Iowa Nutrient Reduction Strategy - Baseline Load Assessment

December 20, 2018

Big Picture History

- INRS Strategy Development (2011/2012):
  - Benchmark value determination needed
  - Evaluate feasibility of meeting NRS goals

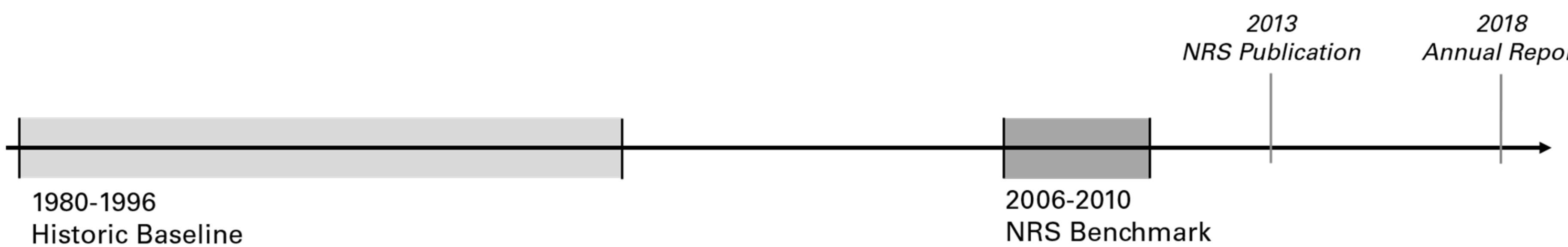
- Hypoxia Task Force (HTF) Targets (2015):
  - Reduce N and P load to Gulf of Mexico 20% by 2025 and 45% by 2035
  - Relative to 1980-1996 "baseline" period

- Iowa Senate File 512 (2018):
  - Baseline condition for evaluating progress toward the HTF and INRS goals shall be calculated for the time period from 1980-1996

Why is this important?

- It establishes a firm baseline to track progress against

Conceptual Timeline



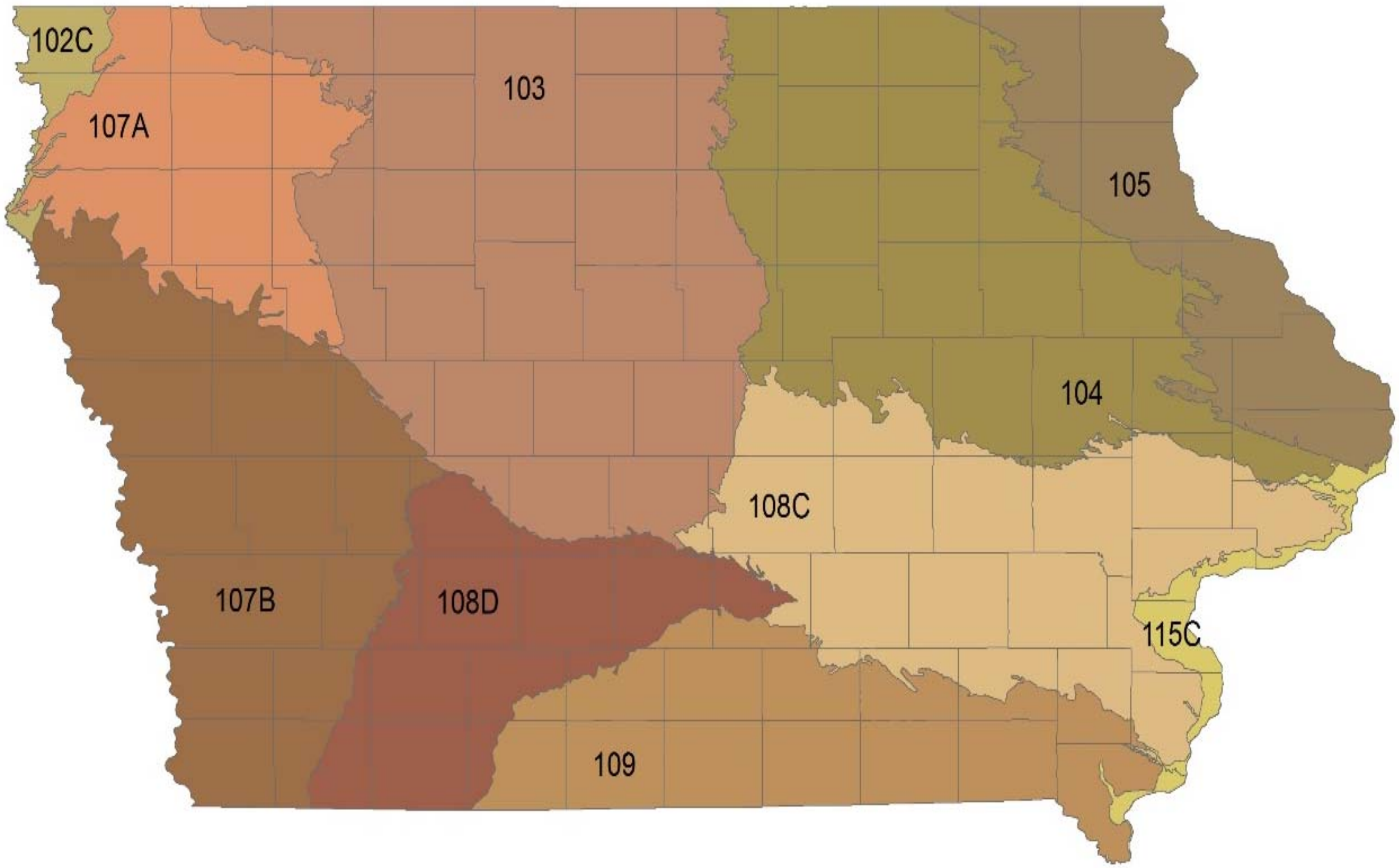
Assessment of the Estimated Non-Point Source Nitrogen and Phosphorus Loading from Agricultural Sources from Iowa During the 1980-96 Hypoxia Task Force Baseline Period

