Nitrogen Management
Products

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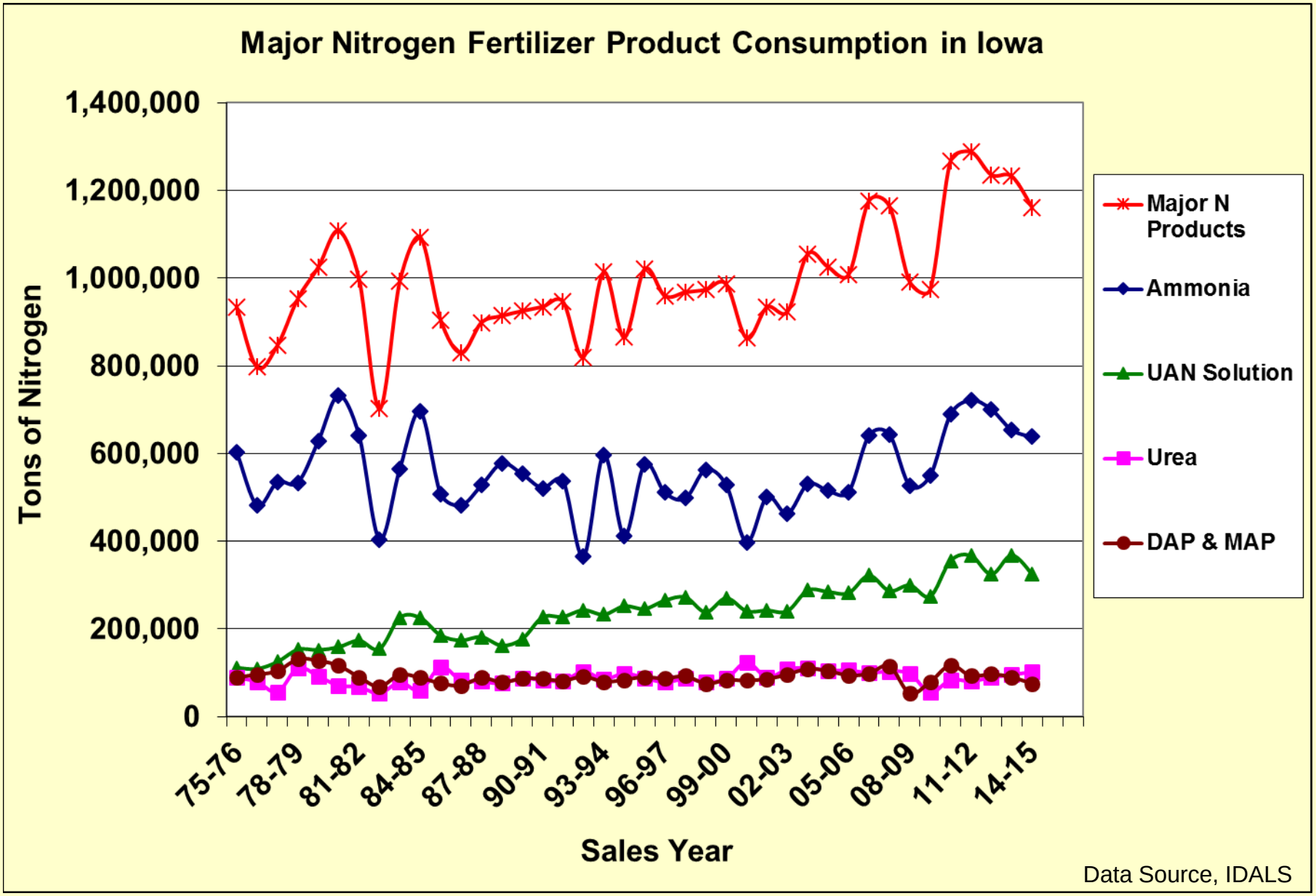

Major Nitrogen Fertilizer Product Consumption in Iowa
Tons of Nitrogen
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
75-76
78-79
81-82
84-85
87-88
90-91
93-94
96-97
99-00
02-03
05-06
08-09
11-12
14-15
Sales Year
Major N Products
Ammonia
UAN Solution
Urea
DAP & MAP
Data Source, IDALS

