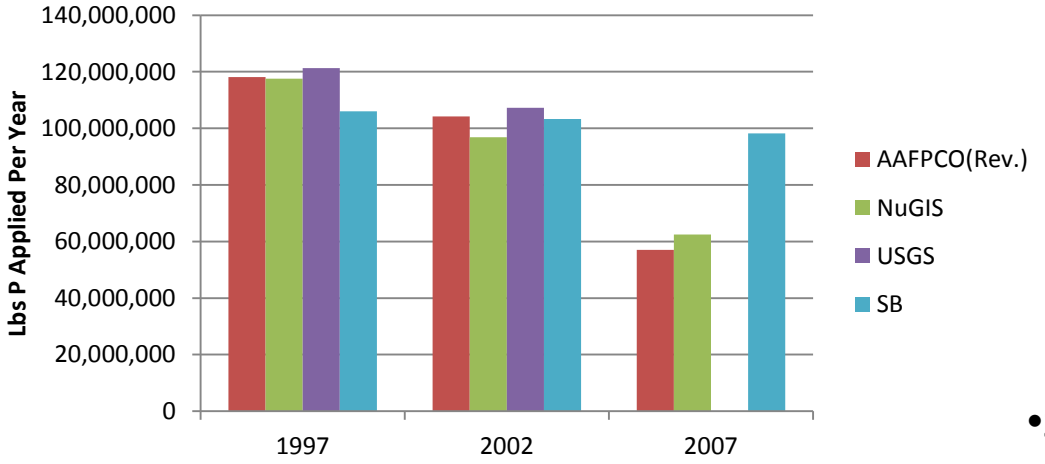
N Fertilizer Use Across Watershed



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%

P Fertilizer Use Across Watershed



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%

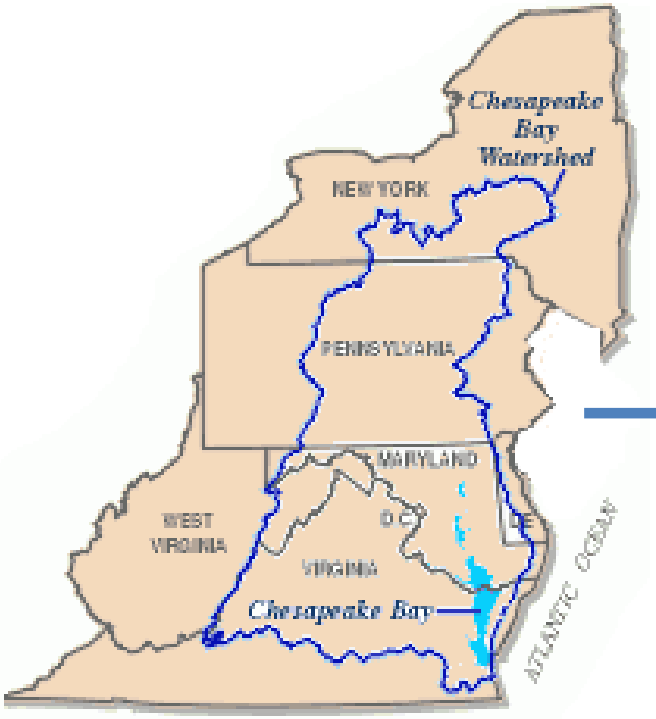
•Slide taken from May 14, 2014 presentation to AMS.

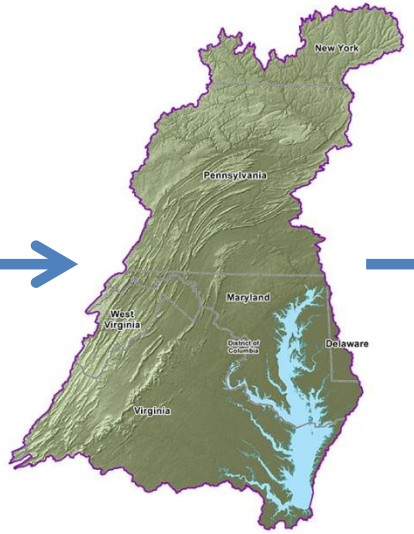
Inorganic Fertilizer Available: Fertilizer Sales (Beta 3a)

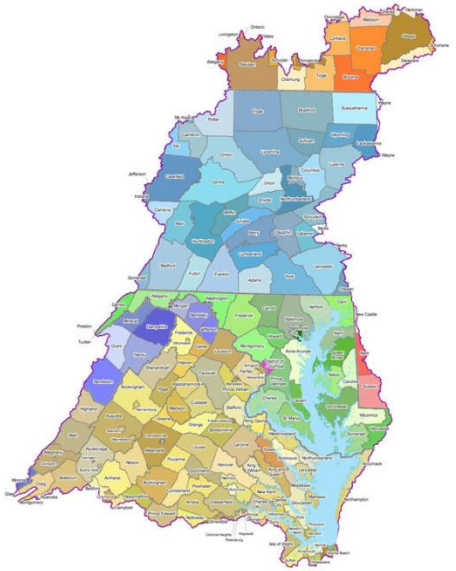
- Fertilizer used in all counties equals estimated fertilizer sold across the watershed.
- Watershed-wide fertilizer is distributed to counties based upon each county's share of the total watershed's:
  - Dollars spent on fertilizer, lime and soil conditioners (from Ag Census);
  - Remaining crop application goal after manure is applied.
- Applications are prioritized to row and commodity crops over pasture and hay.
- All crops do NOT receive 100% of application goal. Some crops in some counties may be above or below 100% of goal.

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

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





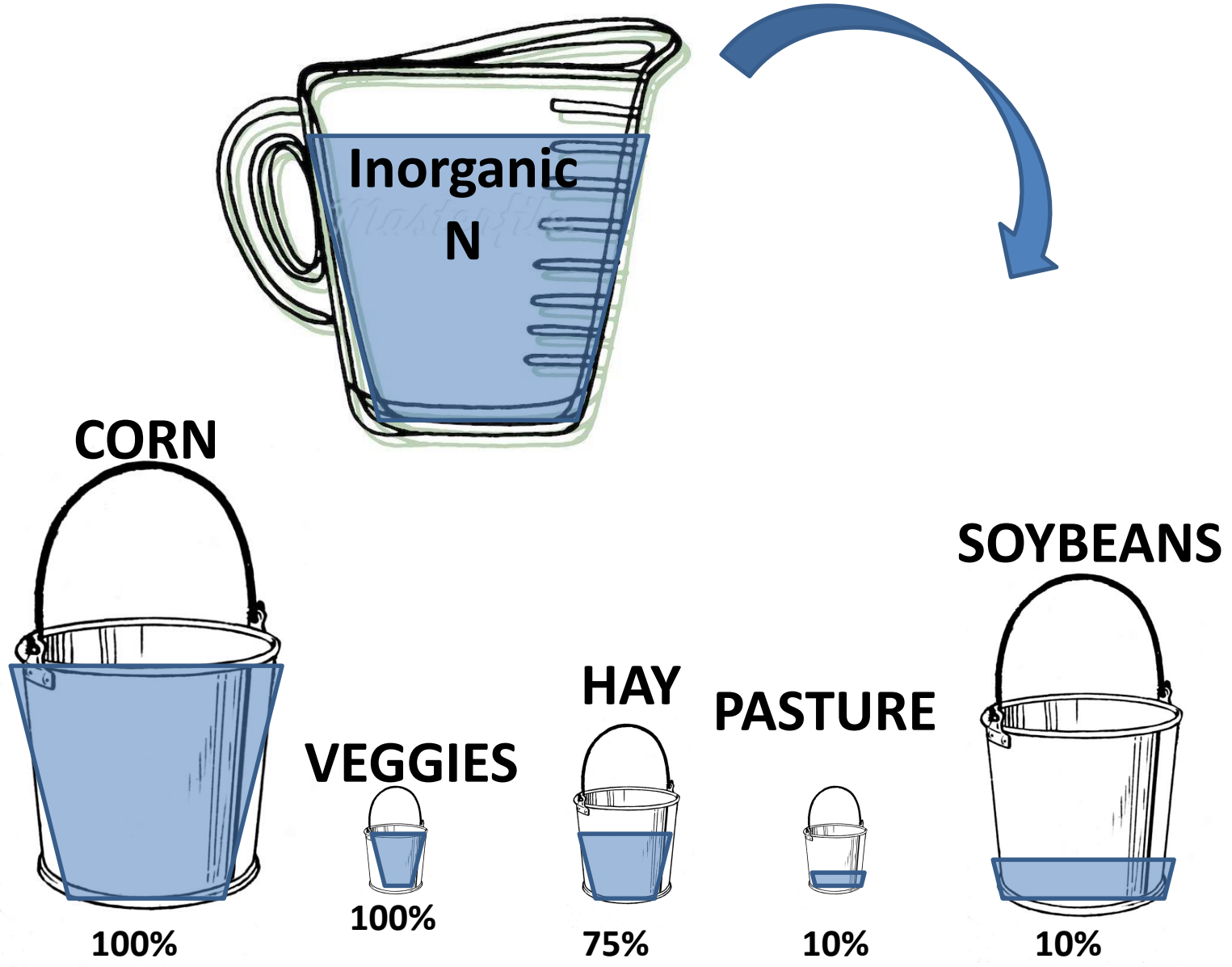


•Sum AAPFCO sales across 6 states, and estimate sales used by farms.

•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.

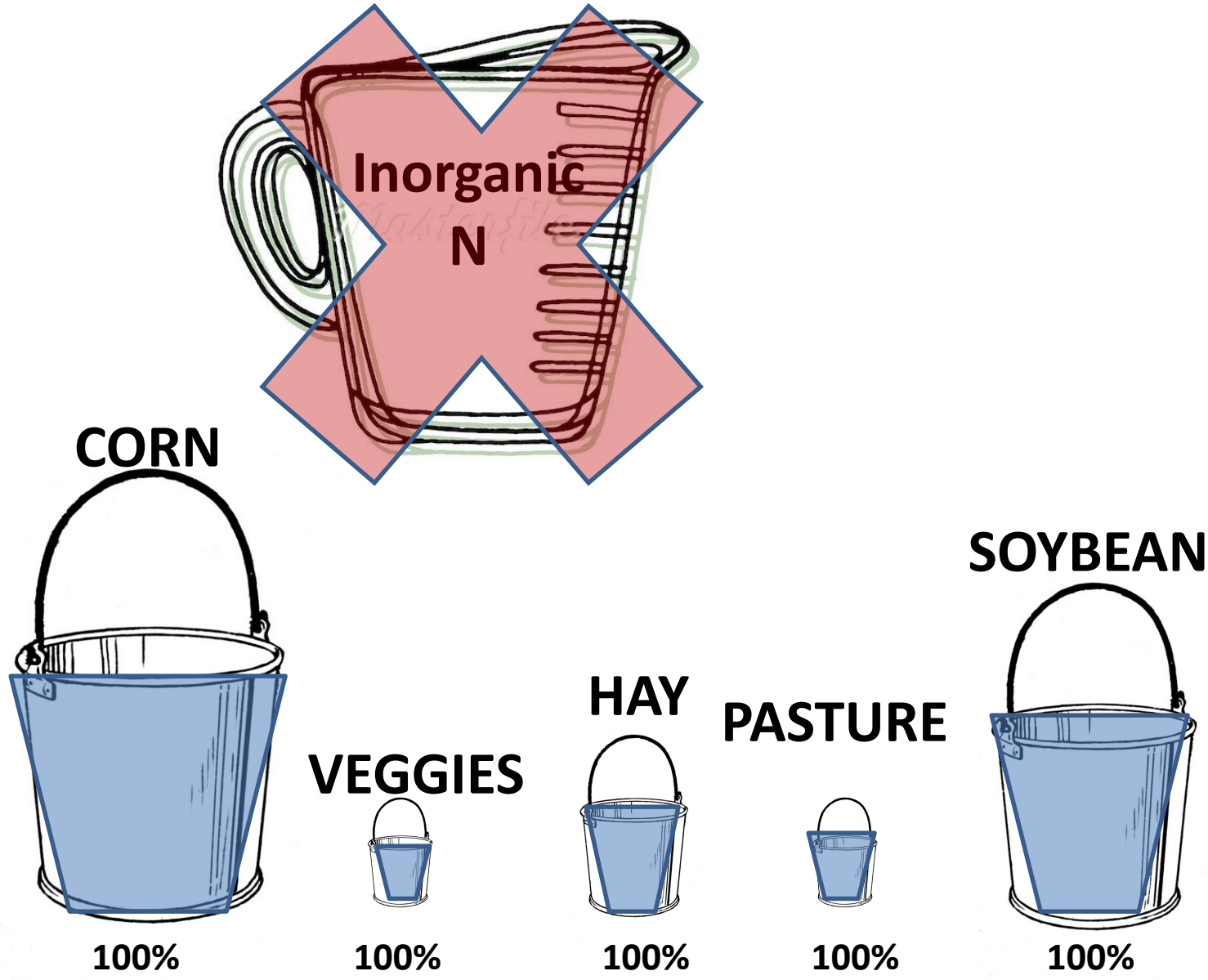
Filling the Buckets of Inorganic Crop Application Goal Beta 3a



Inorganic Fertilizer Available: Backfill (Beta 3b)

- Fertilizer use in each county equals remaining crop application goal after manure applications.
- No prioritization is made between applications to different crops.
- All crops receive at least 100% of crop application goal.