Supported by INREC

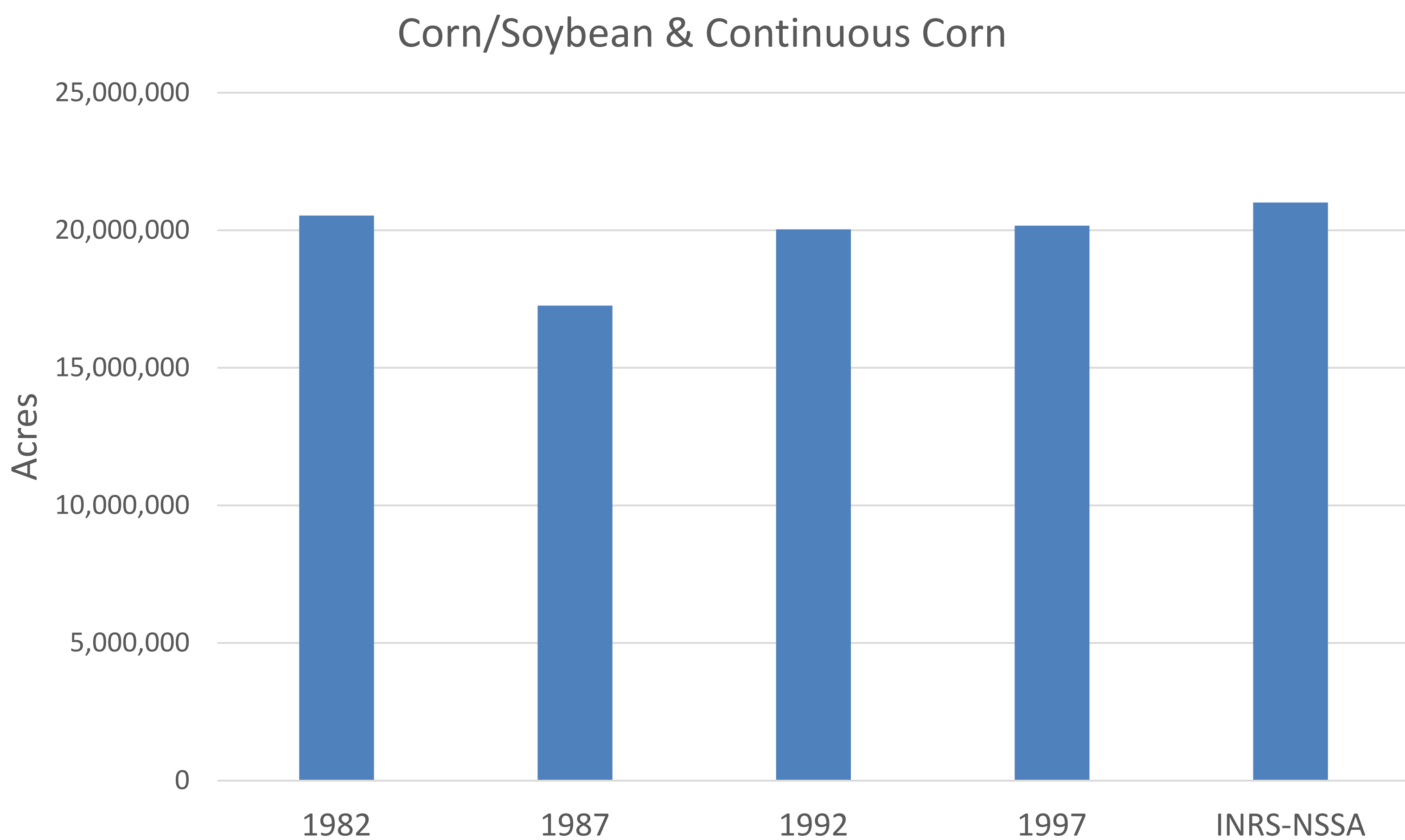
Background

- Followed similar procedures as Iowa Nutrient Reduction Strategy Non-point Source Science Assessment (INRS-NSSA)
  - Same estimated water yield as in Science Assessment
- Commercial fertilizer based on sales numbers
- Manure based on census of ag
- Land use based on census of ag
- Tillage based on CTIC and extrapolation to period before CTIC estimates
- STP based on lab measured values in a couple periods and then changes based on P balance