Ammonia Synthesis

- Natural Gas
  - Source of energy
  - Source of H_2
    - $CH_4 + H_2O = CO + 3\ H_2$
    - $CH_4 + 2\ H_2O = CO_2 + 4\ H_2$
  - Remove CO and CO_2
- Atmosphere
  - Source of N_2 (33,000 tons N_2 in air over every acre)
- Haber-Bosch Process
  - $3\ H_2 + N_2 = 2\ NH_3$

Energy - Producing Nitrogen Fertilizer

- For each ton of ammonia production
  - 26,000 cu ft natural gas
    - 82% for feedstock (hydrogen source)
    - 18% for fuel (heat)
  - Net energy requirement is 30 million BTU per ton N = 15,000 BTU per lb N
- Conversion of ammonia to other N products requires additional energy
  - Urea = 18,000 BTU per lb N
  - UAN = 16,000 BTU per lb N

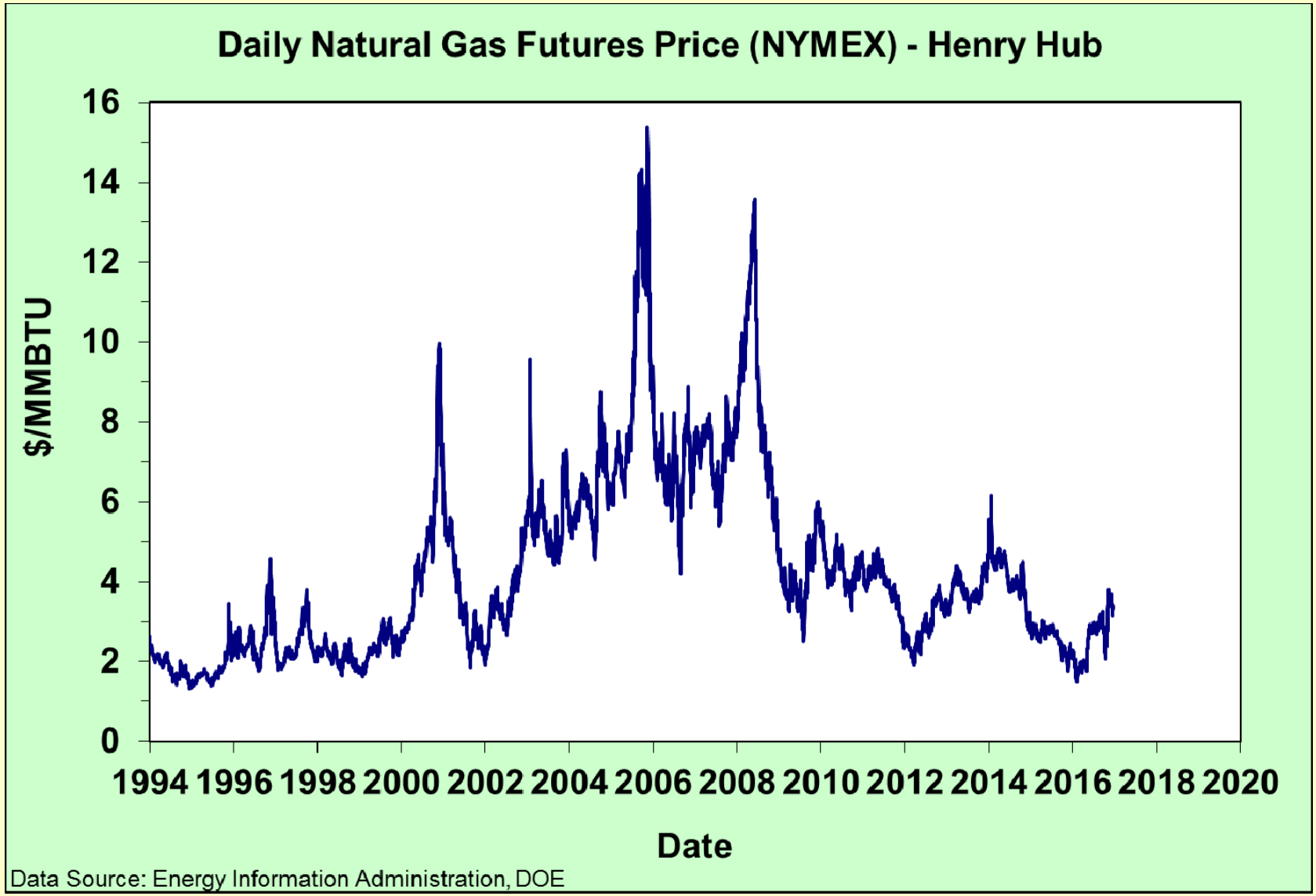
Source: G. Kongshaug, 1998 (T. Jenssen amended, 2003)