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

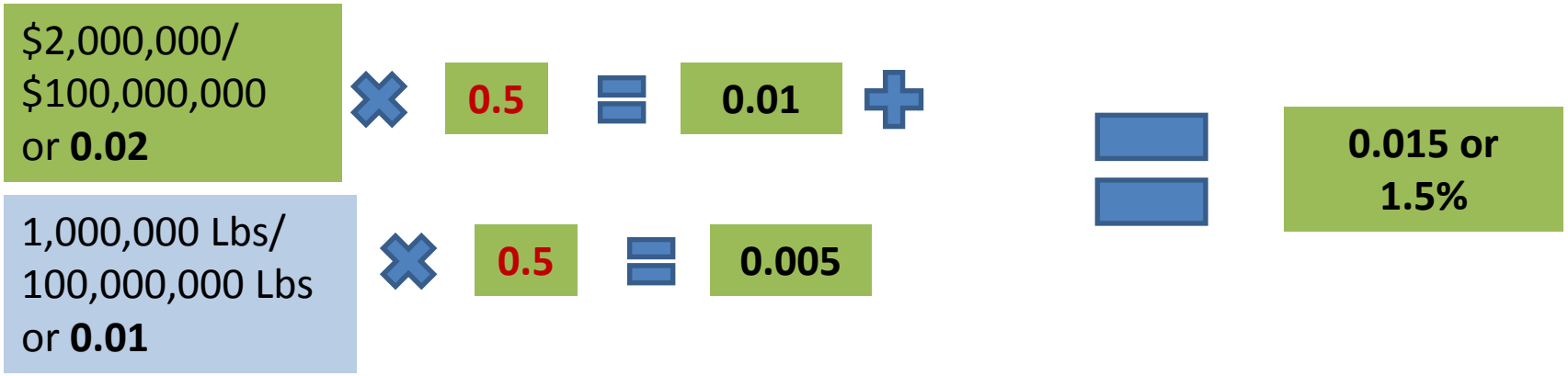


Inorganic Fertilizer Available: Fertilizer Sales Revised (Beta 3a1)

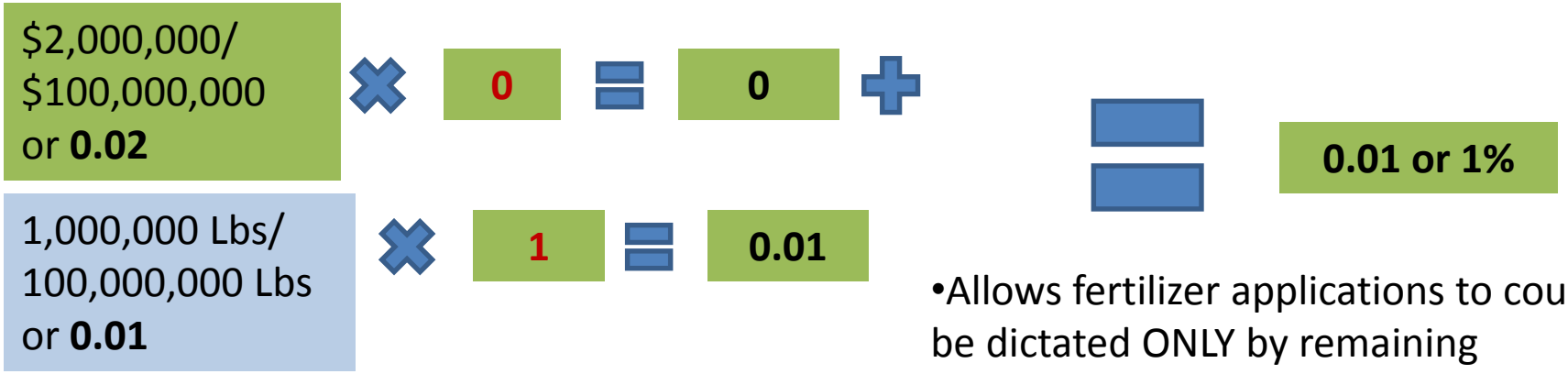
- Fertilizer used in all counties equals estimated fertilizer sold across the watershed.
- Watershed-wide fertilizer is distributed to counties based upon each county's share of the total watershed's:
  - ~~Dollars spent on fertilizer, lime and soil conditioners (from Ag Census);~~
  - Remaining crop application goal after manure is applied.
- Applications are prioritized to row and commodity crops over pasture and hay.
- All crops do NOT receive 100% of application goal. Some crops in some counties may be above or below 100% of goal.

Change for Fertilizer Sales Revised (Beta3a1)

Fertilizer Sales (Beta 3a) Approach for Distributing Fertilizer to County



Fertilizer Sales Revised (Beta 3a1) Approach



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

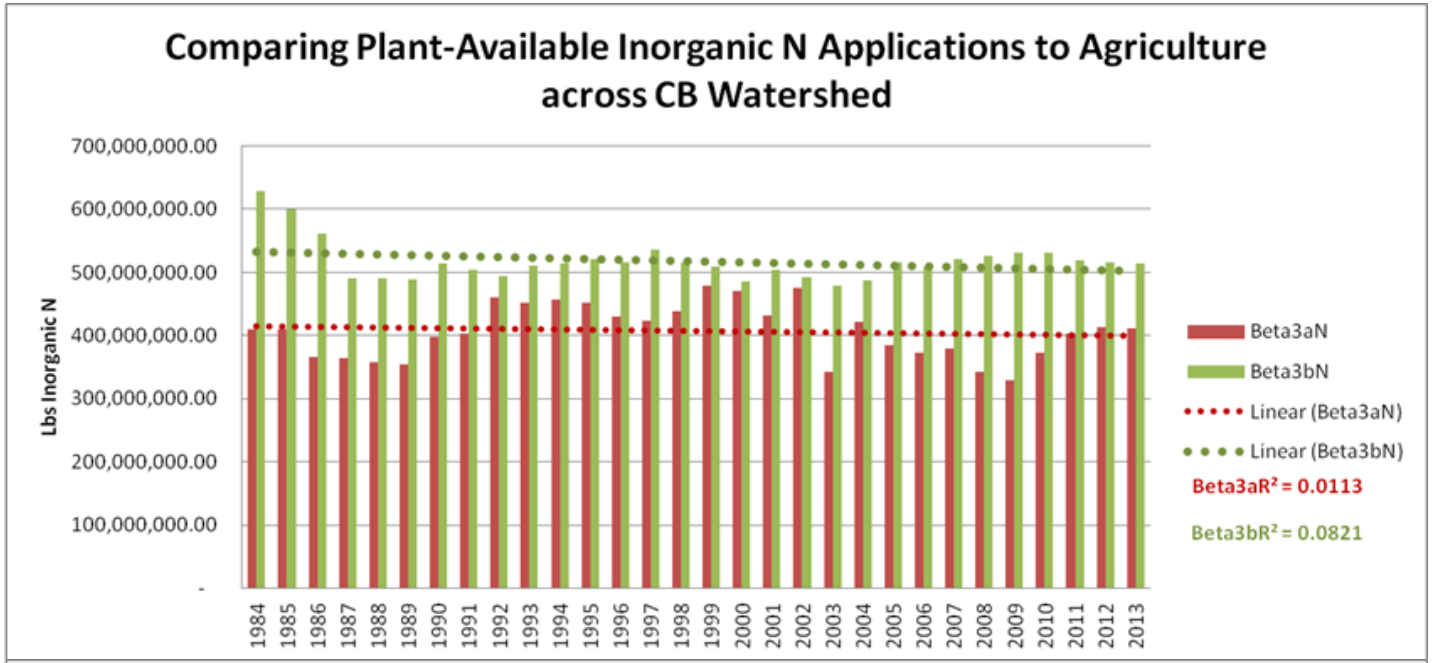
Results

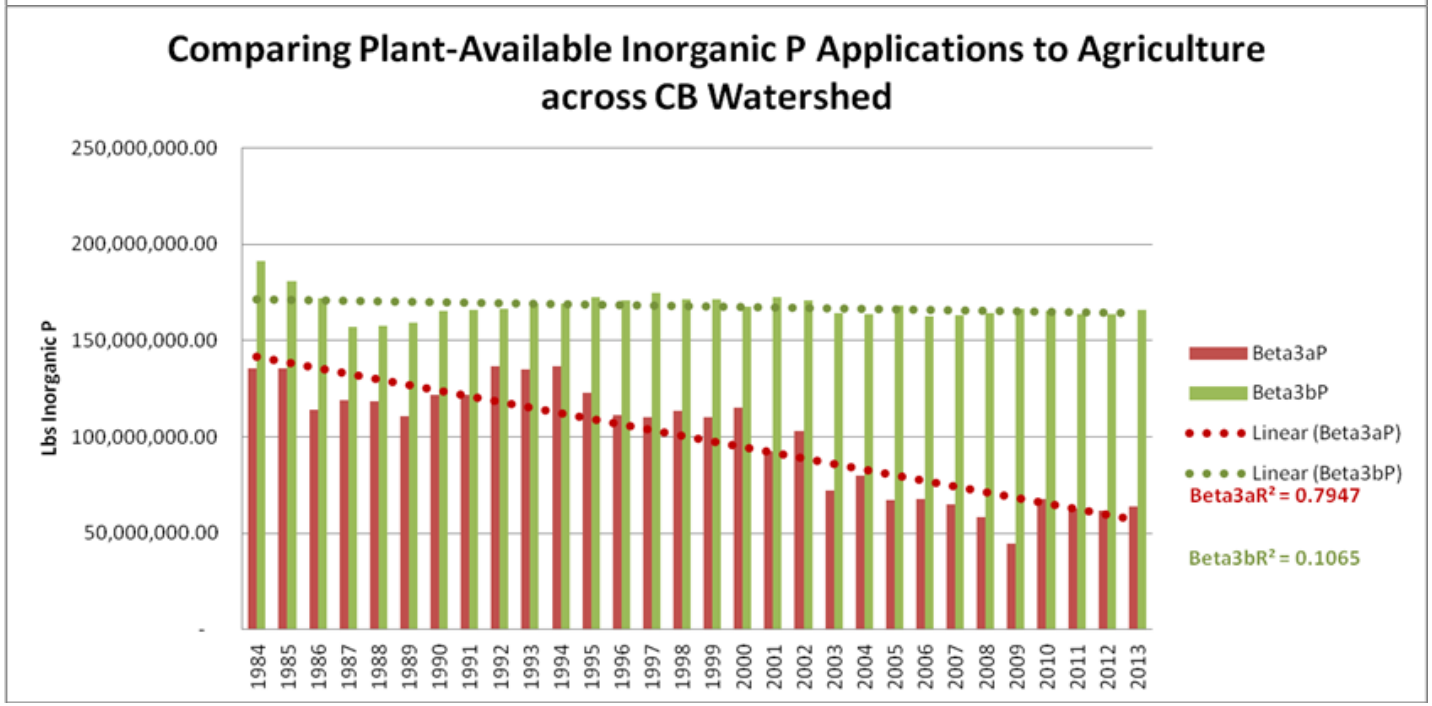
Statewide Comparison of Plant-Available Applications to MD AIR 2012

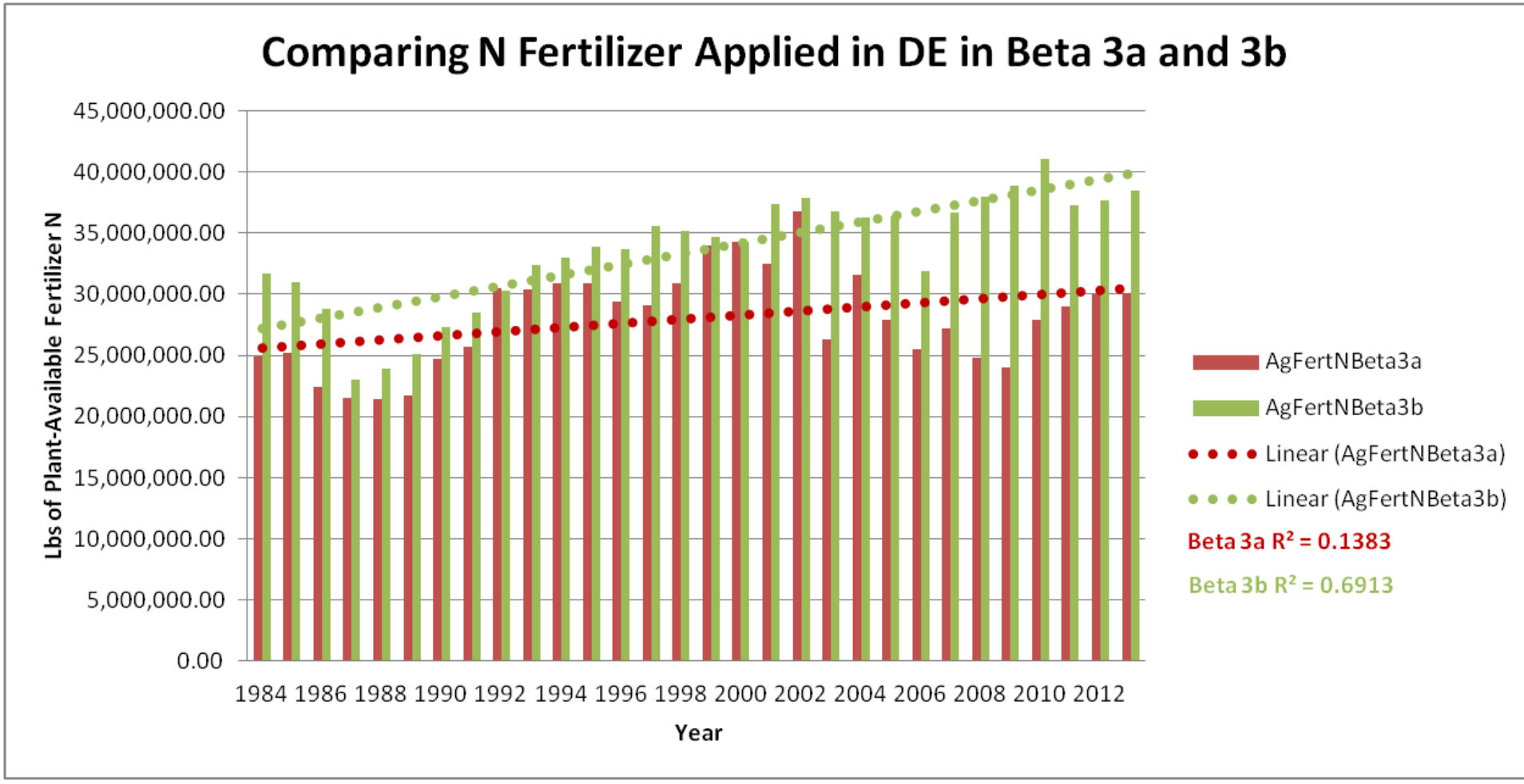
Scenario	Lbs Fert N	Lbs Fert P	% Delta from AIR for N	% Delta from AIR for P
MD AIR	76,946,211	8,087,974	NA	NA
Fert Sales (3a)	78,715,404	12,139,718	2%	50%
Backfill (3b)	95,019,384	32,411,068	23%	301%
Fert Sales Rev. (3a1)	76,133,253	12,184,432	-1%	51%

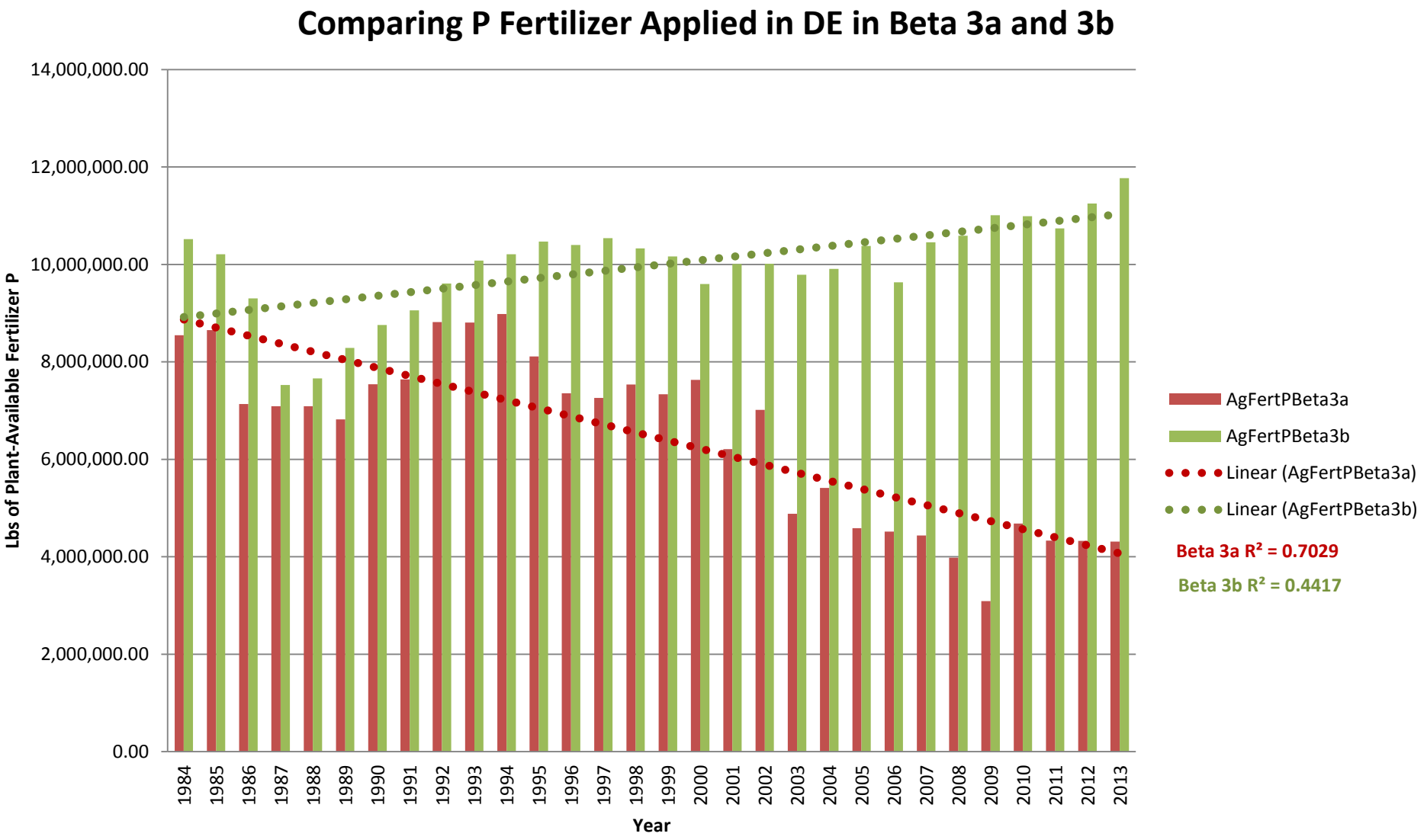
Watershed-Wide Comparison of Beta 3a and 3b Fertilizer Applications (avg. 2001-2006) to USDA CEAP