MLRAs

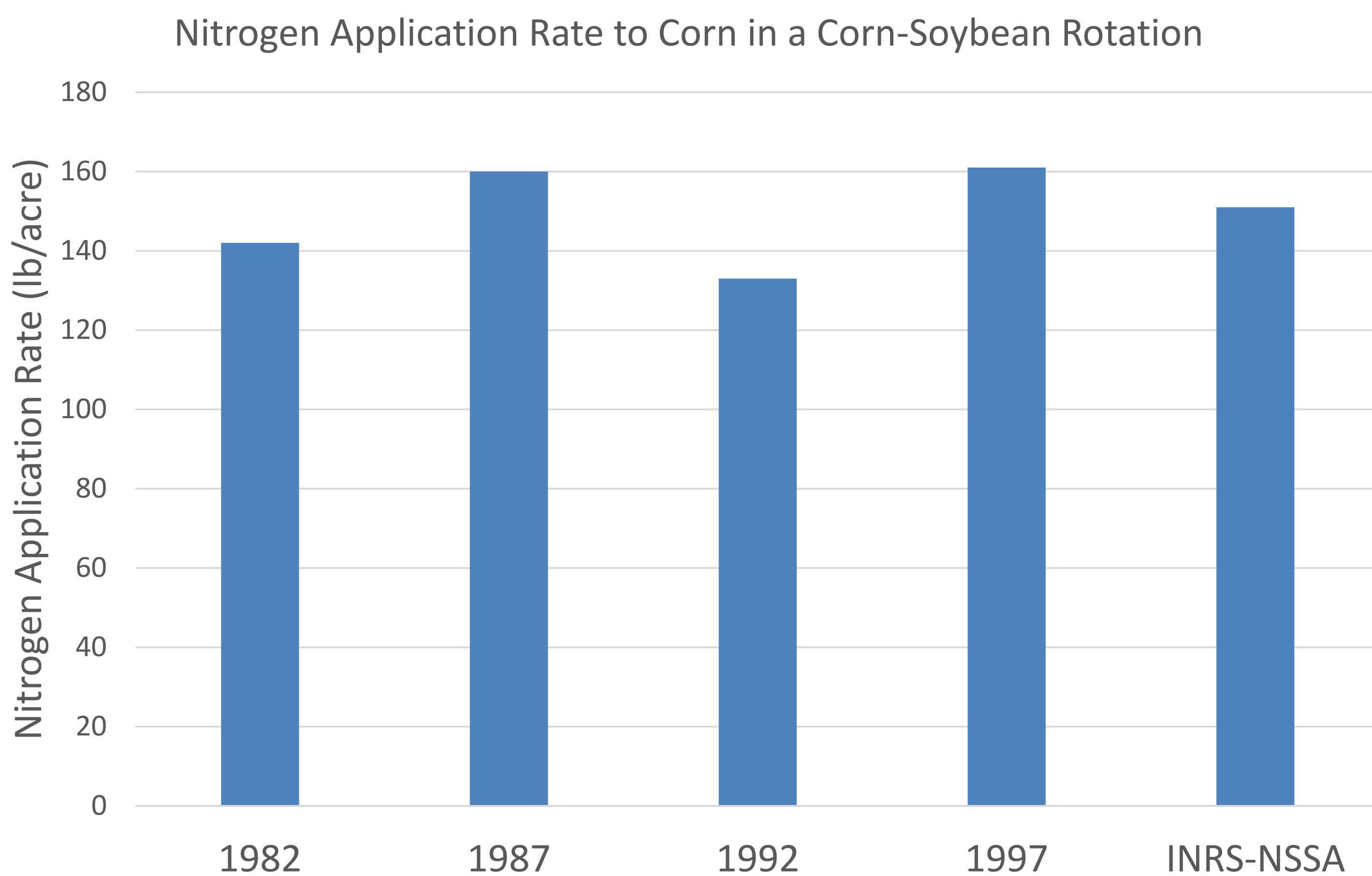


Land Use

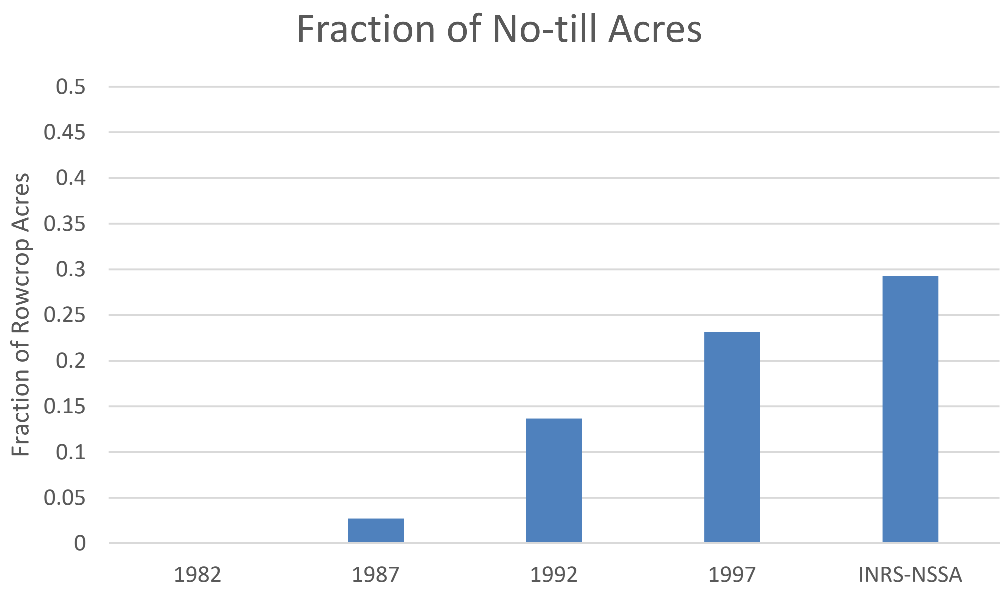


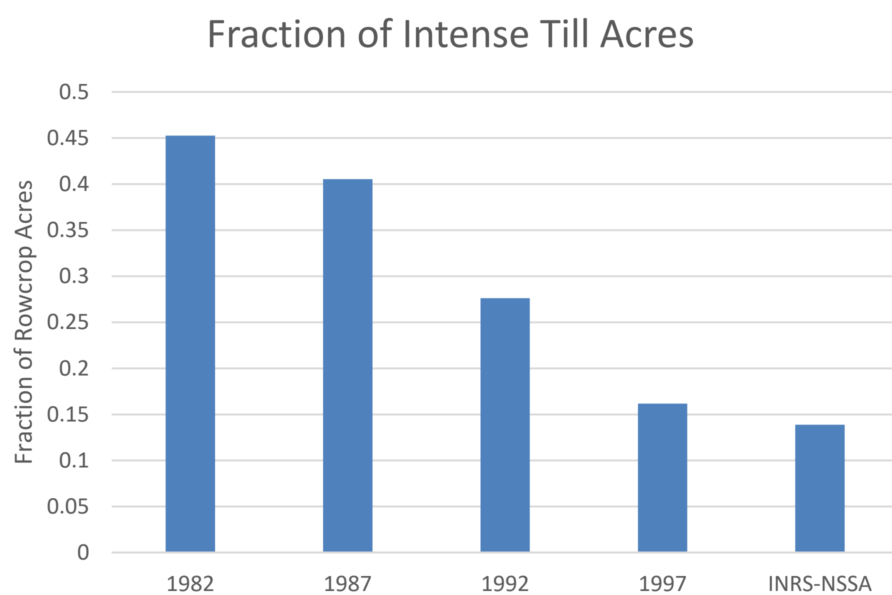
Corn/Soybean & Continuous Corn
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
Acres
1982
1987
1992
1997
INRS-NSSA

Nitrogen Application per Acre

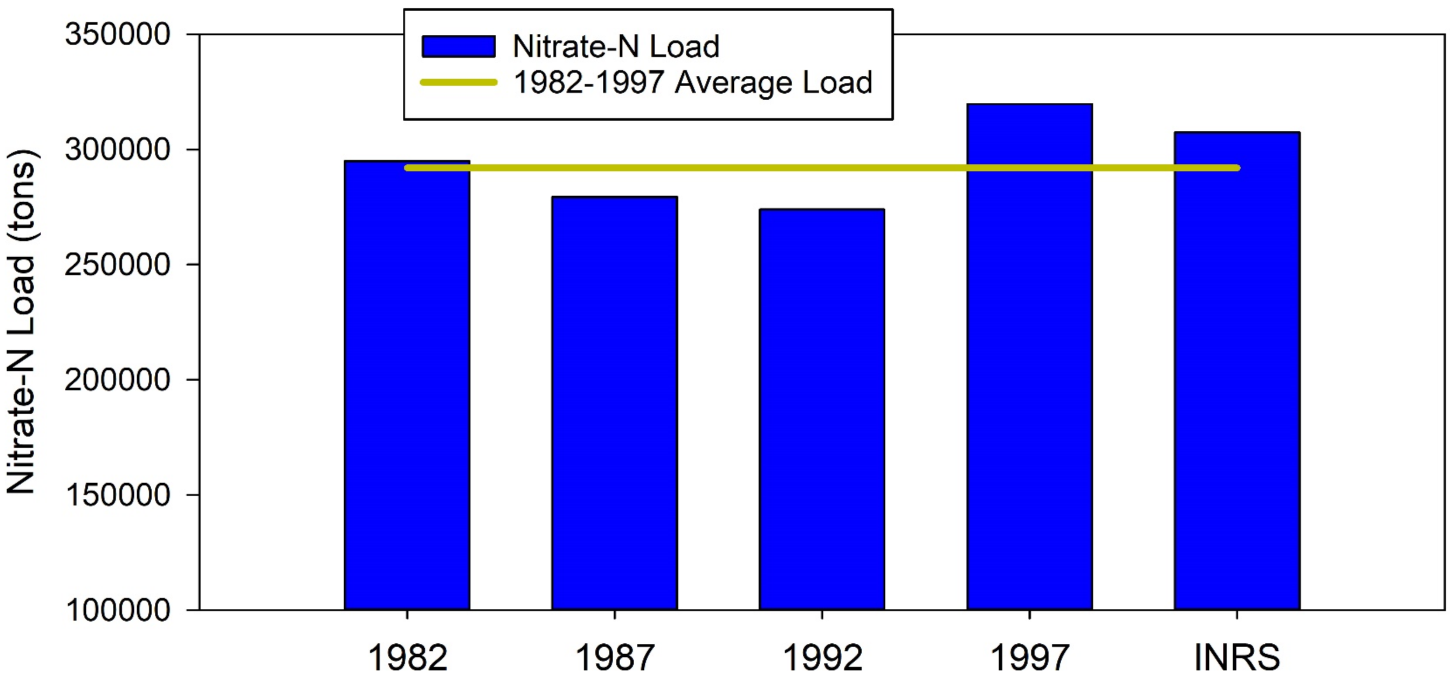


Tillage


Fraction of No-till Acres
Fraction of Rowcrop Acres
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1982
1987
1992
1997
INRS-NSSA


Fraction of Intense Till Acres
Fraction of Rowcrop Acres
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1982
1987
1992
1997
INRS-NSSA

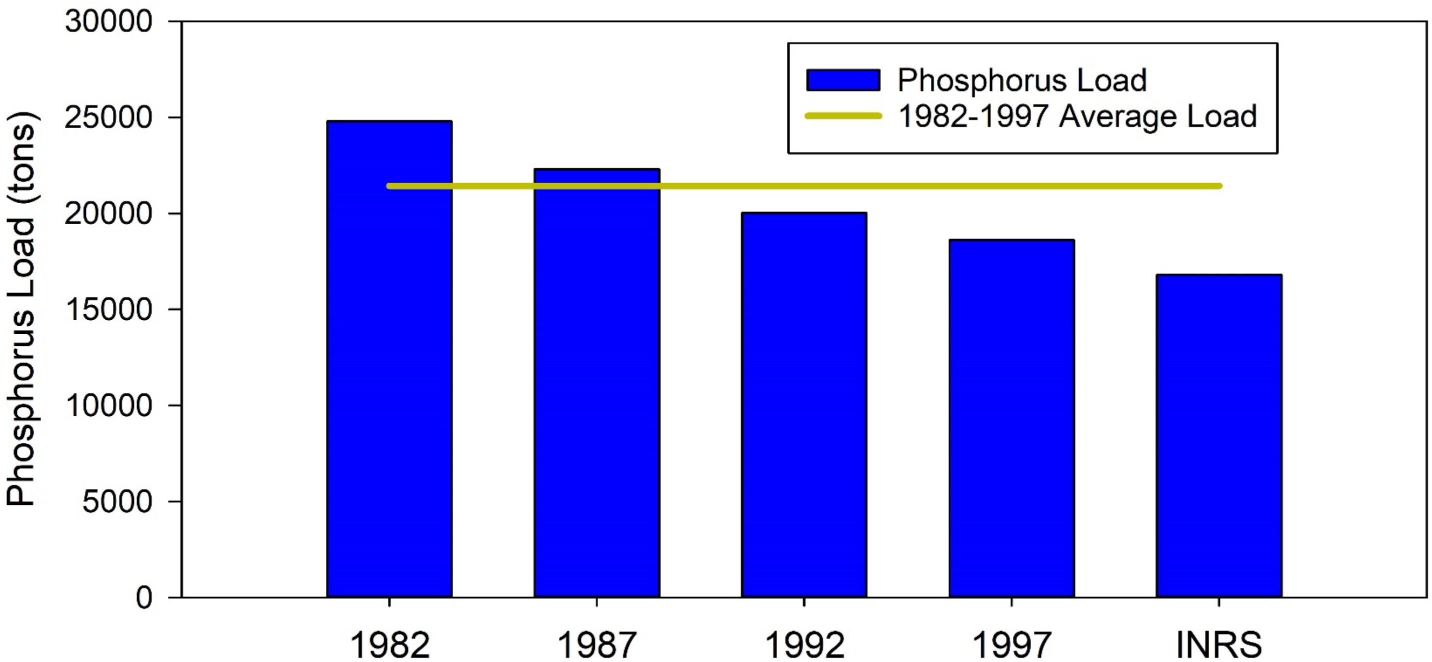
Estimated Nitrogen Load



- 1982-1997 Average Load – 292,000 tons
- NRS Load – 307,000 tons
- 5% increase

Nitrogen loads indirectly include point sources

Phosphorus Load



- 1982-1997 Average Load – 21,436 tons
- NRS Load – 16,800 tons
- 22% decrease

Field to stream P estimate

Summary

Nutrient	1980-96 Average Load (Tons)	INRS-NSSA Load (Tons)	% Change From 1980-96 to INRS-NSSA
Nitrate-N	292,022	307,449	5% Increase
Phosphorus	21,436	16,800	22% Decrease