Energy -- Using Nitrogen Fertilizer

	Transportation	Application
	- - - - BTU/lb N - - - -	
Ammonia	1,100	1,000
Urea	2,000	300

- Total per 100 lb N/acre (diesel fuel equivalent)
  - Ammonia 12 gal
  - Urea 15 gal

Source: G. Kongshaug, 1998 (T. Jenssen amended, 2003)
Hoeft and Siemens, 1975


Daily Natural Gas Futures Price (NYMEX) - Henry Hub
$/MMBTU
16
14
12
10
8
6
4
2
0
1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Date
Data Source: Energy Information Administration, DOE

Nitrogen Fertilizer Manufacture

- Nitrogen fertilizers originate from anhydrous ammonia
  - Urea
    - Ammonia + Carbon Dioxide
  - Ammonium Nitrate
    - Ammonia + Nitric Acid
  - Urea - Ammonium Nitrate Solutions
    - Urea + Ammonium Nitrate + Water + Ammonia
    - 32% and diluted 28%

Nitrogen Fertilizer Manufacture

- Nitrogen fertilizers originate from anhydrous ammonia
  - Ammonium Sulfate
    - Ammonia + Sulfuric Acid
    - Industrial by-product; coal coke ovens, lysine manufacture, nylon manufacture
  - Aqua Ammonia
    - Ammonia dissolved in water
  - Ammoniated Phosphates - DAP, MAP
    - Ammoniation of phosphoric acid

Nitrogen Fertilizer Manufacture

- Nitrogen fertilizers originate from anhydrous ammonia
  - Ammonium Polyphosphate
    - Solutions (10-34-0, 11-37-0)
      - Ammonia + superphosphoric acid + water
    - Dry (12-58-0, 15-61-0)
      - Ammonia + superphosphoric acid

Anhydrous Ammonia

- Advantages
  - Historically least expensive N source
  - High N analysis
  - Dealer system / equipment
  - Slower nitrification
  - Use with nitrification inhibitor
  - Preferred fall N application source
  - Non-leachable in soil immediately after application
    - $NH_3 + H_2O = NH_4 + OH$