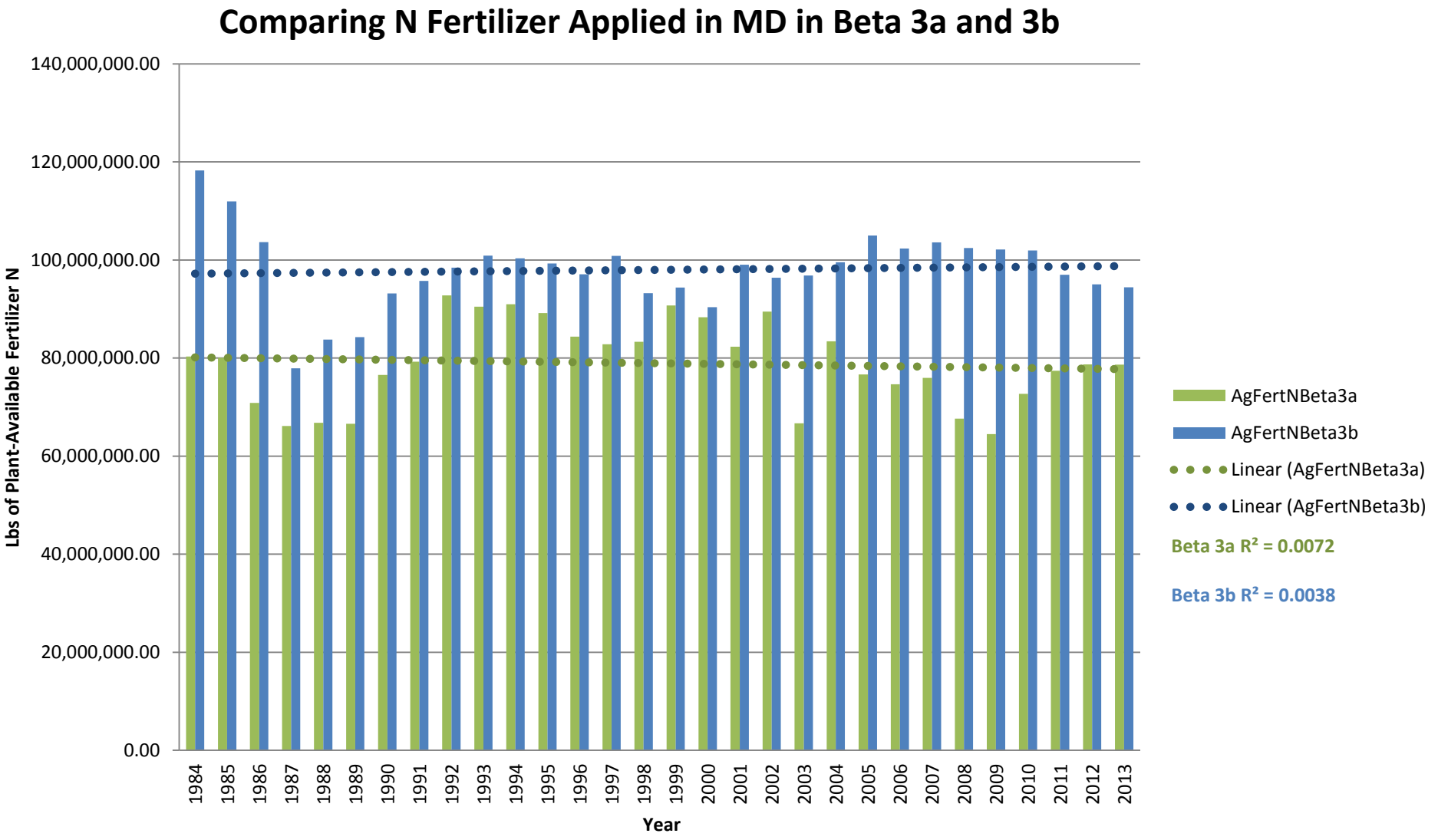
Data Source	Lbs Inorganic PAN	Lbs Inorganic P	% Delta from CEAP N	% Delta from CEAP P
Fert Sales (Beta 3A)	405,182,999	80,360,063	-0.2%	-0.6%
Backfill (Beta 3B)	497,976,530	167,020,450	22.6%	106.5%
CEAP	406,020,000	80,870,000	NA	NA

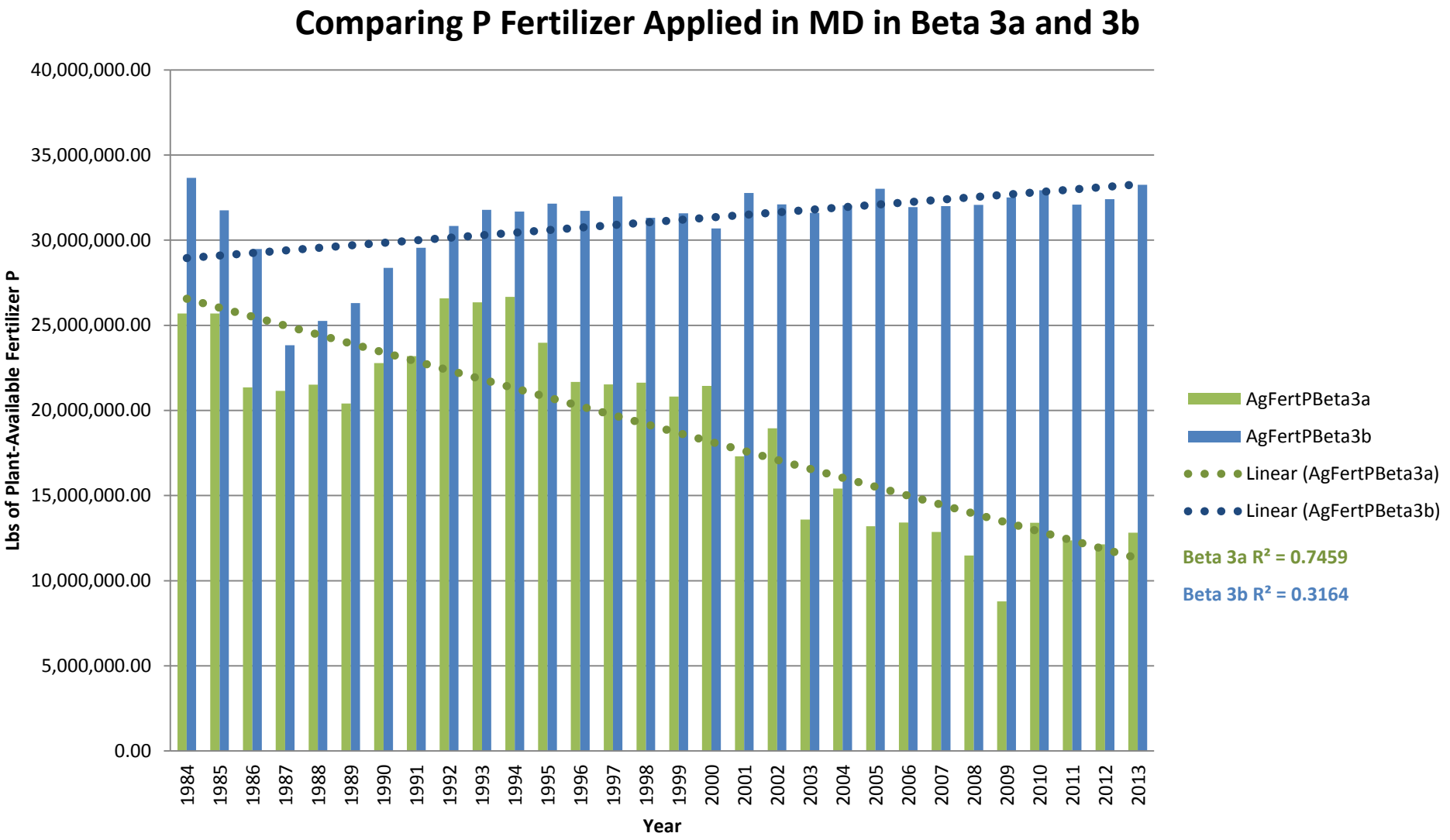

Comparing Plant-Available Inorganic N Applications to Agriculture across CB Watershed
Lbs Inorganic N
700,000,000.00
600,000,000.00
500,000,000.00
400,000,000.00
300,000,000.00
200,000,000.00
100,000,000.00
-
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002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

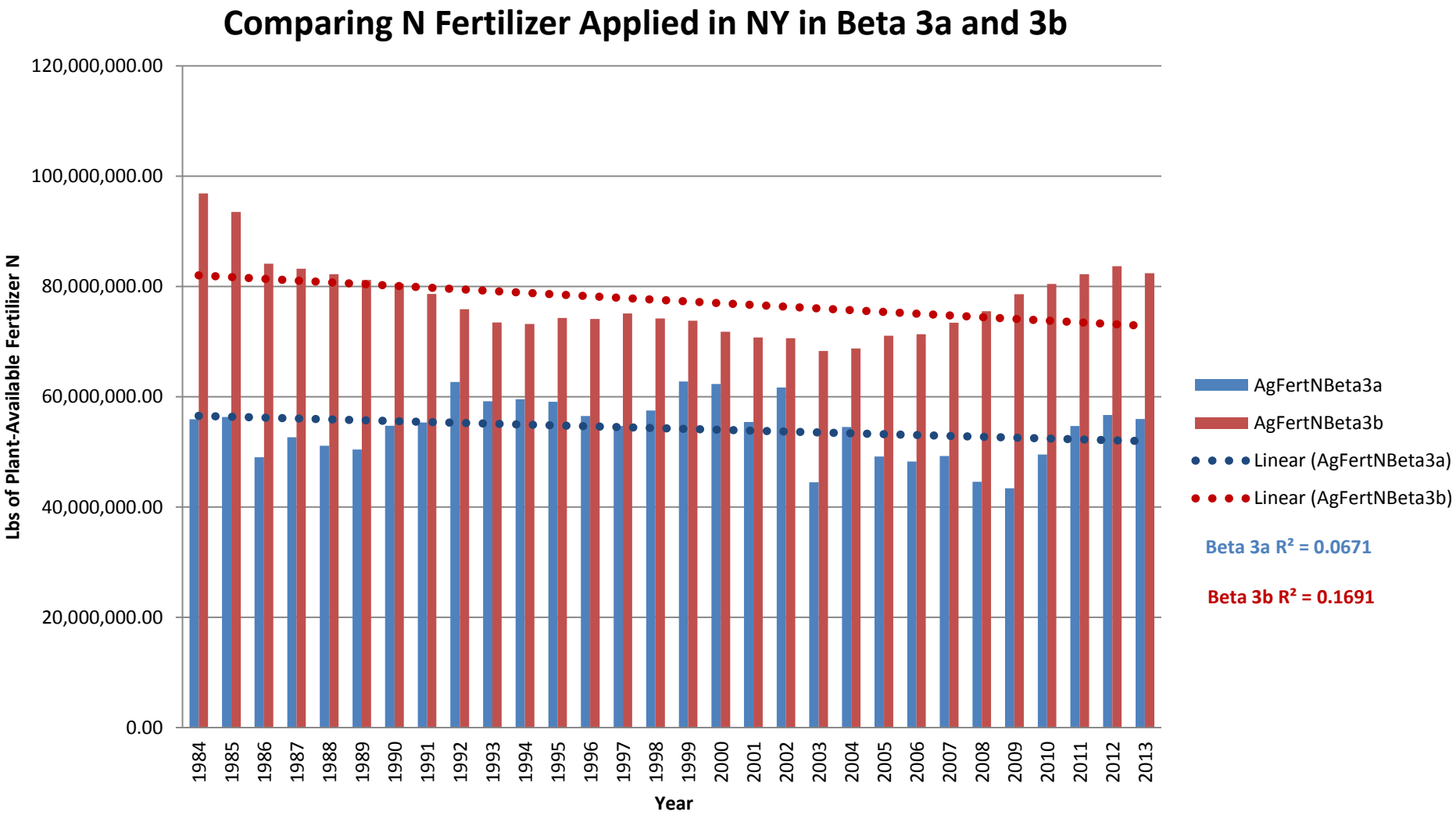

Comparing Plant-Available Inorganic P Applications to Agriculture across CB Watershed
Lbs Inorganic P
250,000,000.00
200,000,000.00
150,000,000.00
100,000,000.00
50,000,000.00
-
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008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


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 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012
Year
AgFertNBeta3a
AgFertNBeta3b
Linear (AgFertNBeta3a)
Linear (AgFertNBeta3b)
Beta 3a R² = 0.1383
Beta 3b R² = 0.6913