Limitation and Future Needs

- Did not include stream bank contribution to phosphorus – Active area of research with INRC
- Assumed same level of structural practice implementation as INRS-NSSA
  - Future BMP mapping projects may impact P load estimation
- Assumed uniform N application rate
- Assumed constant weather conditions

Future

- Can utilize practice information to compute estimated load to compare to baseline load?
  - Some information not available every year
- Working to document this process (including both estimated loads and monitoring)

Iowa DNR Point Source Nutrient Baseline Effort

- **Background**
  - Iowa Nutrient Reduction Strategy (INRS) (2013):
    - Requires major POTWs and certain industrial dischargers to evaluate feasibility for biological nutrient removal (BNR)
    - Assuming typical domestic sewage (TDS) = 25 mg/L TN and 4 mg/L TP, and
    - Effluent limits achievable using BNR = 10 mg/L TN and 1 mg/L TP
    - Equates to 66% TN and 75% TP removal goals (from raw waste to final effluent)

Iowa DNR Point Source Nutrient Baseline Effort

- **Multiple Ways to Measure Point Source Progress**
  - # Facilities with TN and TP monitoring
  - # Facilities with completed feasibility studies
  - # Facilities with construction schedules to install BNR
  - # Facilities implementing BNR
  - # Facilities with TN and/or TP limits
  - Facility-specific % removals and load reductions achieved
  - Overall point source load changes since INRS development (2013)
  - Overall point source load changes since <u>1980-1996 baseline</u>
    - Focus of this presentation is on Iowa DNR efforts to estimate this baseline

Iowa DNR Point Source Nutrient Baseline Effort

- **Evaluation of Draft Load Estimates Shared by USGS**
  - USGS shared a draft data set with Iowa DNR that included annual TN and TP load estimates for Iowa point sources for years 1992, 1997, and 2002
  - Estimates were based on a preliminary data compilation from EPA's permit compliance system (PCS) and EPA/USGS methodology (Maupin and Ivahnenko, 2011)
  - Iowa DNR evaluated the flows and nutrient concentrations underlying the 1992 load estimates to determine if the loads could be used directly as the point source baseline
  - Evaluation showed that 1992 flows could be used
  - Nutrient concentrations were "typical pollutant concentrations" (TPCs)
    - Based on SIC code, flow class, season, and river basin
    - Underestimated nutrient levels for Iowa major POTW point sources (e.g., more reflective of advanced treatment than secondary)
    - Either overestimated or underestimated nutrient levels for those Iowa industries evaluated

Iowa DNR Point Source Nutrient Baseline Effort

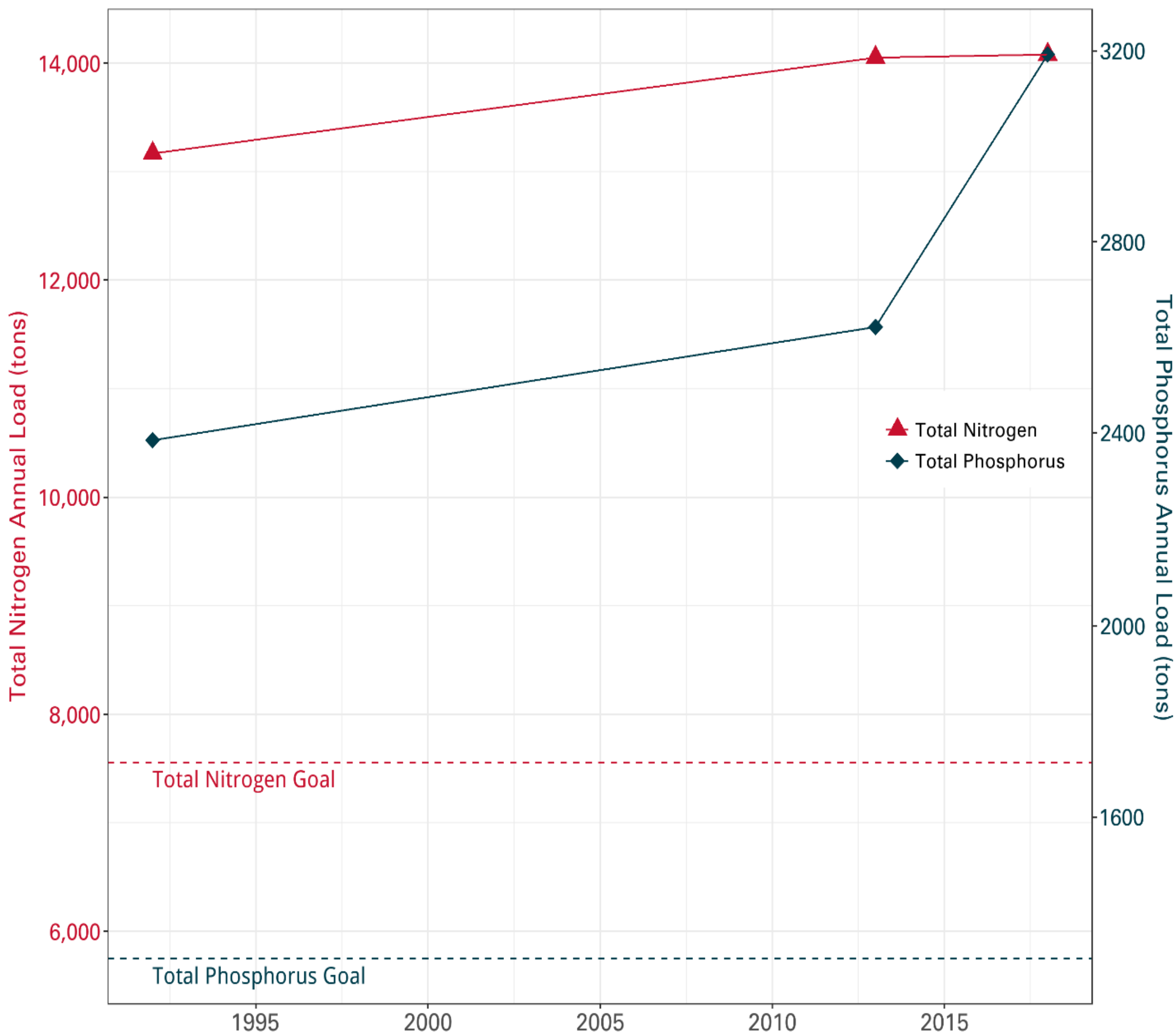
- **Iowa DNR Point Source Baseline Load Estimates**
  - A modified approach was used to derive 1992 annual baseline TN and TP load estimates for 3 point source categories
    1. Major POTWs (n=106)
    2. Minor Domestic Wastewater Dischargers (n=919)
       - POTWs
       - semi-publics
    3. Industrial Dischargers (n=32)
       - majors and minors with…
       - biological treatment of process wastewater (BTP)

  - Why use 1992 as the reference point for baseline estimates?
    - Comprehensive effluent flow data set available
    - Within 1980-1996 baseline period
    - Representative year in terms of average rainfall for the 1980-1996 period

Iowa DNR Point Source Nutrient Baseline Effort

- **Major POTWs**
  - Baseline loads derived using:
    - Actual facility-specific effluent flows from 1992
    - Iowa-specific TPCs
      - Used actual facility-specific monthly average effluent data from 2016 for 54 POTWs
      - TN and TP effluent concentrations divided into 3 “flow class” categories based on the associated effluent flow
      - TPCs reflect the average concentration in each flow class

Statistic	Flow Class	Sample Size	TPC (mg/L)	
			TN	TP
Average	<1 MGD	216	15.8	3.2
	1-5 MGD	322	13.3	2.6
	>5 MGD	102	24.7	2.9