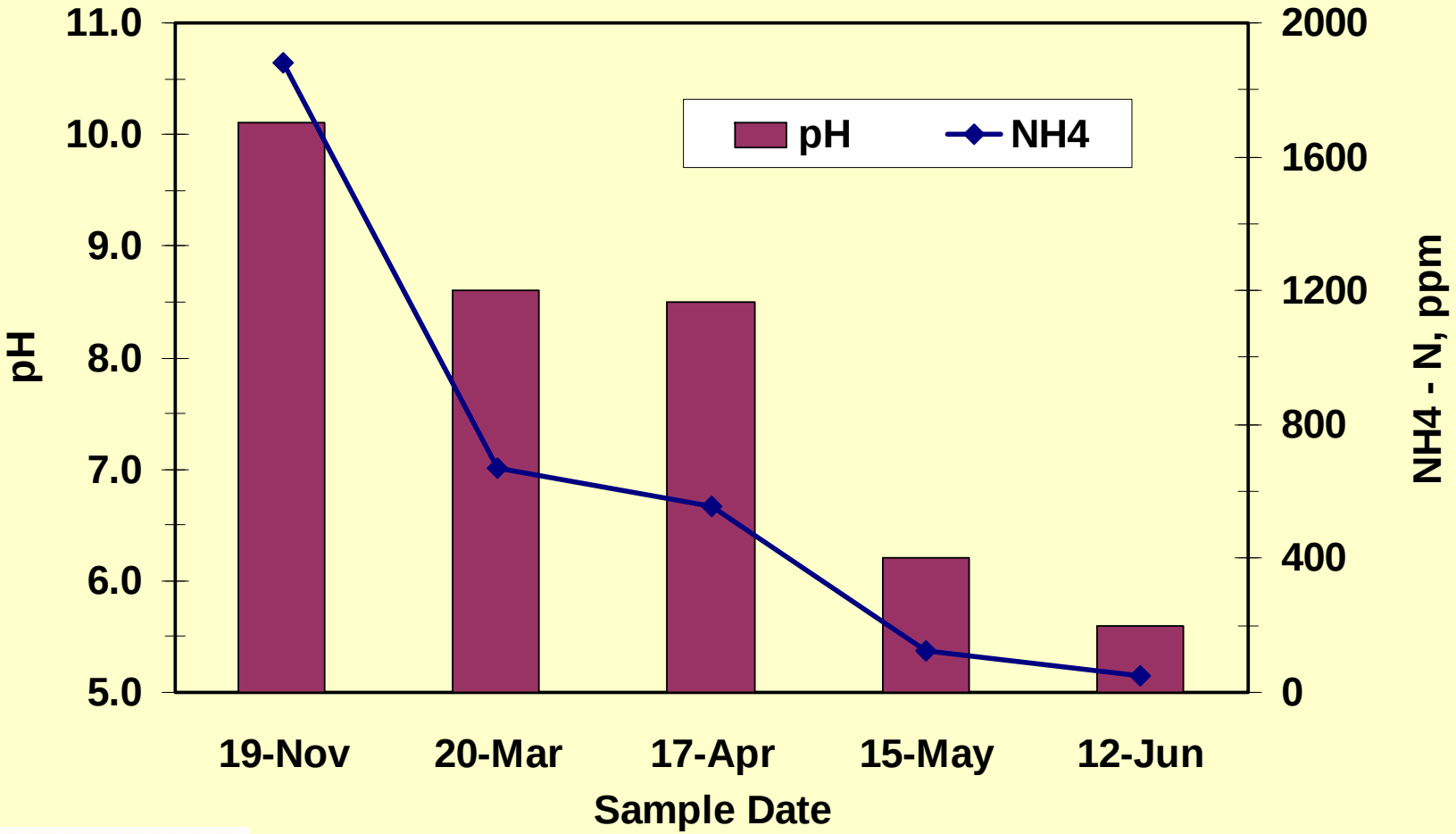
Anhydrous Ammonia
Field Application

- Requires Injection
  - Depth and soil moisture to retain ammonia
  - For corn -- 20 to 40 inch knife spacing
  - For small grains -- 15 inch or narrower knife spacing
  - Skip row spacing
    - Sidedress
    - Preplant with GPS guidance

Anhydrous Ammonia Band

pH in Highest NH_4-N Zone

120 lb N/acre as Ammonia -- 40 inch rows applied Nov. 19
McIntosh and Frederick, 1958 ISU - Ames, IA -- Nicollet SCL