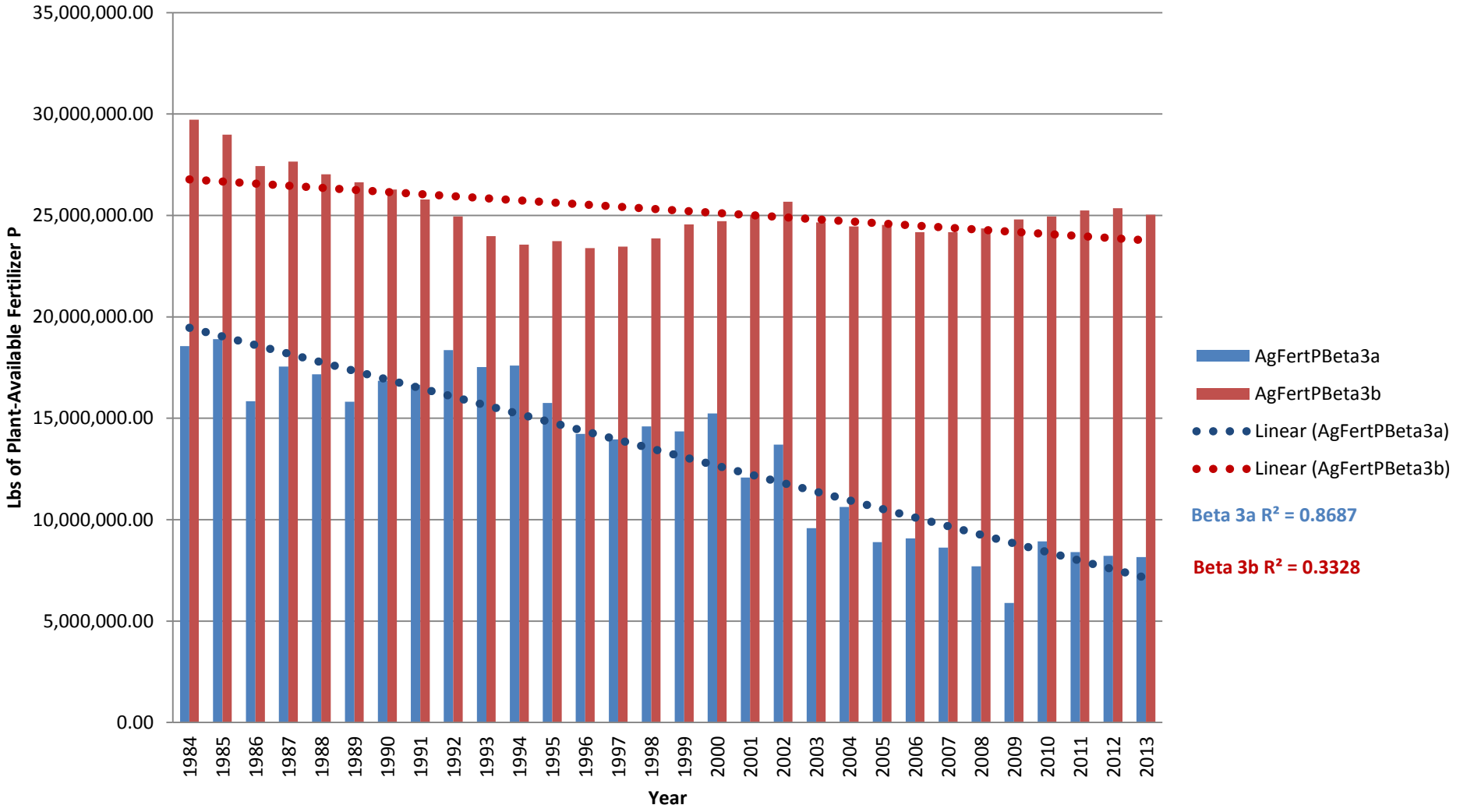

Comparing P Fertilizer Applied in DE in Beta 3a and 3b
Lbs of Plant-Available Fertilizer P
14,000,000.00
12,000,000.00
10,000,000.00
8,000,000.00
6,000,000.00
4,000,000.00
2,000,000.00
0.00
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006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

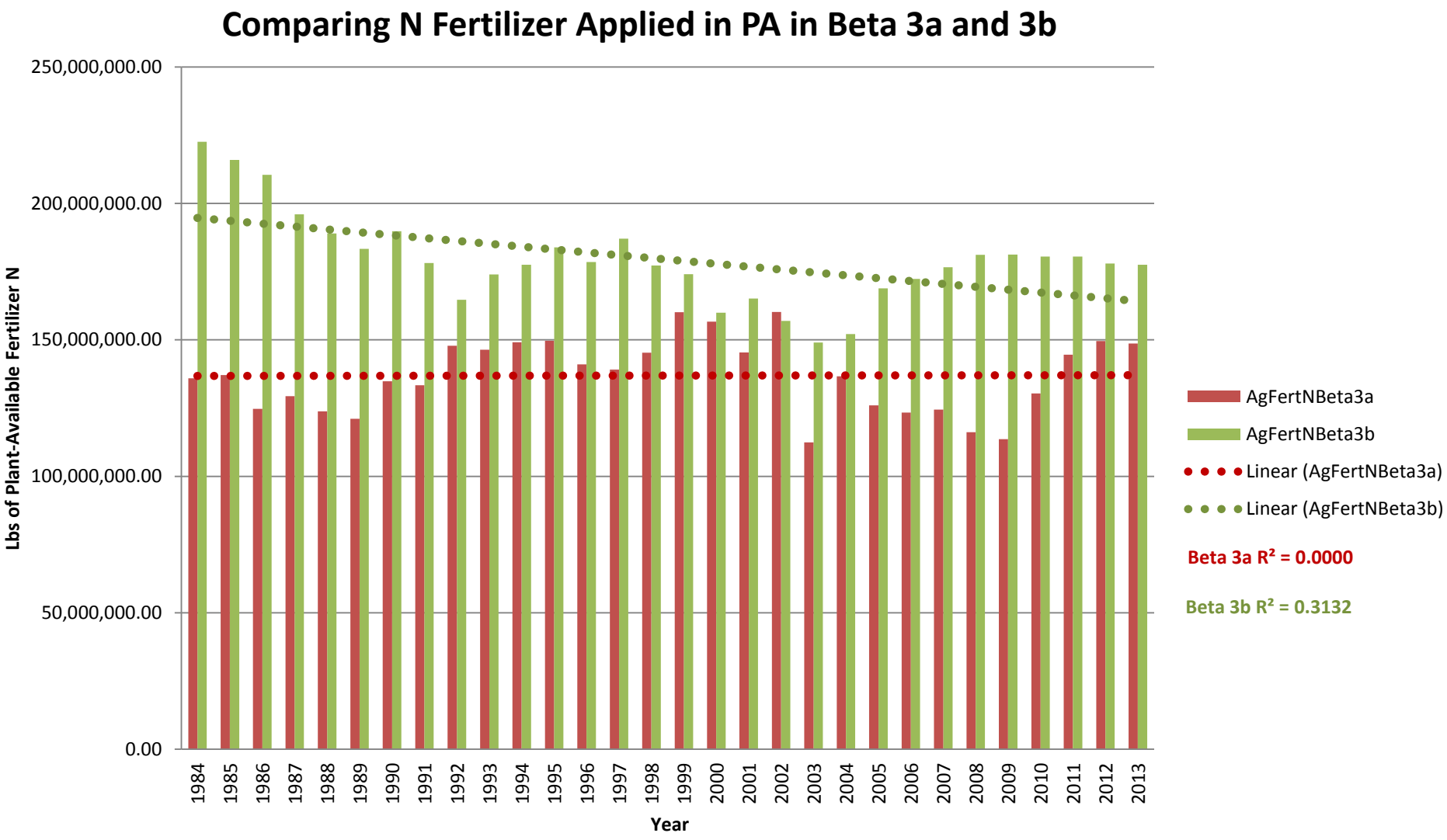

Comparing N Fertilizer Applied in MD in Beta 3a and 3b
140,000,000.00
120,000,000.00
100,000,000.00
80,000,000.00
60,000,000.00
40,000,000.00
20,000,000.00
0.00
Lbs of Plant-Available Fertilizer N
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
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

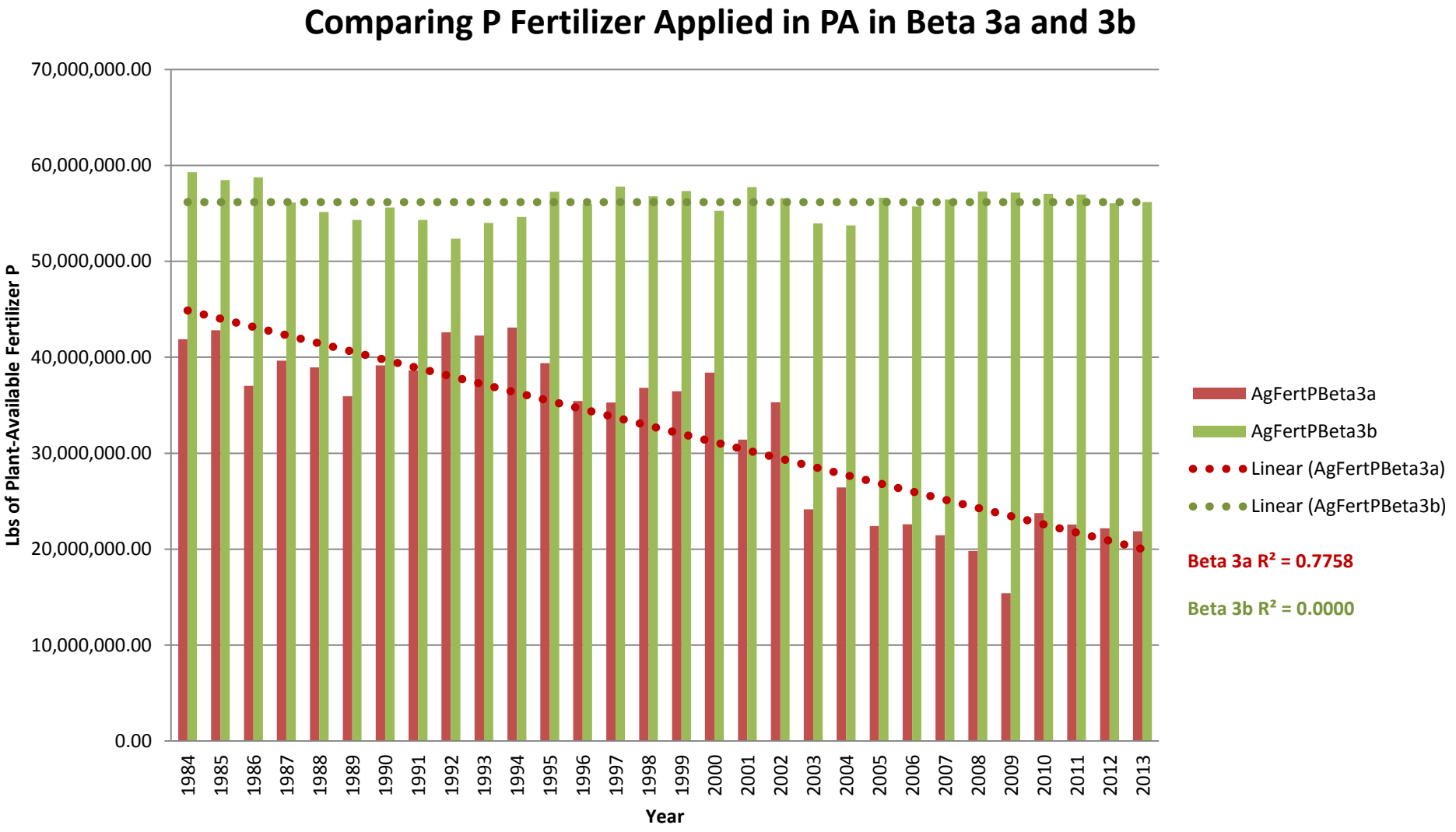

Comparing P Fertilizer Applied in MD in Beta 3a and 3b
Lbs of Plant-Available Fertilizer P
40,000,000.00
35,000,000.00
30,000,000.00
25,000,000.00
20,000,000.00
15,000,000.00
10,000,000.00
5,000,000.00
0.00
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
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

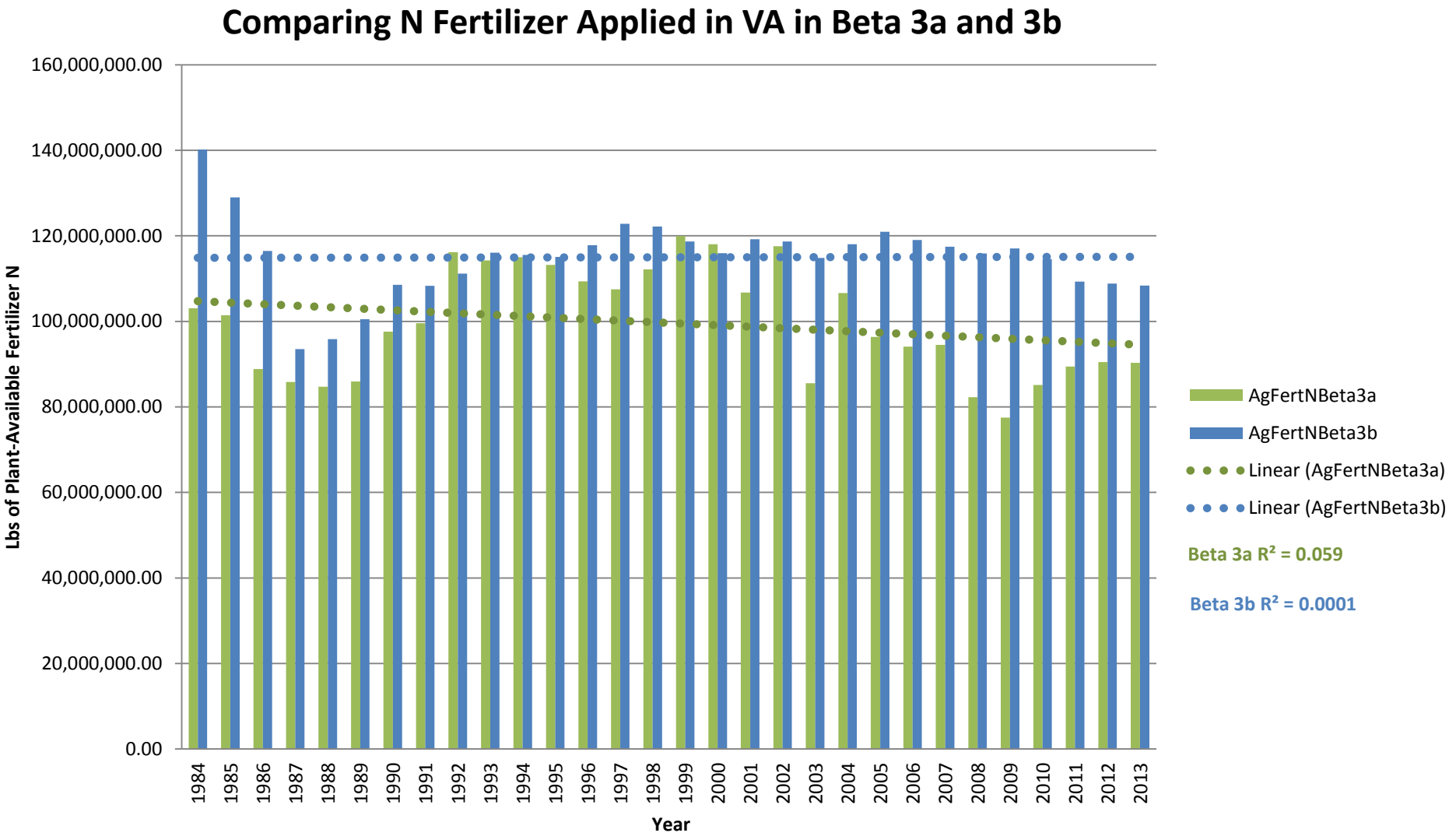

Comparing N Fertilizer Applied in NY in Beta 3a and 3b
120,000,000.00
100,000,000.00
80,000,000.00
60,000,000.00
40,000,000.00
20,000,000.00
0.00
Lbs of Plant-Available Fertilizer N
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
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