14,000
12,000
10,000
8,000
6,000
Total Nitrogen Annual Load (tons)
3200
2800
2400
2000
1600
Total Phosphorus Annual Load (tons)
1995
2000
2005
2010
2015
Total Nitrogen
Total Phosphorus
Total Nitrogen Goal
Total Phosphorus Goal

Combined Loading

		1980-96 Baseline Load (tons)	2006-10 Benchmark Load (tons)	Change, 1980-96 to 2006-10		Major cause of change
Nitrogen	NPS*	278,852	293,395	5.2%	Increase	Land use change
	PS	13,170	14,054	6.7%	Increase	Flow increase
	Total	292,022	307,449	5.3%	Increase	
Phosphorus	NPS	21,436	16,800	21.6%	Decrease	Reduced tillage and soil test P
	PS	2,386	2,623	9.9%	Increase	Flow increase
	Total	23,822	19,423	18.5%	Decrease	

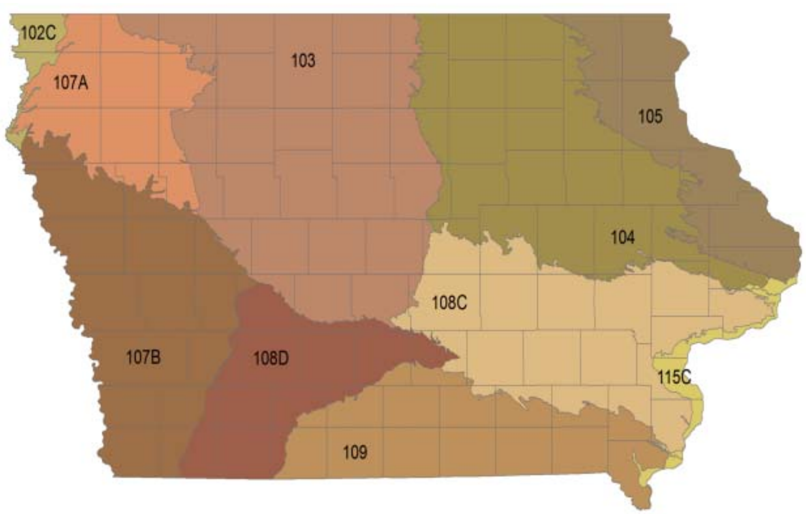
*The method used to derive the total nitrogen estimate indirectly reflected the point source contributions.

Discussion

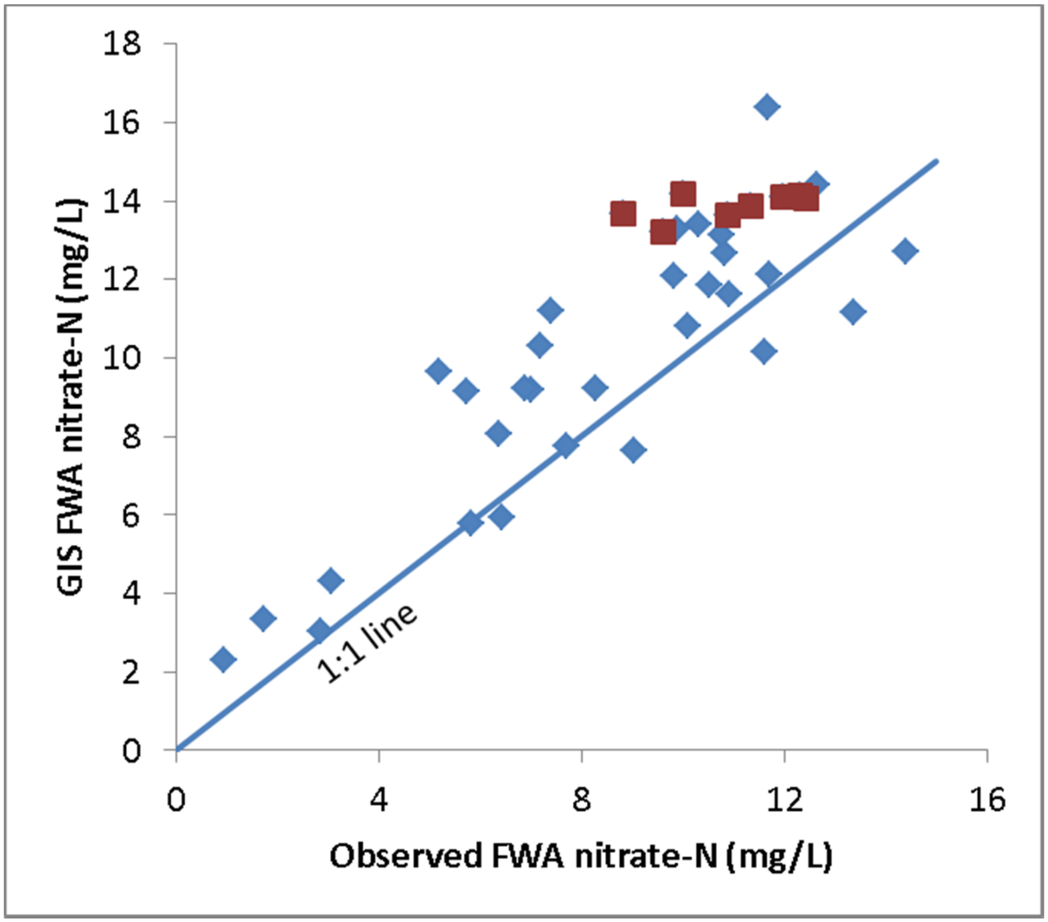
Load Estimation

- Nitrate-N concentration estimated from land use and nitrogen management
- Nitrate-N load for each MLRA a product of the nitrate-N concentration and water yield (estimated surface and subsurface flow)

MLRA	Water Yield
	in/yr
103	10.4
104	11.9
105	11.3
107A	7.1
107B	8.2
108C	11.2
108D	9.8
109	12.0



Nitrate-N Comparison



- Nitrate concentrations estimated based on land use and N application rates overestimate the observed nitrate concentrations by about 17% on the basis of a least squares statistical model.
- This 17% difference could be largely explained by in stream loss of nitrate and by dilution due to surface runoff.
- Overall, empirically based modeling approach to predict impacts of practice implementation (83% subsurface flow and 17% surface runoff)

Extra Slides

Questions for Matt Helmers

- Now that there is a baseline, what will be the process for measuring progress each year? In other words, how much progress did we make in 2017 relative to this baseline?

- Was water monitoring used in this baseline development? How will it be used moving forward for tracking progress?

- Was phosphorus bed and bank contributions considered? If not, what is happening to address that?

Iowa DNR Point Source Nutrient Baseline Effort

- **Major POTWs (Example)**

POTW Name	Month	Season	1992 Flow (MGD)	Total Nitrogen		Total Phosphorus	
				IA-specific TPC (mg/L)	Baseline Load (lbs)	IA-specific TPC (mg/L)	Baseline Load (lbs)
CRESCO CITY OF STP	Jan	WI	0.70	15.8	2,865	3.2	580
CRESCO CITY OF STP	Feb	WI	0.55	15.8	2,038	3.2	413
CRESCO CITY OF STP	Mar	SP	1.43	13.3	4,907	2.6	959
CRESCO CITY OF STP	Apr	SP	0.81	15.8	3,216	3.2	651
CRESCO CITY OF STP	May	SP	1.71	13.3	5,870	2.6	1,148
CRESCO CITY OF STP	Jun	SU	1.12	13.3	3,723	2.6	728
CRESCO CITY OF STP	Jul	SU	0.77	15.8	3,151	3.2	638
CRESCO CITY OF STP	Aug	SU	0.63	15.8	2,555	3.2	517
CRESCO CITY OF STP	Sep	FA	1.06	13.3	3,526	2.6	689
CRESCO CITY OF STP	Oct	FA	0.74	15.8	3,041	3.2	616
CRESCO CITY OF STP	Nov	FA	0.95	15.8	3,774	3.2	764
CRESCO CITY OF STP	Dec	WI	0.85	15.8	3,466	3.2	702
CRESCO CITY OF STP	**Annual**				**42,132**		**8,406**