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Initial Soil pH = 6.9


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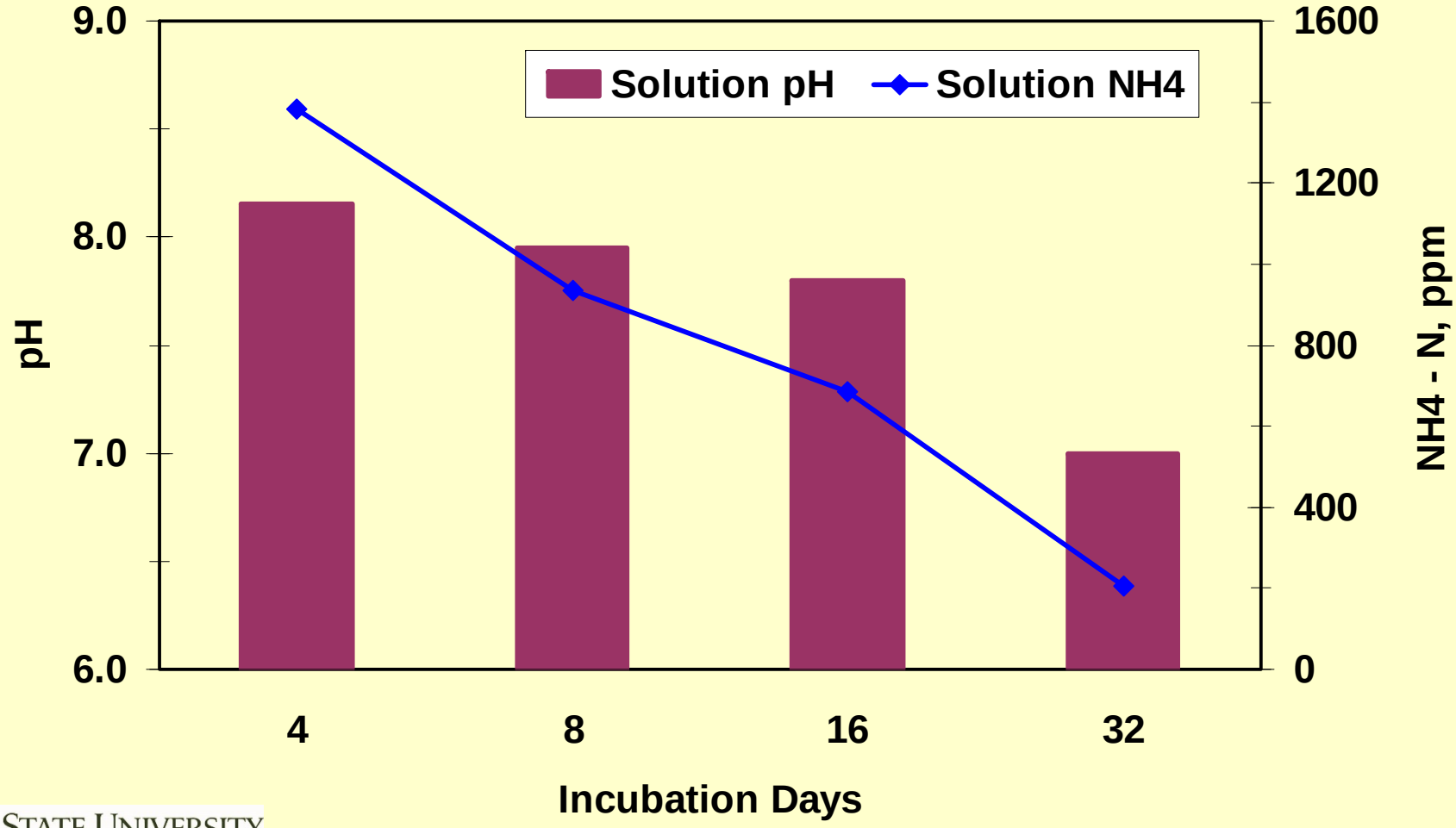
Urea
Field Application

- Urea Hydrolysis
  - When urea surface applied
    - Formation of NH_3 allows volatile loss
    - Up to 20-30% loss under high loss conditions
  - When urea banded or starter with seed
    - Plant damage may occur because of ammonia toxicity
    - pH in the 7 to 9 range for 1 to 3 weeks

Urea Band

Soil Solution pH and NH_4-N

60 lb N/acre as Banded Urea -- Incubated at 75 F
Isensee and Walsh, 1971; Griswold Loam, pH 7.1