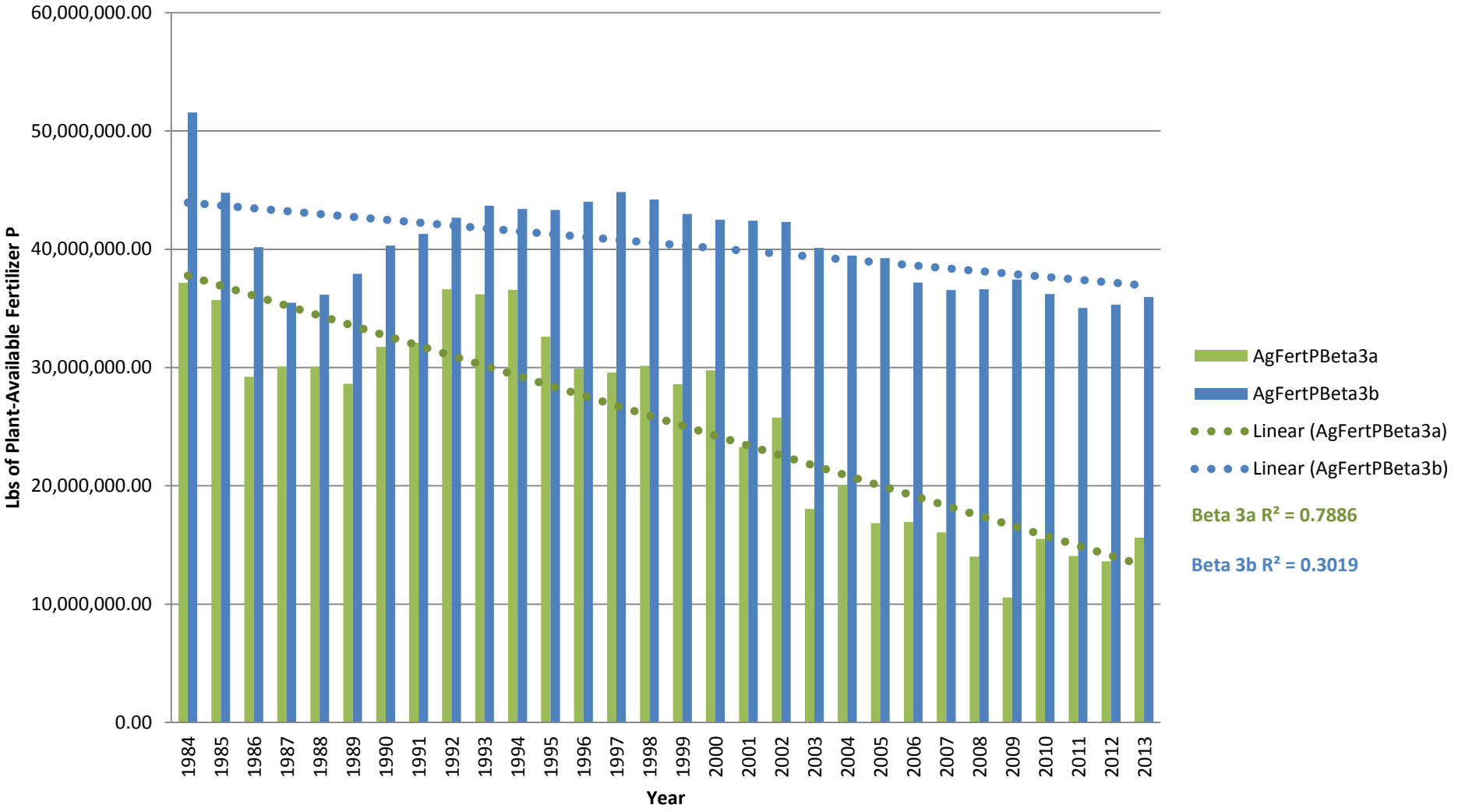


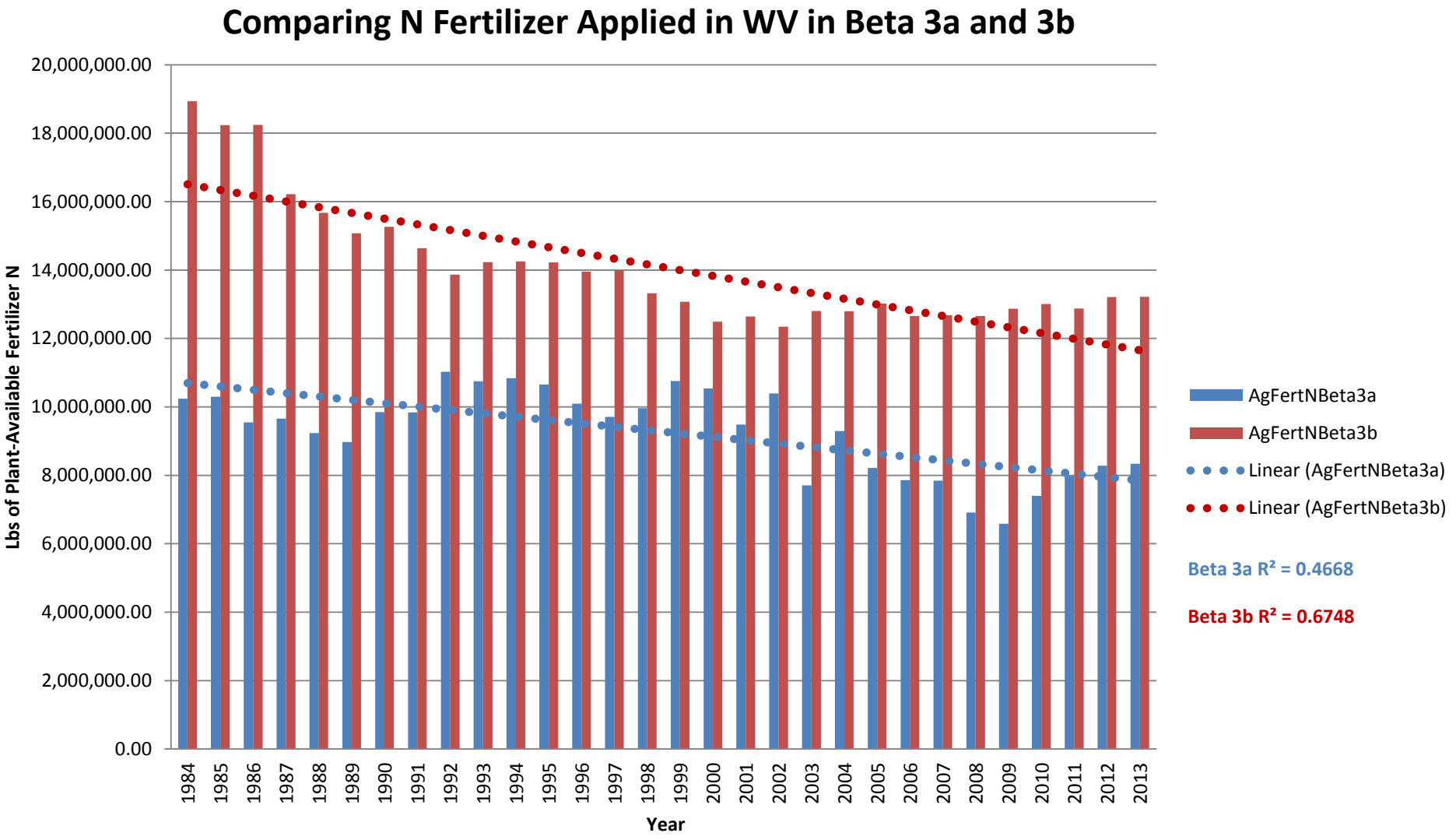

Comparing N Fertilizer Applied in PA in Beta 3a and 3b
250,000,000.00
200,000,000.00
150,000,000.00
100,000,000.00
50,000,000.00
0.00
Lbs of Plant-Available Fertilizer N
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
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
1989
1990
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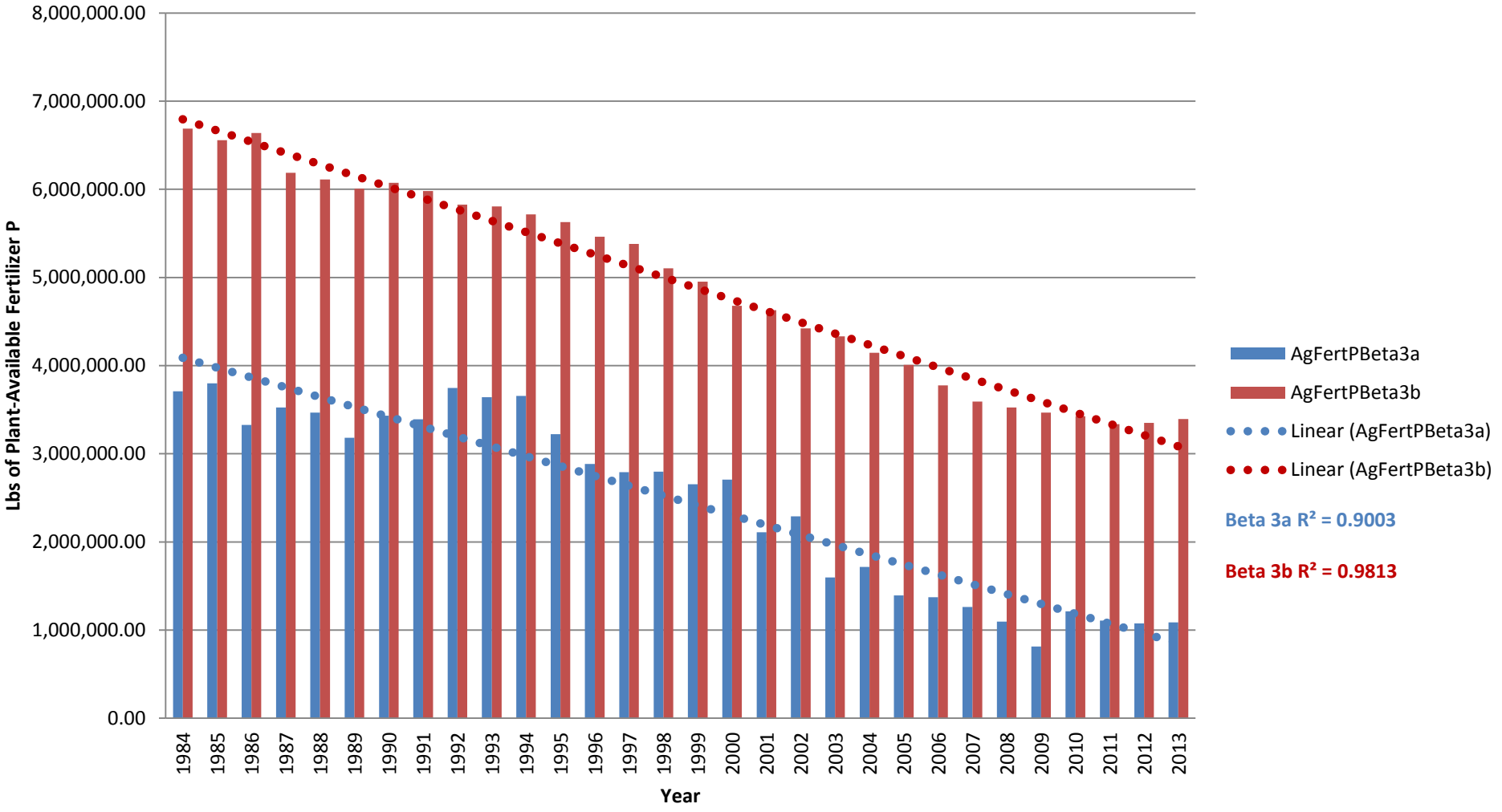
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
AgFertNBeta3a
AgFertNBeta3b
Linear (AgFertNBeta3a)
Linear (AgFertNBeta3b)
Beta 3a R² = 0.4668
Beta 3b R² = 0.6748