Iowa DNR Point Source Nutrient Baseline Effort

- **Minor Domestic Wastewater Dischargers**
  - Only ~50% represented in the data set shared by USGS, so different approach used to estimate baseline loads
  - Determined current AWW design flow for total universe of major POTWs (650.98 MGD) vs minor domestic wastewater dischargers (147.88 MGD)
  - Adjusted these design flows to number of facilities existing in 1992
  - Determined ratio of these 1992-adjusted total AWW design flows (20.98%)
  - Applied ratio to the 1992 total annual effluent flow from the major POTWs (115.48 billon gallons) in order to estimate the 1992 total annual effluent flow from minor domestic wastewater dischargers
  - Multiplied the resulting flow (24.23 billion gallons) by the Iowa-specific TPCs for the <1 MGD flow class

Iowa DNR Point Source Nutrient Baseline Effort

- Industrial Dischargers with BTP
  - Generally derived baseline loads using either:
    1. Actual facility-specific effluent flows from 1992 and actual facility-specific long-term averages (LTAs) of daily TN and TP effluent concentrations from Sept 2013 to April 2017
    2. Or, where 1992 flows unavailable, used actual facility-specific LTAs of daily TN and TP effluent loads from Sept 2013 to April 2017 then multiplied by 365 days per year

Iowa DNR Point Source Nutrient Baseline Effort

- ## Industrial Dischargers with BTP (Examples)

Discharger Name	Outfall	Month	Season	1992 Flow (MGD)	Total Nitrogen		Total Phosphorus	
					LTA Conc (mg/L)	Baseline Load (lbs)	LTA Conc (mg/L)	Baseline Load (lbs)
JOHN DEERE DUBUQUE	011	Jan	WI	0.11	6.60	191	20.63	598
JOHN DEERE DUBUQUE	011	Feb	WI	0.12	6.60	182	20.63	569
JOHN DEERE DUBUQUE	011	Mar	SP	0.12	6.60	205	20.63	640
JOHN DEERE DUBUQUE	011	Apr	SP	0.11	6.60	174	20.63	542
JOHN DEERE DUBUQUE	011	May	SP	0.11	6.60	188	20.63	587
JOHN DEERE DUBUQUE	011	Jun	SU	0.11	6.60	189	20.63	589
JOHN DEERE DUBUQUE	011	Jul	SU	0.13	6.60	217	20.63	678
JOHN DEERE DUBUQUE	011	Aug	SU	0.16	6.60	270	20.63	843
JOHN DEERE DUBUQUE	011	Sep	FA	0.16	6.60	258	20.63	806
JOHN DEERE DUBUQUE	011	Oct	FA	0.12	6.60	198	20.63	619
JOHN DEERE DUBUQUE	011	Nov	FA	0.14	6.60	228	20.63	713
JOHN DEERE DUBUQUE	011	Dec	WI	0.13	6.60	226	20.63	704
JOHN DEERE DUBUQUE	011	Annual				2,526		7,887

Discharger Name	Outfall	Month	#Days/Yr	Total Nitrogen		Total Phosphorus	
				LTA Load (lbs)	Baseline Load (lbs)	LTA Load (lbs)	Baseline Load (lbs)
MONSANTO COMPANY	002	Annual	365	377	137,457	163	59,640

Iowa DNR Point Source Nutrient Baseline Effort

- **Results**
  - 1992 Annual TN and TP Baseline Load Estimates for Point Sources

Discharge Type	TN (tons)	TP (tons)
Major POTWs	10,311	1,380
Minor Domestic Wastewater Dischargers	1,597	324
Industrial with BTP	1,262	683
Sum	**13,170**	**2,386**

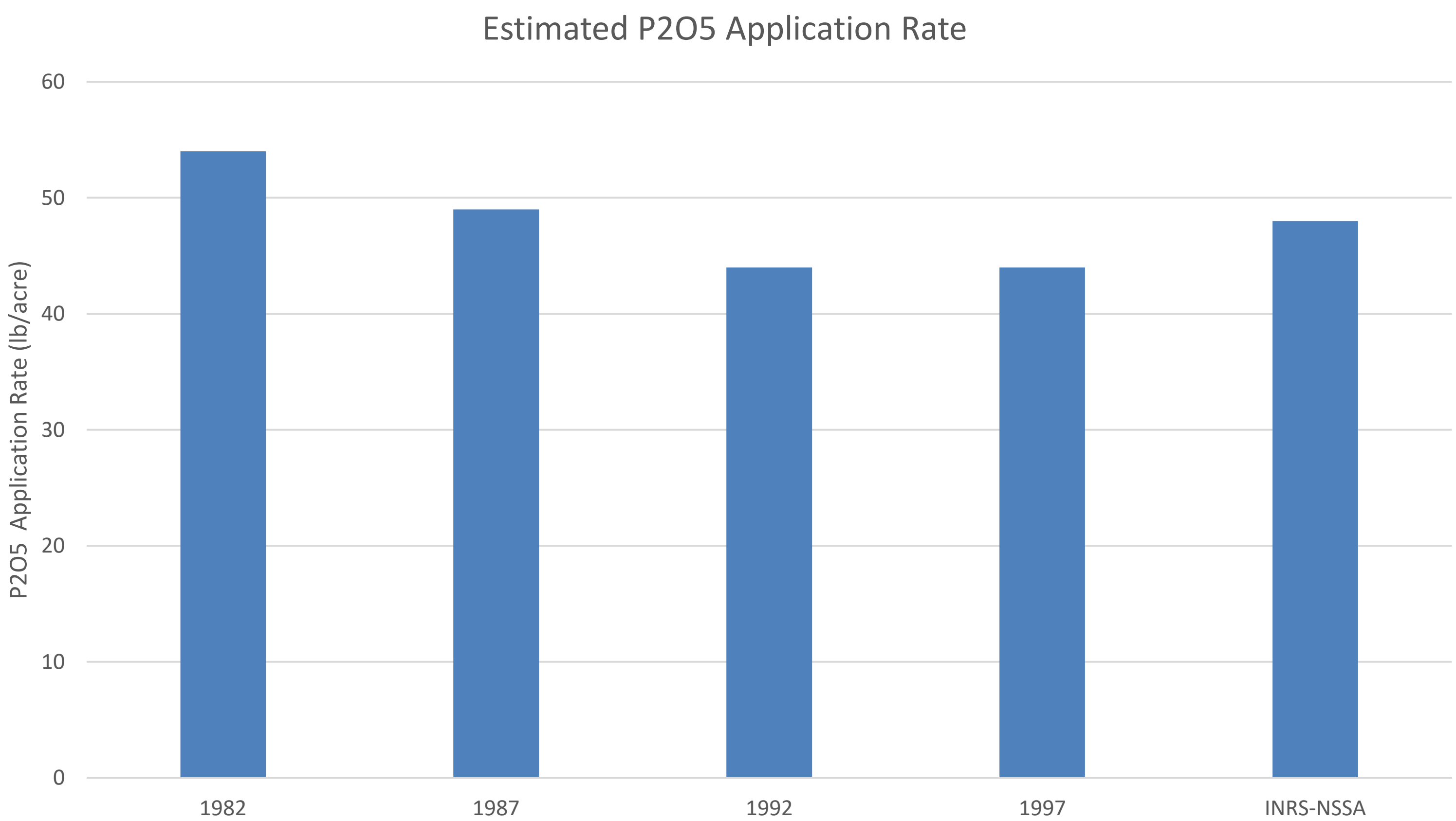
Iowa DNR Point Source Nutrient Baseline Effort

- **Conclusions**
  - The 1992 annual TN and TP baseline load estimates for point sources are useful as a way to measure progress consistent with Senate File 512.
  - The baseline estimates generally reflect actual facility-specific effluent flows from 1992, and 1992 is a representative year in terms of average rainfall for the 1980-1996 period.
  - While the estimates reflect more recent TN and TP effluent concentration data, the concentration data are specific to Iowa POTWs and flow class (in the case of domestic dischargers) or are facility-specific (in the case of industrial dischargers).
  - Further, the Iowa-specific TPCs are generally reflective of standard secondary treatment facilities without BNR, which is appropriate for application in deriving 1992 baseline load estimates.