UAN Solutions
Properties

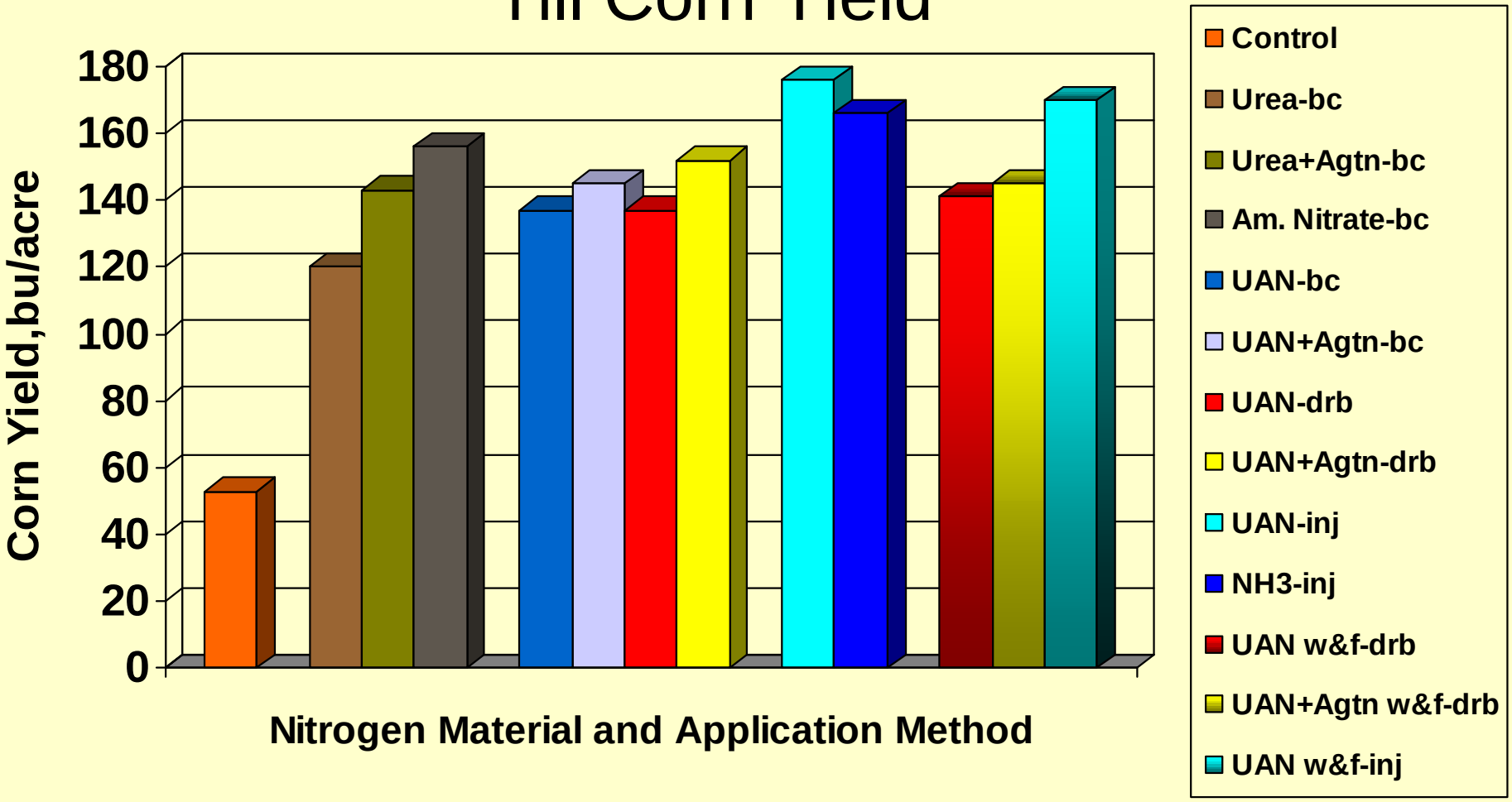
- Mix of urea and ammonium nitrate
- 28% (32%) UAN composition by weight
  - 39.3% (44.3%) Am. Nitrate
  - 30.6% (35.4%) Urea
  - 20.1% (20.3%) water
  - 0.1% Ammonium Hydroxide
  - 10.7 lb/gal (11.0) at 60º F
  - Salt out temperature -1°F (28°F)
  - Biuret 0.4%

Direct Measured Ammonia Loss from Surface Application in No-till

Source	Year			Average
	1992	1993	1994	
	- - - - lb/acre - - - -			%
Urea	34.6 a	29.4 a	42.3 a	29.5
UAN-Spray	16.8 a	19.6 b	21.6 b	16.1
UAN-Dribble	14.6 a	15.3 b	16.9 b	12.9

Fox et al., 1996 SSSAJ 60:596-601.
120 lb N/acre rate surface applied to silt loam soils in May.

Impact of N Source and Placement on No-Till Corn Yield



4-yr average C-S rotation (1995-1998) at Belleville, IL
140 lb N/acre; May preplant or weed & feed split (40 lb N bcst - 100 sidedress)

Broadcast Postemergence UAN Application to Corn

- UAN
- Potential for foliage burn
- Limit applications:
  - Up to 90 lb N/acre at V3 to V4 stage corn
  - Up to 60 lb N/acre at V7 stage corn
  - None if larger than V7 stage

    (Randall, Univ. of Minnesota 1984)
  - Herbicides -- consult label, lower UAN rate

Ammonium Sulfate
Properties

- $(NH_4)_2SO_4$
- 21% N; 24% S
- White crystalline solid
- Dry solid granules
- Very soluble in water
- Non-Volatile
- Highest acidifying effect of N fertilizers
  - Adds about $0.02 per pound of N on acid soils

Other N Fertilizers

- Urea forms
  - Coated
    - Sulfur, polyurethane, semi-permeable
  - Urea-formaldehyde
  - Methylene urea
  - Thiourea
  - IBDU - Isobutylidene diurea