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

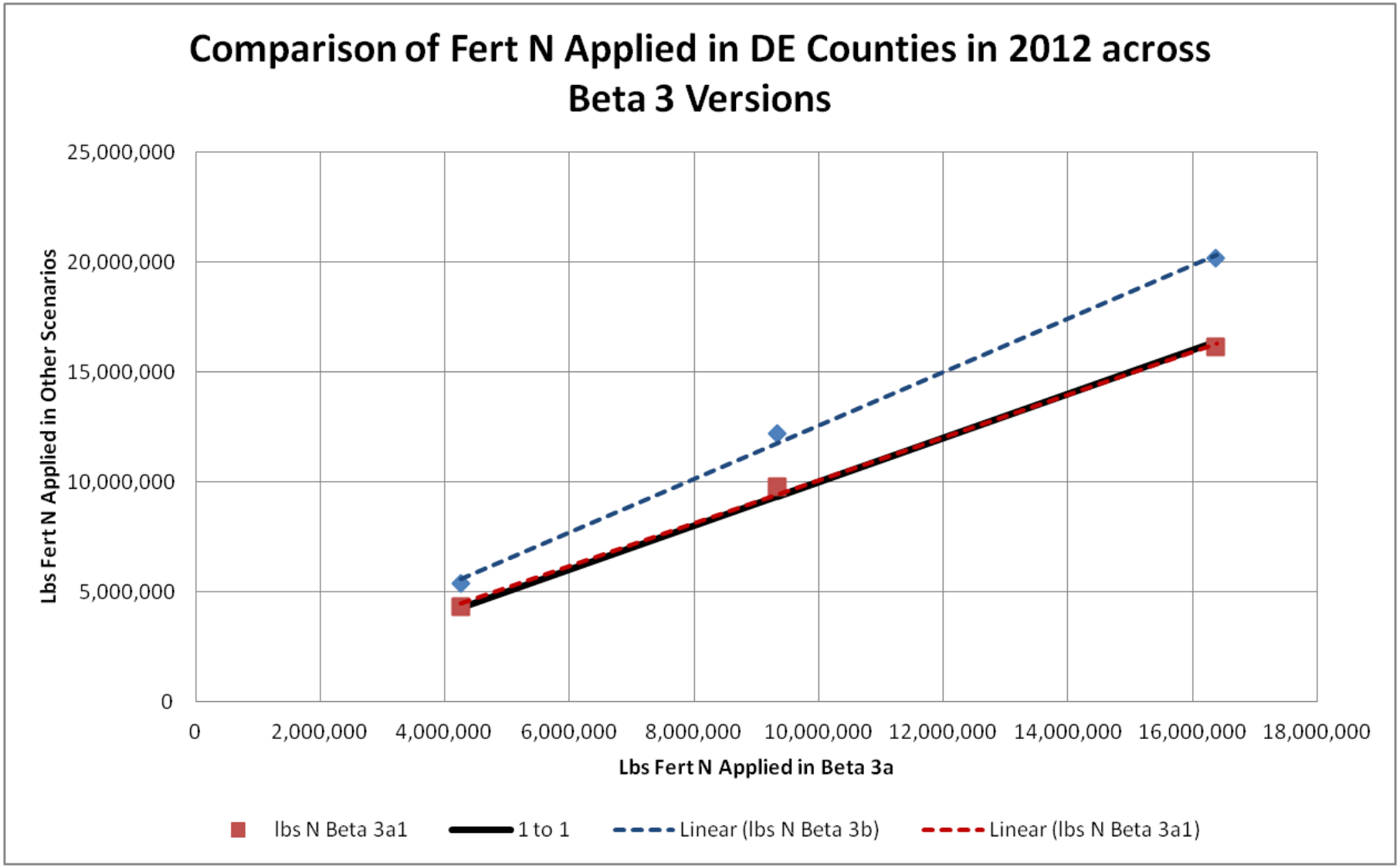


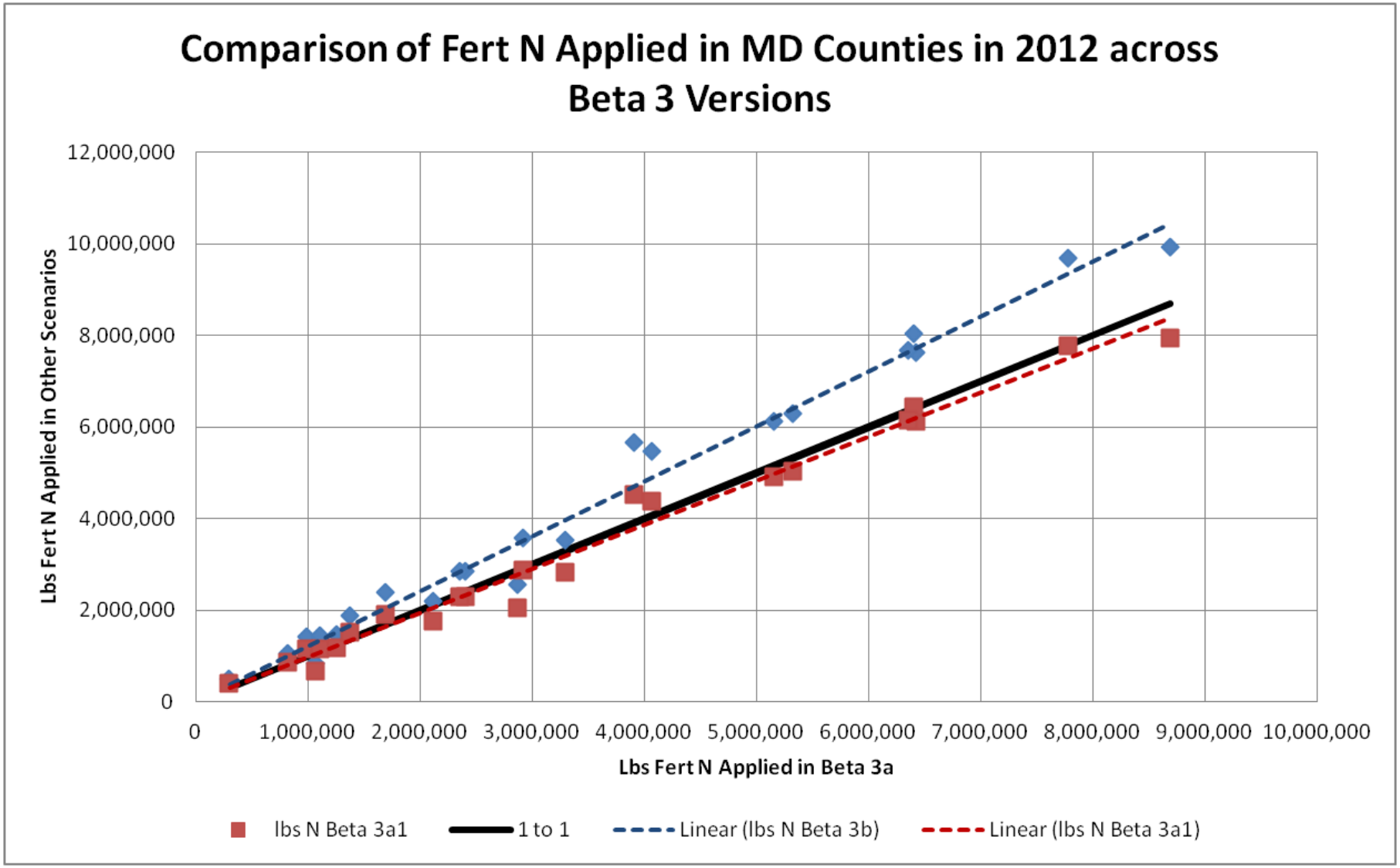
Why is there more N in Backfill (Beta 3b)?

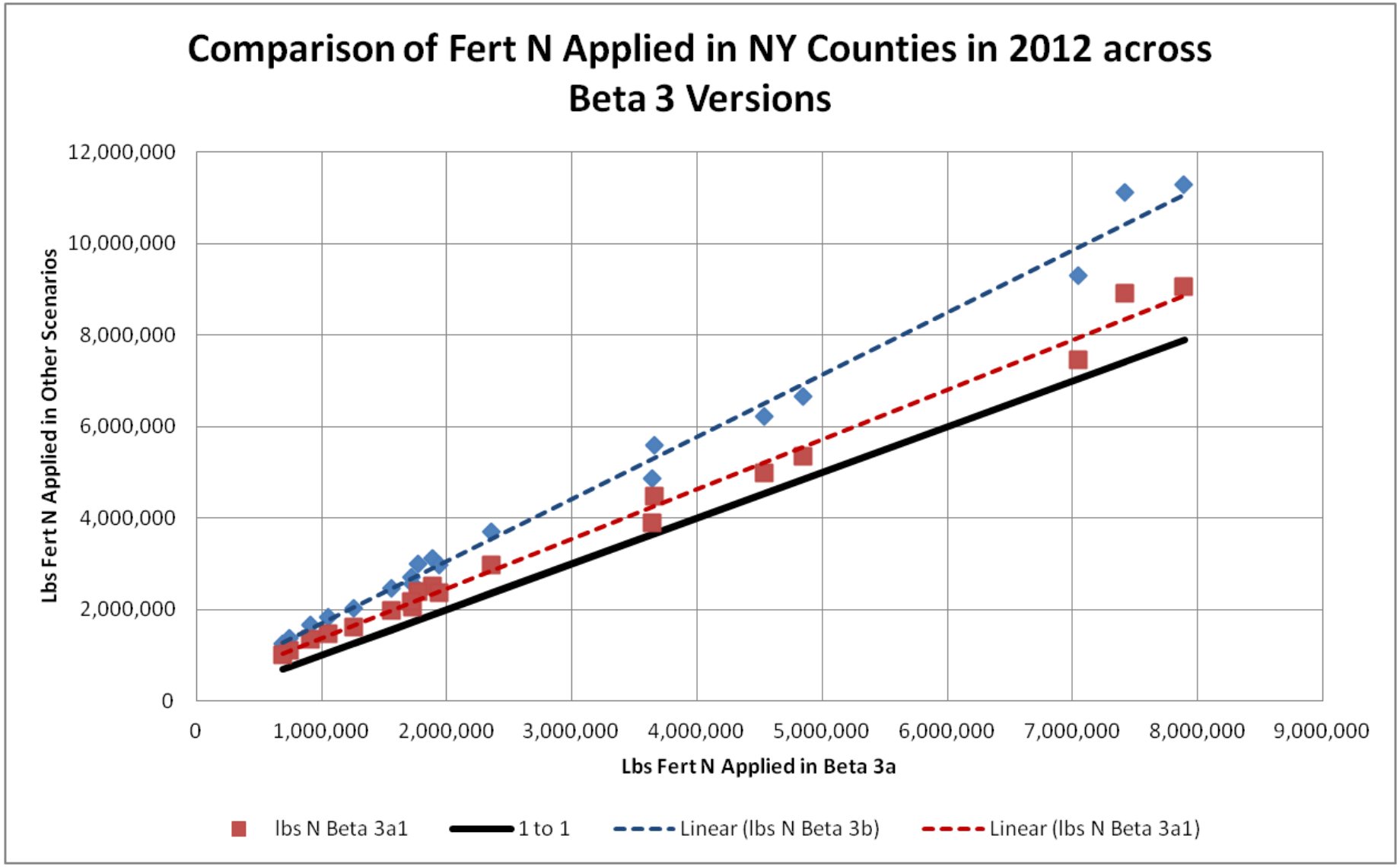
- Backfill (Beta 3b) assumes that every acre of crop, hay and pasture will receive at least the crop application goal.
- Fertilizer Sales (Beta 3a) assumes there is only a finite amount of nitrogen fertilizer within the watershed.
- Fertilizer Sales (Beta 3a) assumes that fertilizer applications are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

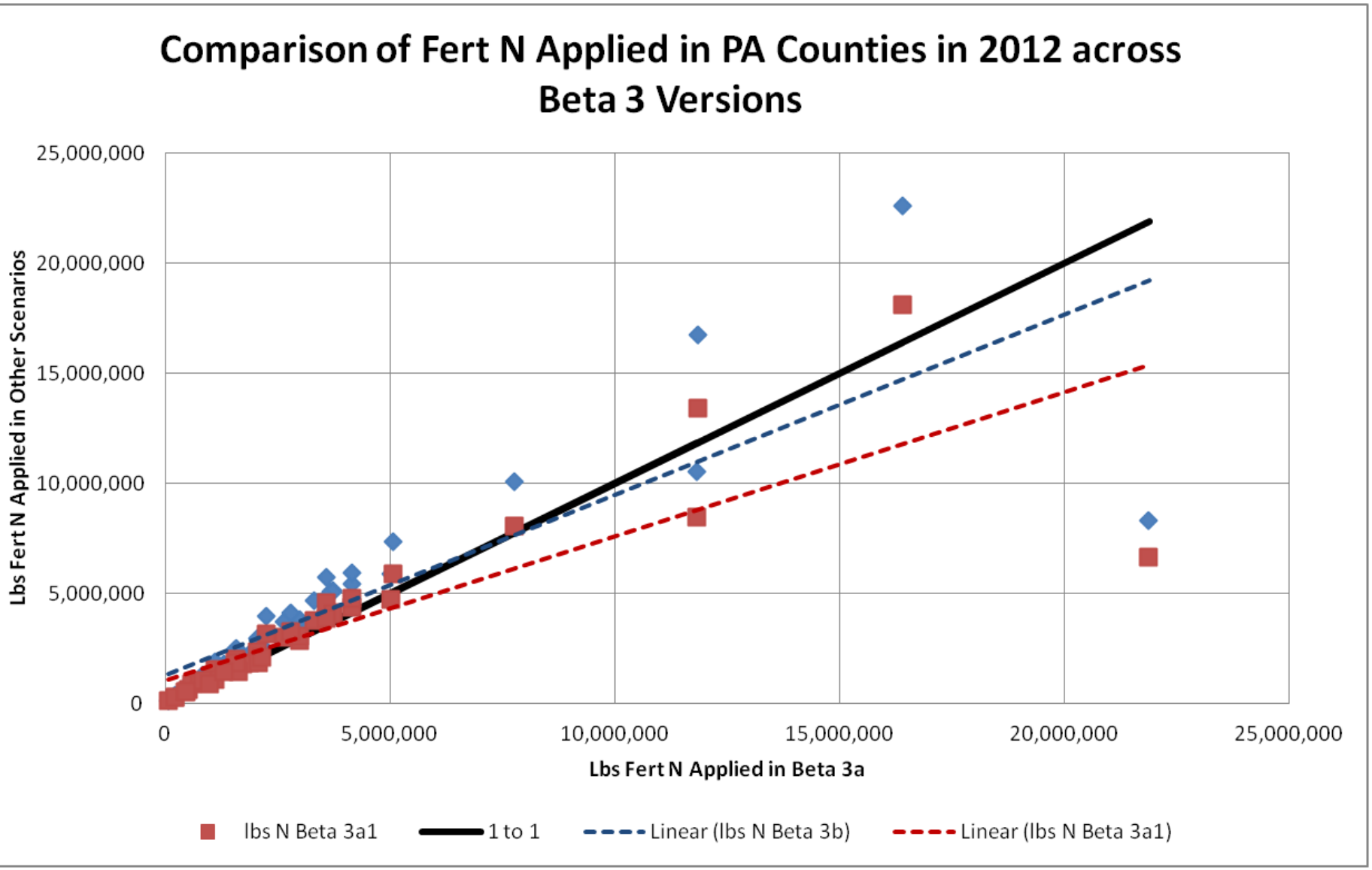
Why is there more P in Backfill (Beta 3b)?

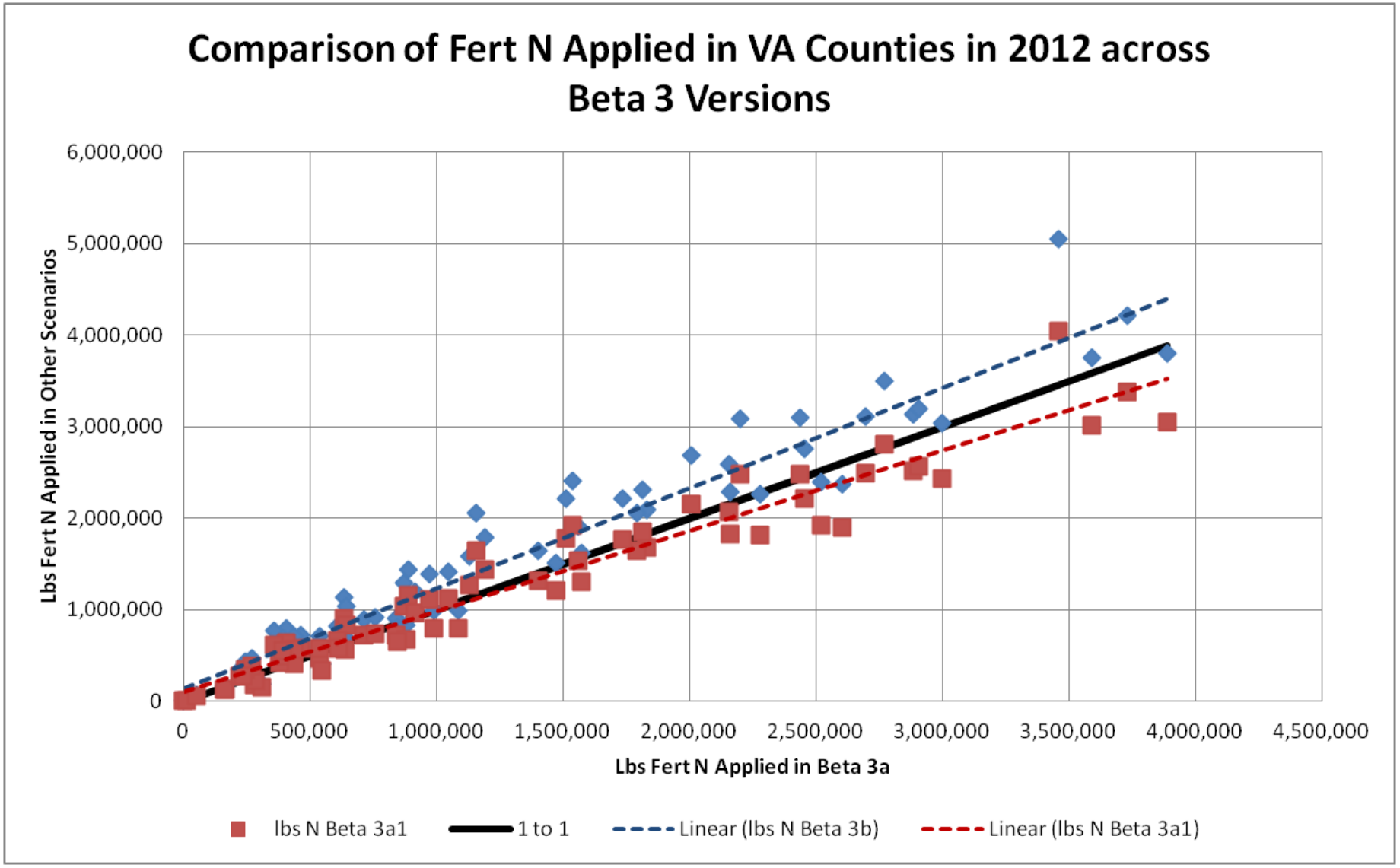
- Backfill (Beta 3b) assumes that every acre of crop, hay and pasture will receive at least the crop application goal.
- Fertilizer Sales (Beta 3a) assumes there is only a finite amount of phosphorus fertilizer within the watershed.
- Every acre of agricultural land in both beta versions are assumed 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.