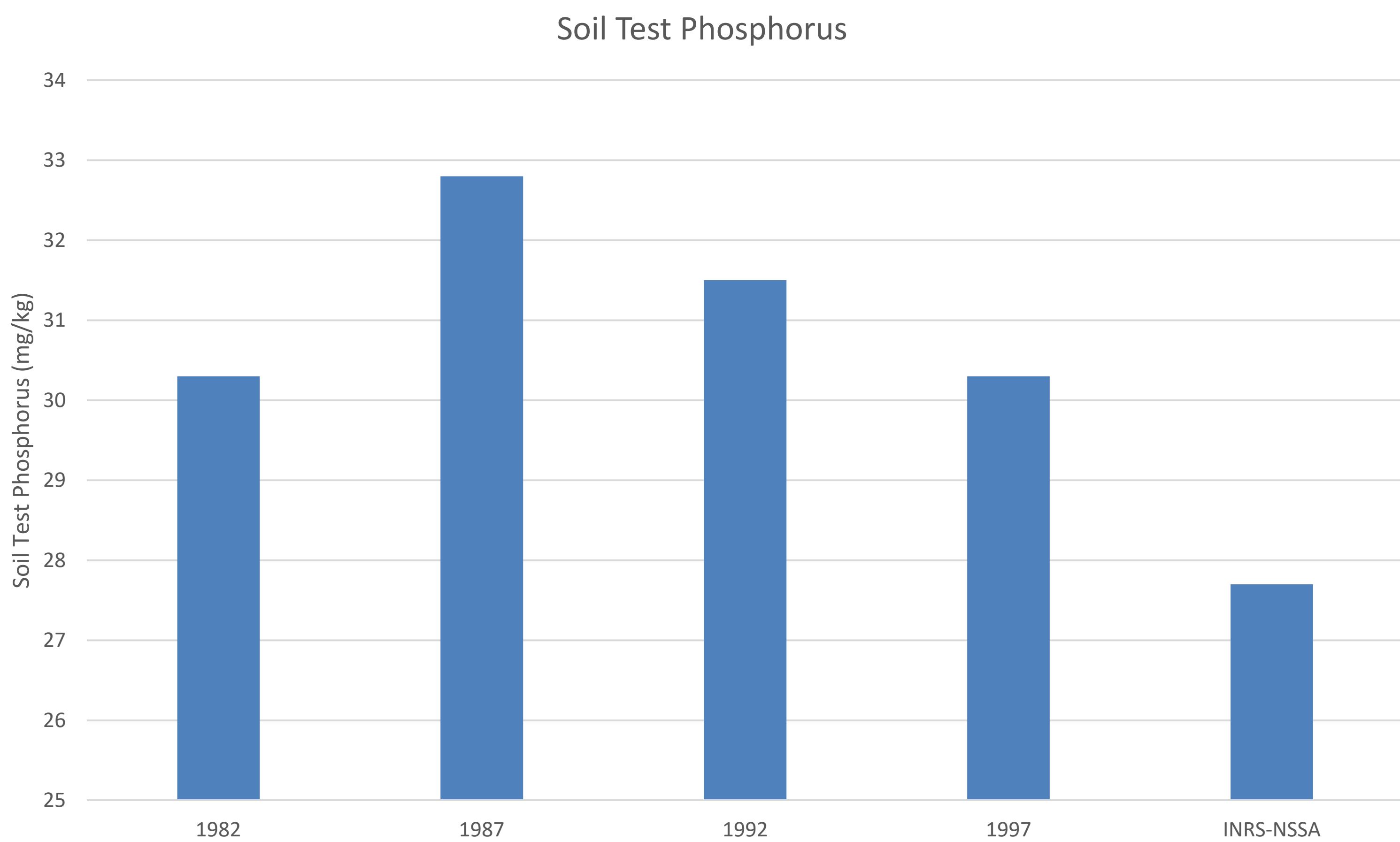
Iowa DNR Point Source Nutrient Baseline Effort

- **Moving Forward**
  - The Iowa-specific TPCs derived under this effort could be used to estimate TN and TP loads where effluent monitoring data for TN and TP are not available but effluent flows are available.
  - Examples:
    - Re-visit the original INRS' anticipated point source nutrient reduction estimates which were based on the following assumptions:
      - 2/3 total AWW design flow for major POTWs and industries with BTP
      - "Current" effluent concentrations = TDS = 25 mg/L TN & 4 mg/L TP
      - "Future" effluent concentrations = BNR = 10 mg/L TN and 1 mg/L TP
    - Future annual report progress tracking
      - Note that the universe of facilities with "missing" TN and TP effluent concentration data will shrink as time progresses such that use of Iowa-specific TPCs should no longer be necessary over time