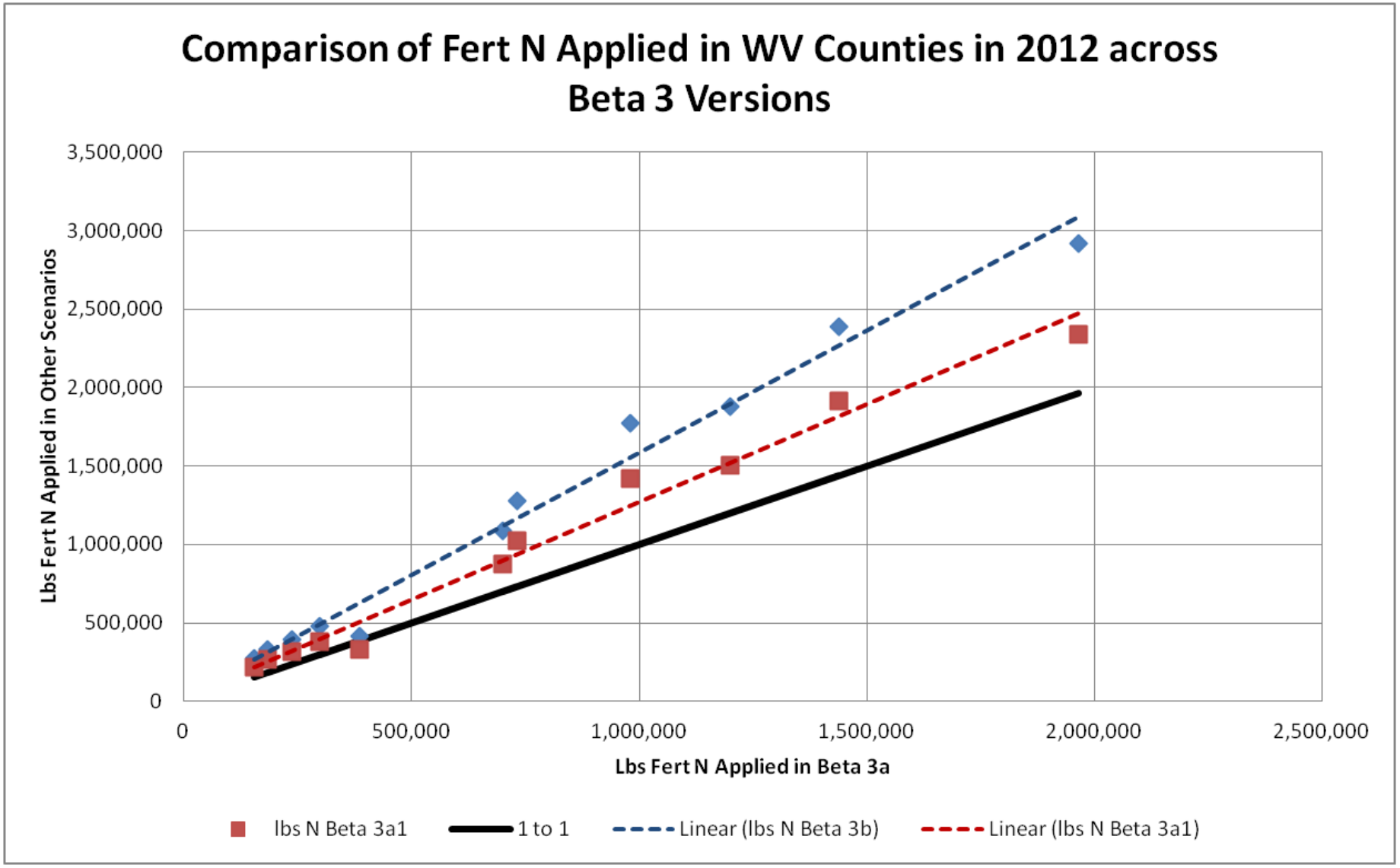

Comparison of Fert N Applied in DE Counties in 2012 across Beta 3 Versions
Lbs Fert N Applied in Other Scenarios
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
0
2,000,000
4,000,000
6,000,000
8,000,000
10,000,000
12,000,000
14,000,000
16,000,000
18,000,000
Lbs Fert N Applied in Beta 3a
lbs N Beta 3a1
1 to 1
Linear (lbs N Beta 3b)
Linear (lbs N Beta 3a1)


Comparison of Fert N Applied in MD Counties in 2012 across Beta 3 Versions
Lbs Fert N Applied in Other Scenarios
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
0
1,000,000
2,000,000
3,000,000
4,000,000
5,000,000
6,000,000
7,000,000
8,000,000
9,000,000
10,000,000
Lbs Fert N Applied in Beta 3a
lbs N Beta 3a1
1 to 1
Linear (lbs N Beta 3b)
Linear (lbs N Beta 3a1)

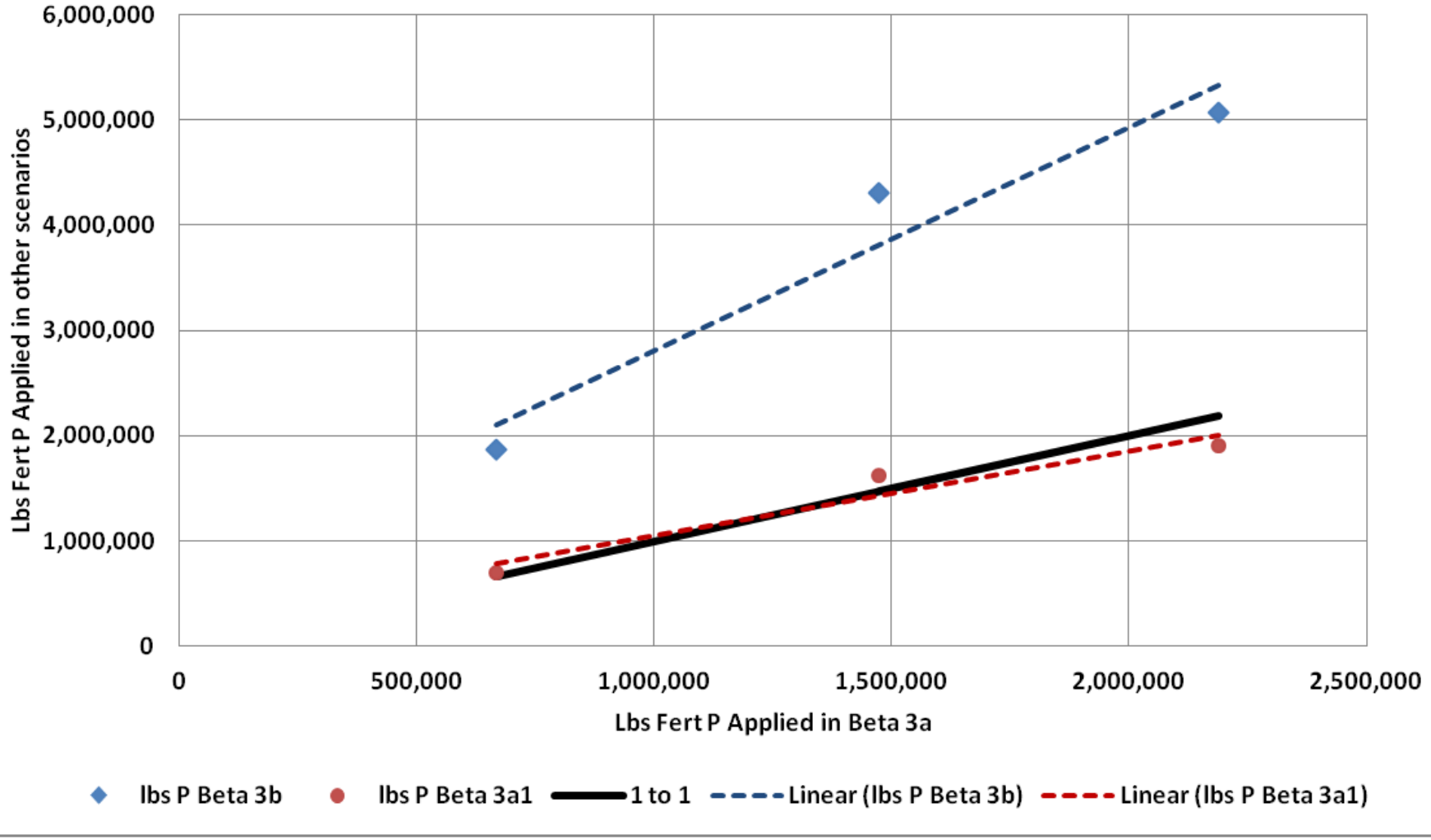

Comparison of Fert N Applied in NY Counties in 2012 across Beta 3 Versions
Lbs Fert N Applied in Other Scenarios
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
0
1,000,000
2,000,000
3,000,000
4,000,000
5,000,000
6,000,000
7,000,000
8,000,000
9,000,000
Lbs Fert N Applied in Beta 3a
lbs N Beta 3a1
1 to 1
Linear (lbs N Beta 3b)
Linear (lbs N Beta 3a1)

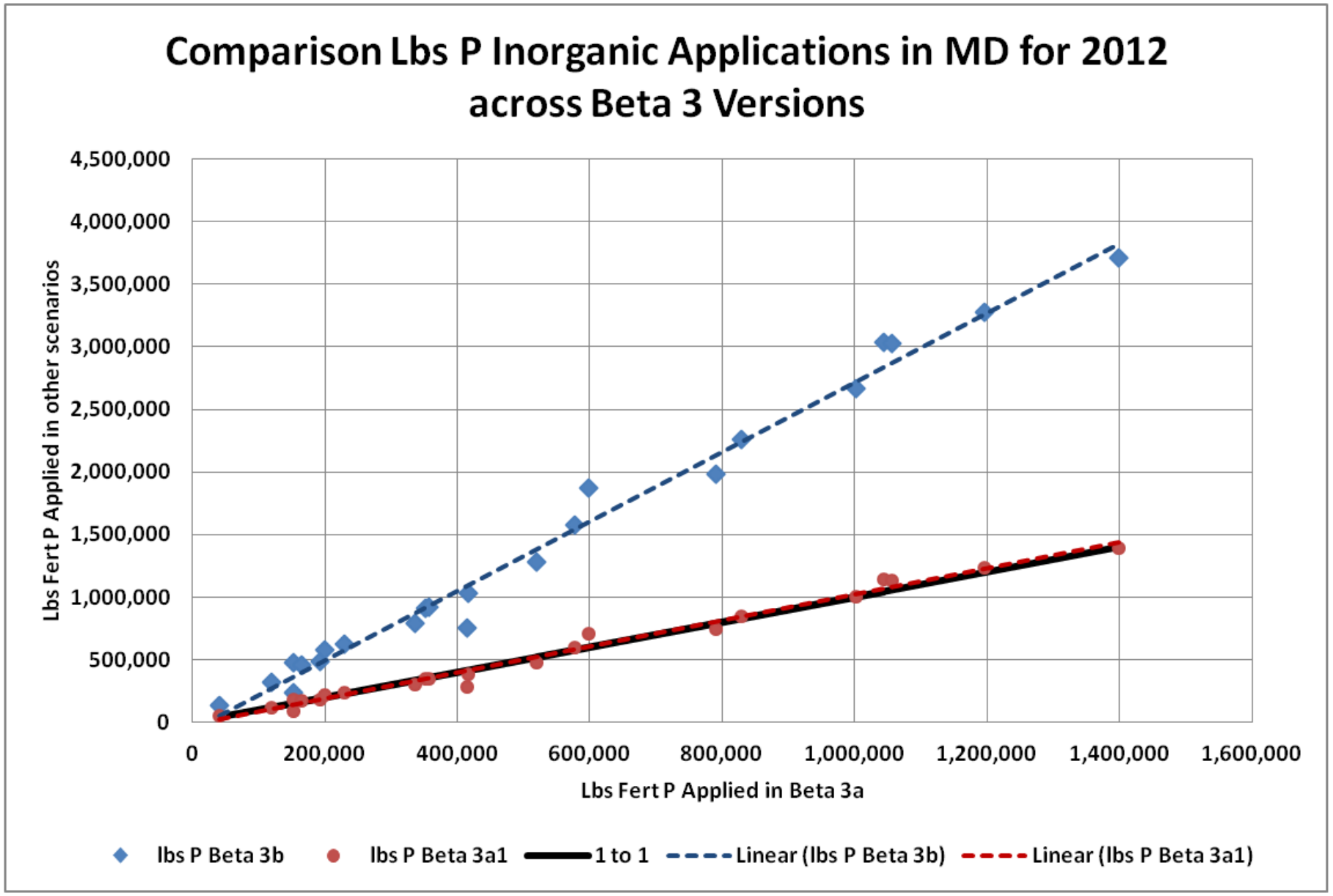

Comparison of Fert N Applied in PA Counties in 2012 across Beta 3 Versions
Lbs Fert N Applied in Other Scenarios
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
0
5,000,000
10,000,000
15,000,000
20,000,000
25,000,000
Lbs Fert N Applied in Beta 3a
lbs N Beta 3a1
1 to 1
Linear (lbs N Beta 3b)
Linear (lbs N Beta 3a1)


Comparison of Fert N Applied in VA Counties in 2012 across Beta 3 Versions
Lbs Fert N Applied in Other Scenarios
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
0
500,000
1,000,000
1,500,000
2,000,000
2,500,000
3,000,000
3,500,000
4,000,000
4,500,000
Lbs Fert N Applied in Beta 3a
lbs N Beta 3a1
1 to 1
Linear (lbs N Beta 3b)
Linear (lbs N Beta 3a1)