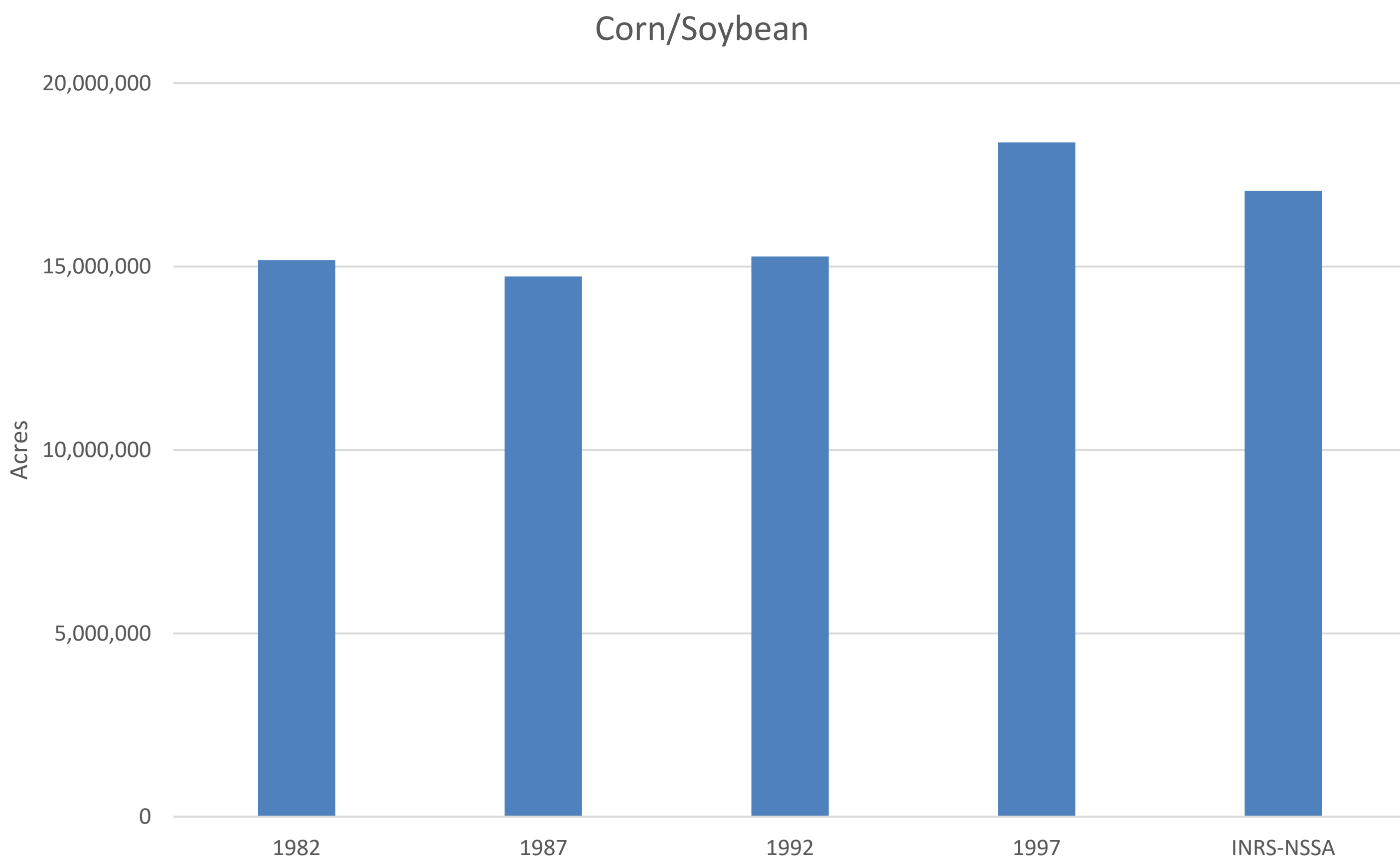
Phosphorus Application



Soil Test Phosphorus

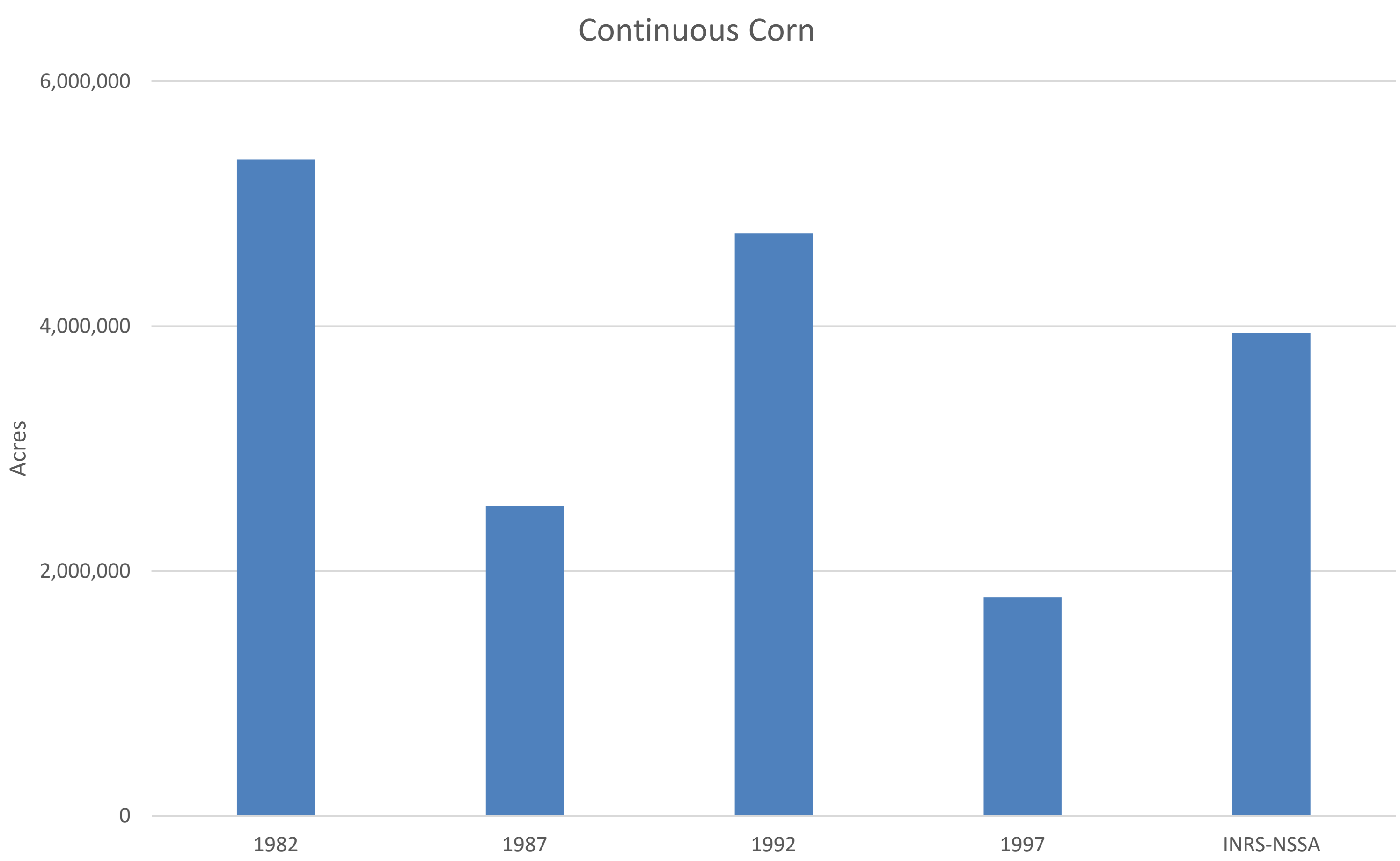


Land Use



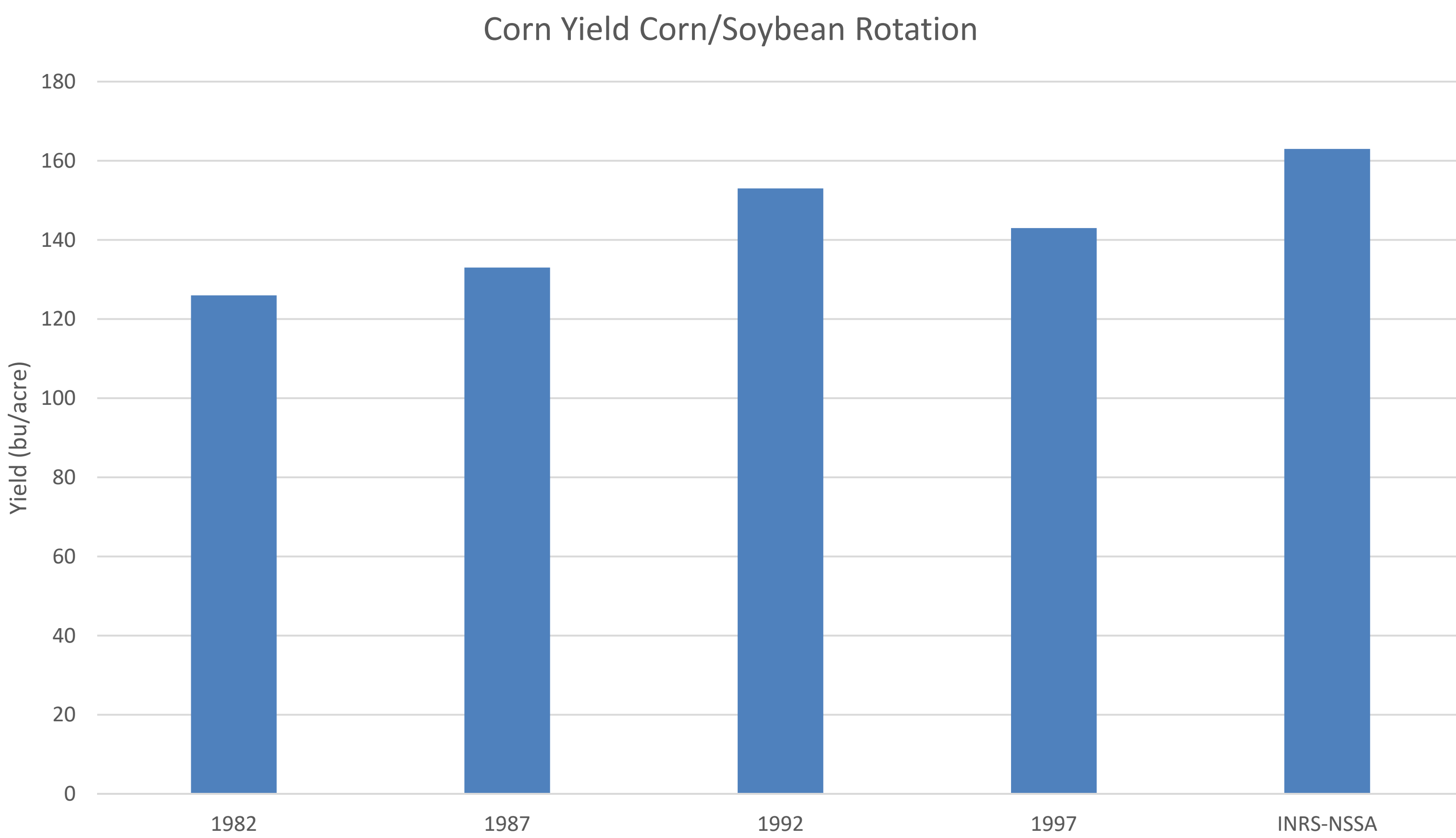
Corn/Soybean
20,000,000
15,000,000
10,000,000
5,000,000
0
Acres
1982
1987
1992
1997
INRS-NSSA

Land Use



Continuous Corn
6,000,000
4,000,000
2,000,000
0
Acres
1982
1987
1992
1997
INRS-NSSA

Corn Yields


Corn Yield Corn/Soybean Rotation
Yield (bu/acre)
180
160
140
120
100
80
60
40
20
0
1982
1987
1992
1997
INRS-NSSA