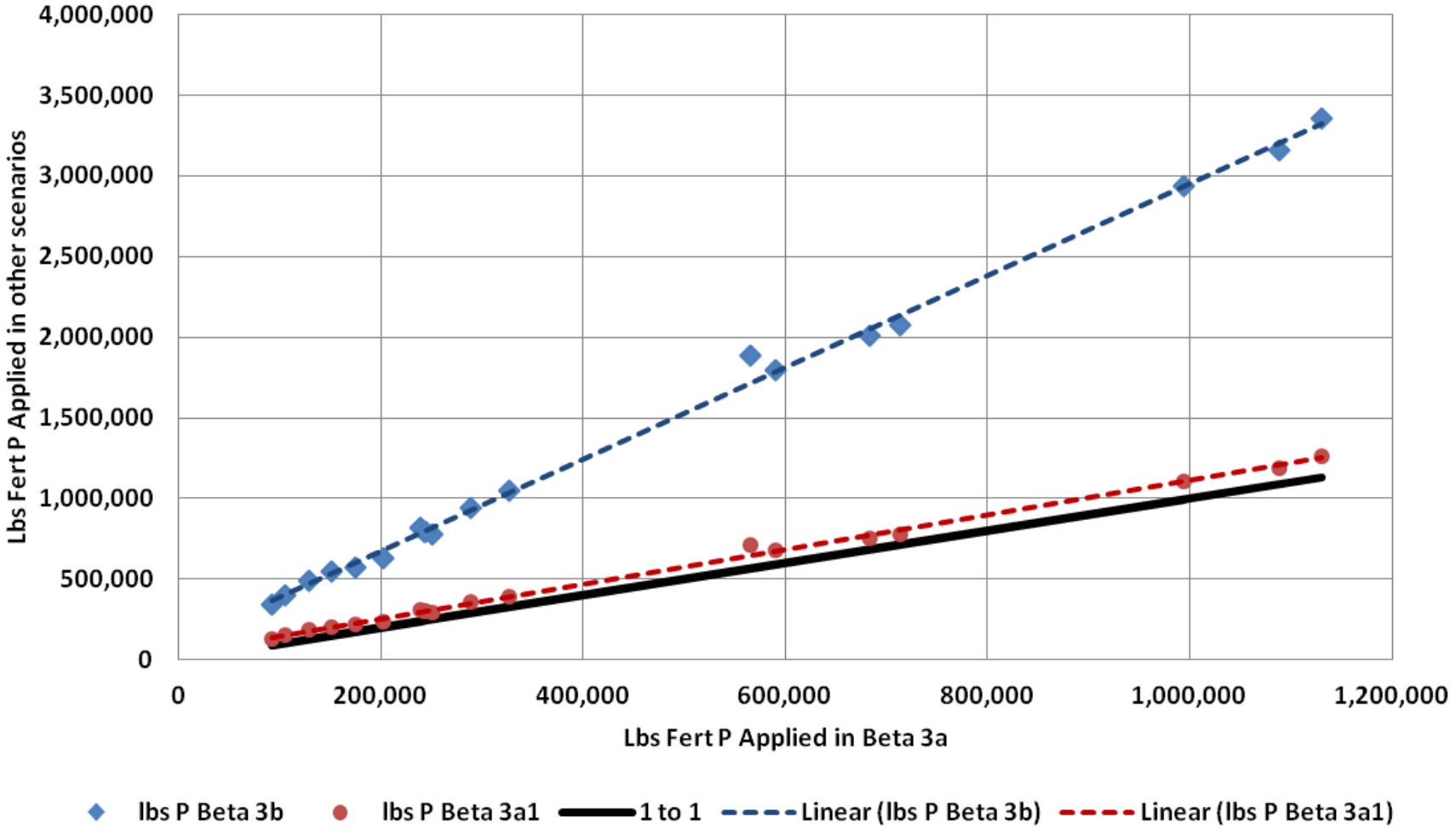

Comparison of Fert N Applied in WV Counties in 2012 across Beta 3 Versions
Lbs Fert N Applied in Other Scenarios
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
0
500,000
1,000,000
1,500,000
2,000,000
2,500,000
Lbs Fert N Applied in Beta 3a
lbs N Beta 3a1
1 to 1
Linear (lbs N Beta 3b)
Linear (lbs N Beta 3a1)

Comparison Lbs P Inorganic Applications in DE for 2012 across Beta 3 Versions

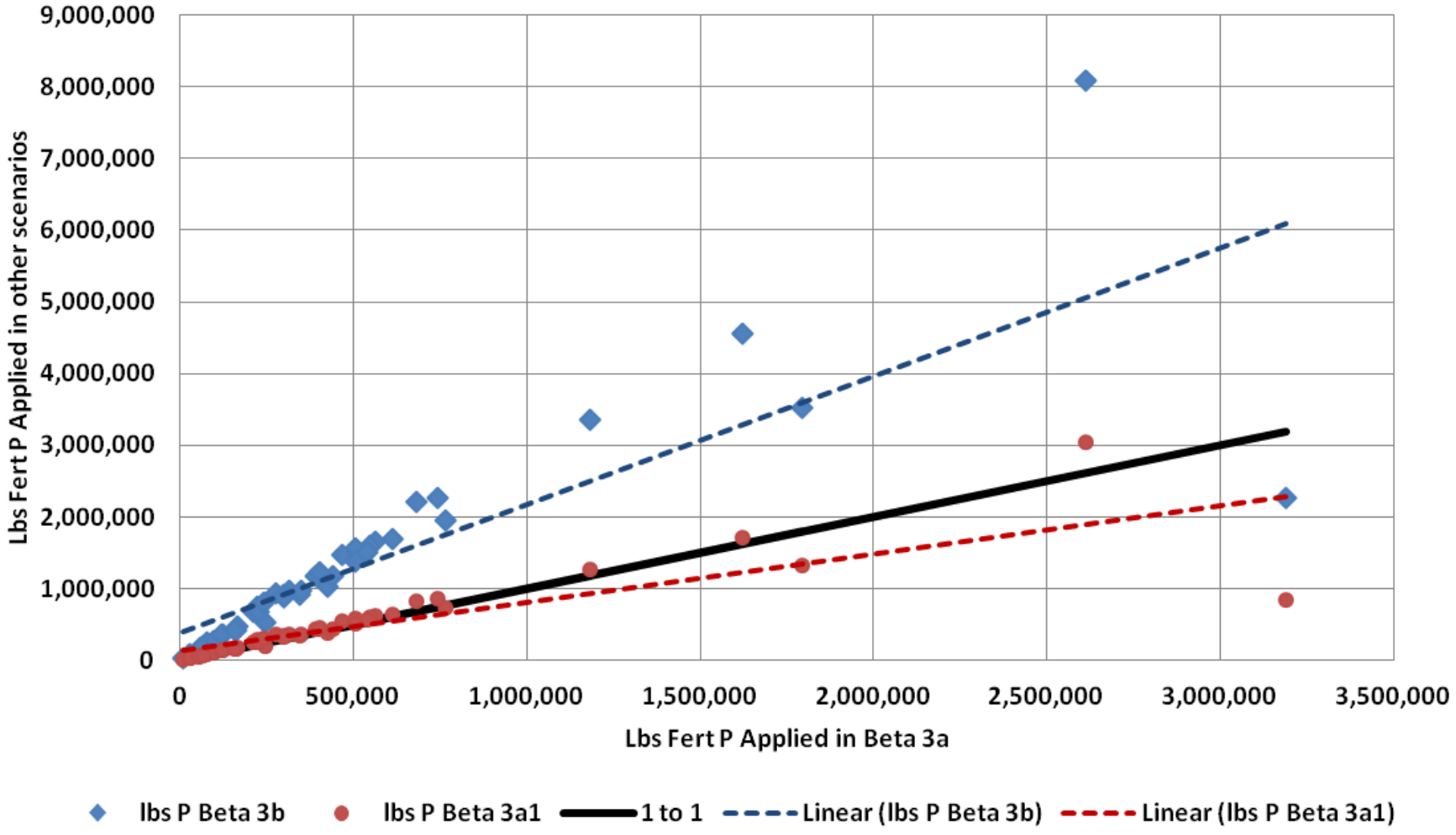


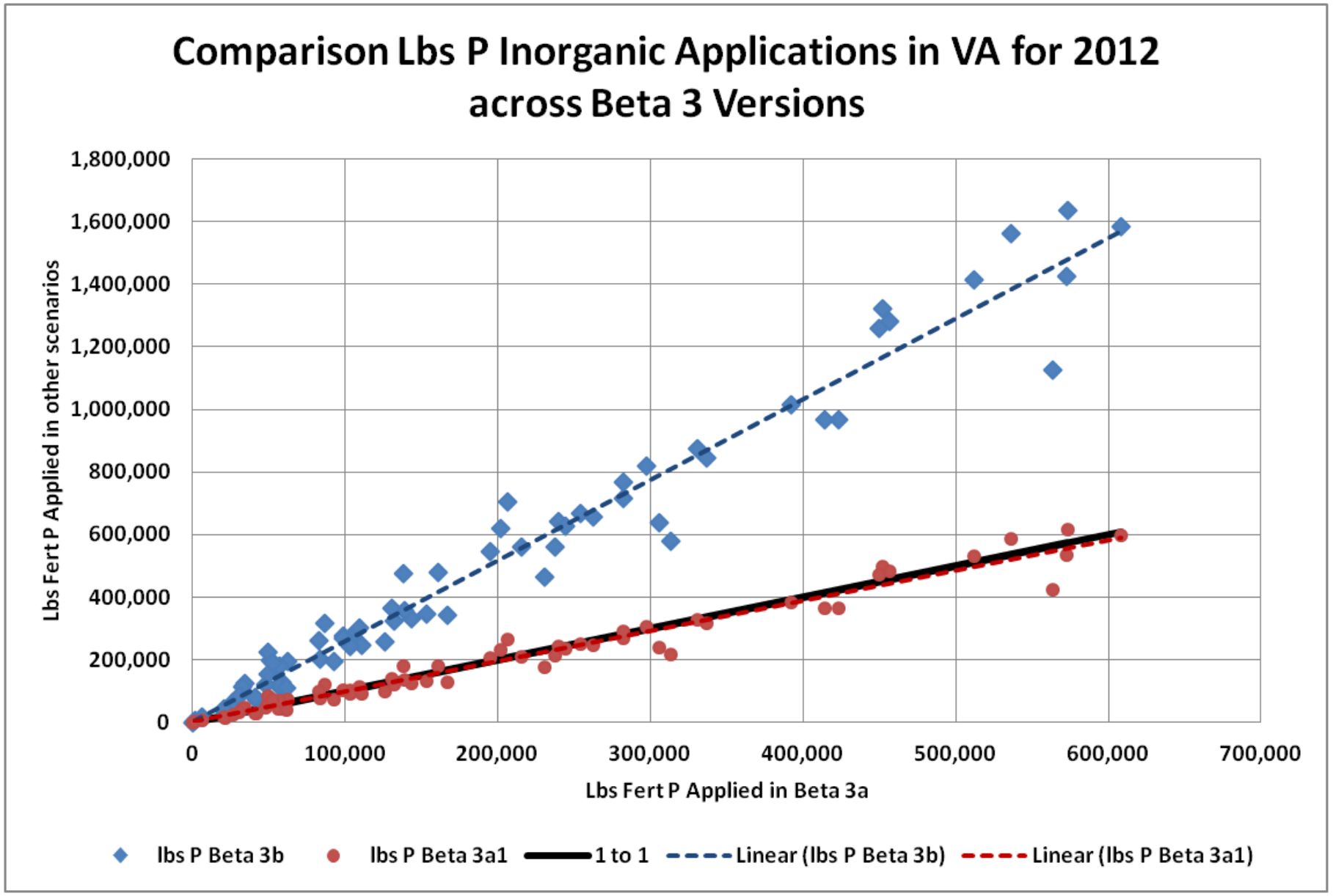

Comparison Lbs P Inorganic Applications in MD for 2012 across Beta 3 Versions
Lbs Fert P Applied in other scenarios
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
0
200,000
400,000
600,000
800,000
1,000,000
1,200,000
1,400,000
1,600,000
Lbs Fert P Applied in Beta 3a
lbs P Beta 3b
lbs P Beta 3a1
1 to 1
Linear (lbs P Beta 3b)
Linear (lbs P Beta 3a1)

Comparison Lbs P Inorganic Applications in NY for 2012 across Beta 3 Versions

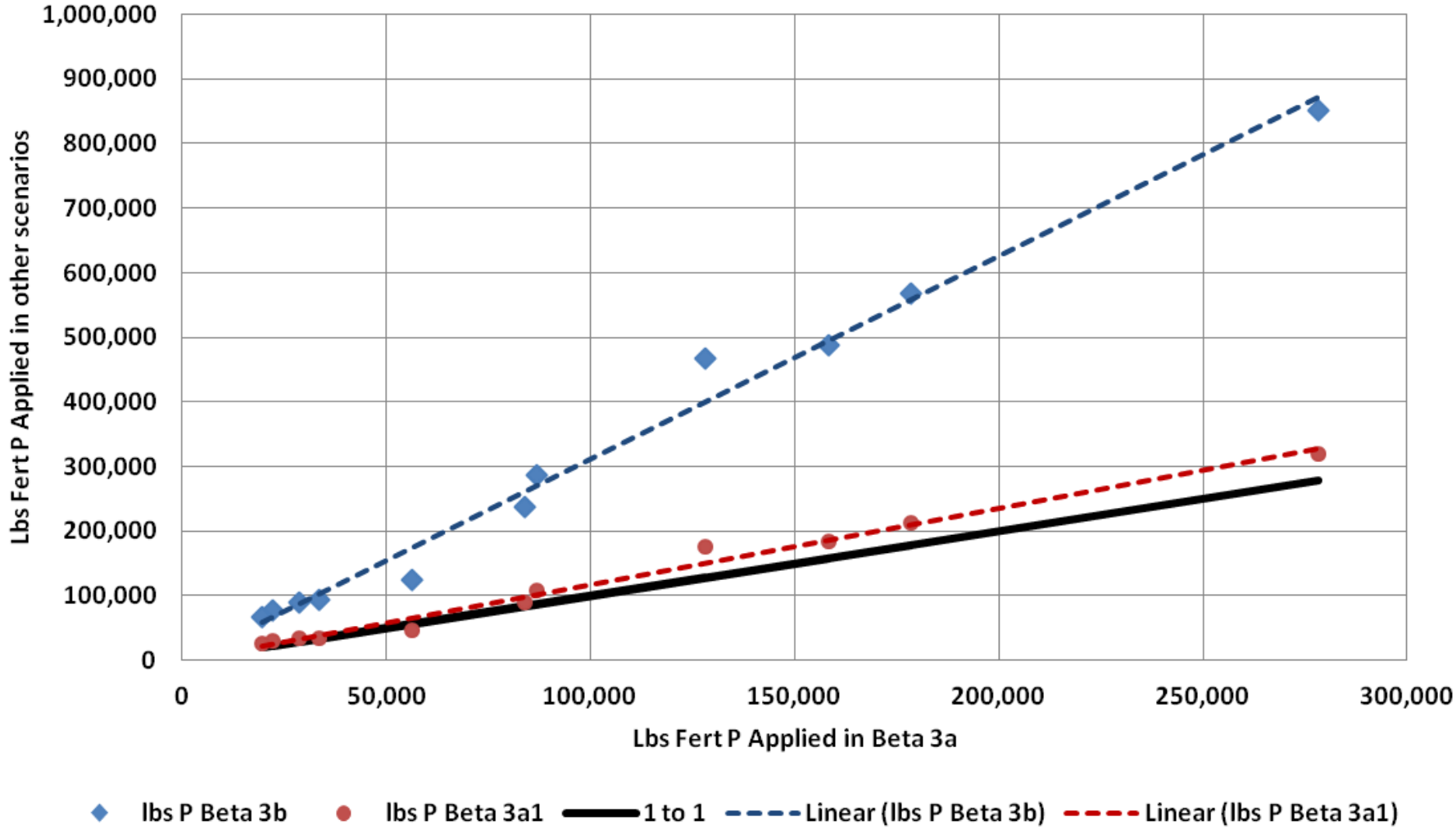


Comparison Lbs P Inorganic Applications in PA for 2012 across Beta 3 Versions




Comparison Lbs P Inorganic Applications in VA for 2012 across Beta 3 Versions
Lbs Fert P Applied in other scenarios
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
lbs P Beta 3b
lbs P Beta 3a1
1 to 1
Linear (lbs P Beta 3b)
Linear (lbs P Beta 3a1)

Comparison Lbs P Inorganic Applications in WV for 2012 across Beta 3 Versions



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 (Fertilizer Sales OR Beta 3a).
  - NO. Fertilizer should be applied to fulfill all unmet crop application goals in a county after manure is applied (Backfill OR Beta 3b).

Follow-up Question

- **If YES, Fertilizer applied in a county should be a fraction of the total fertilizer sold across the watershed, should fertilizer be distributed to counties based upon relative share of remaining crop application goal?**
  - YES (Fertilizer Sales Revised, Beta 3a1)
  - NO. Continue to use both relative share of crop application goal and dollars spent on fertilizer, lime and soil conditioners from the Ag Census to distribute fertilizer (Fertilizer Sales, Beta 3a).