

Wind to NH₃

Freedom Fertilizer

Green Fertilizer and Fuel for the Future

freedomfertilizer.com

3006 Hwy 71
Spirit Lake, IA 51360

Presentation by:
Steve Gruhn - Barry Sackett

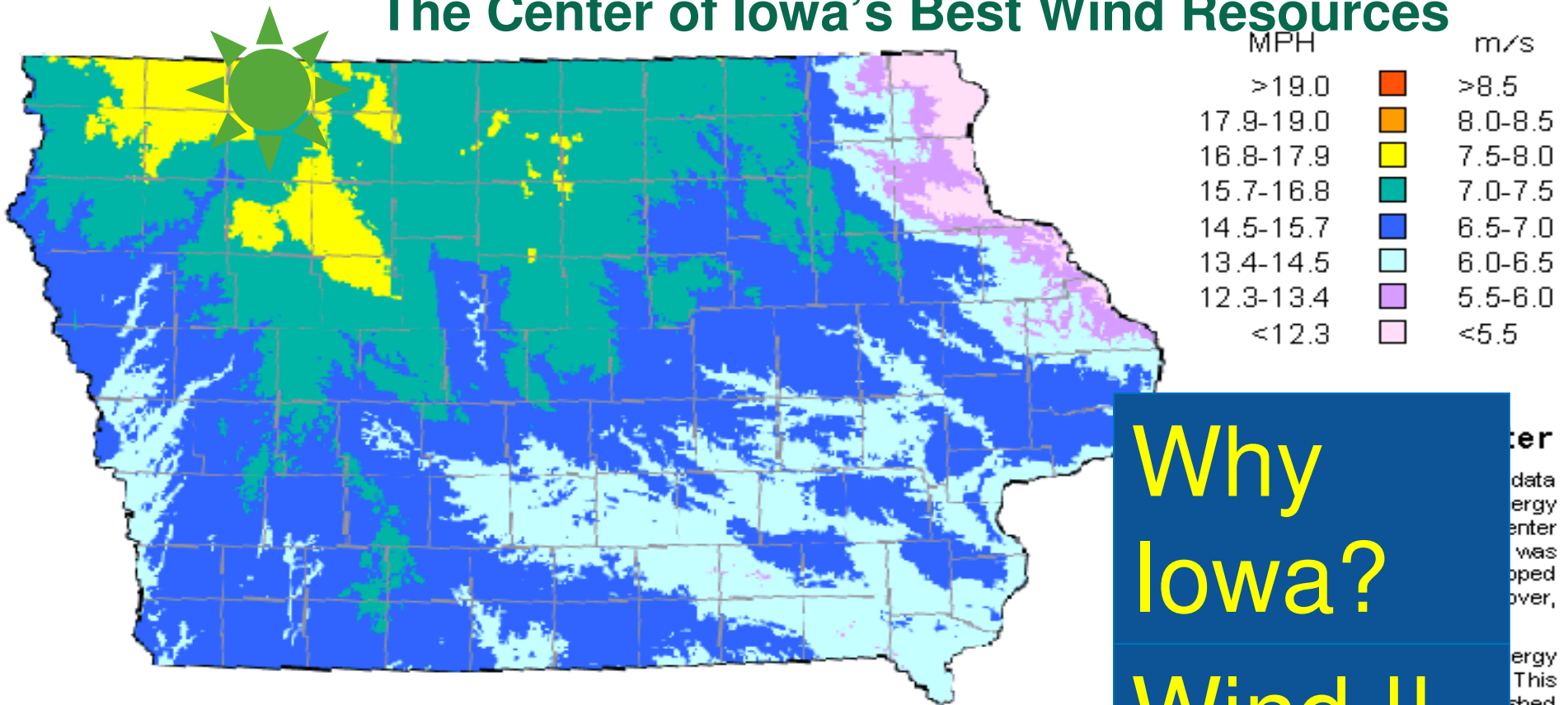
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Estimated Average Annual Wind Speeds

Typical average wind speeds on well exposed sites at 50 m above ground

The Center of Iowa's Best Wind Resources



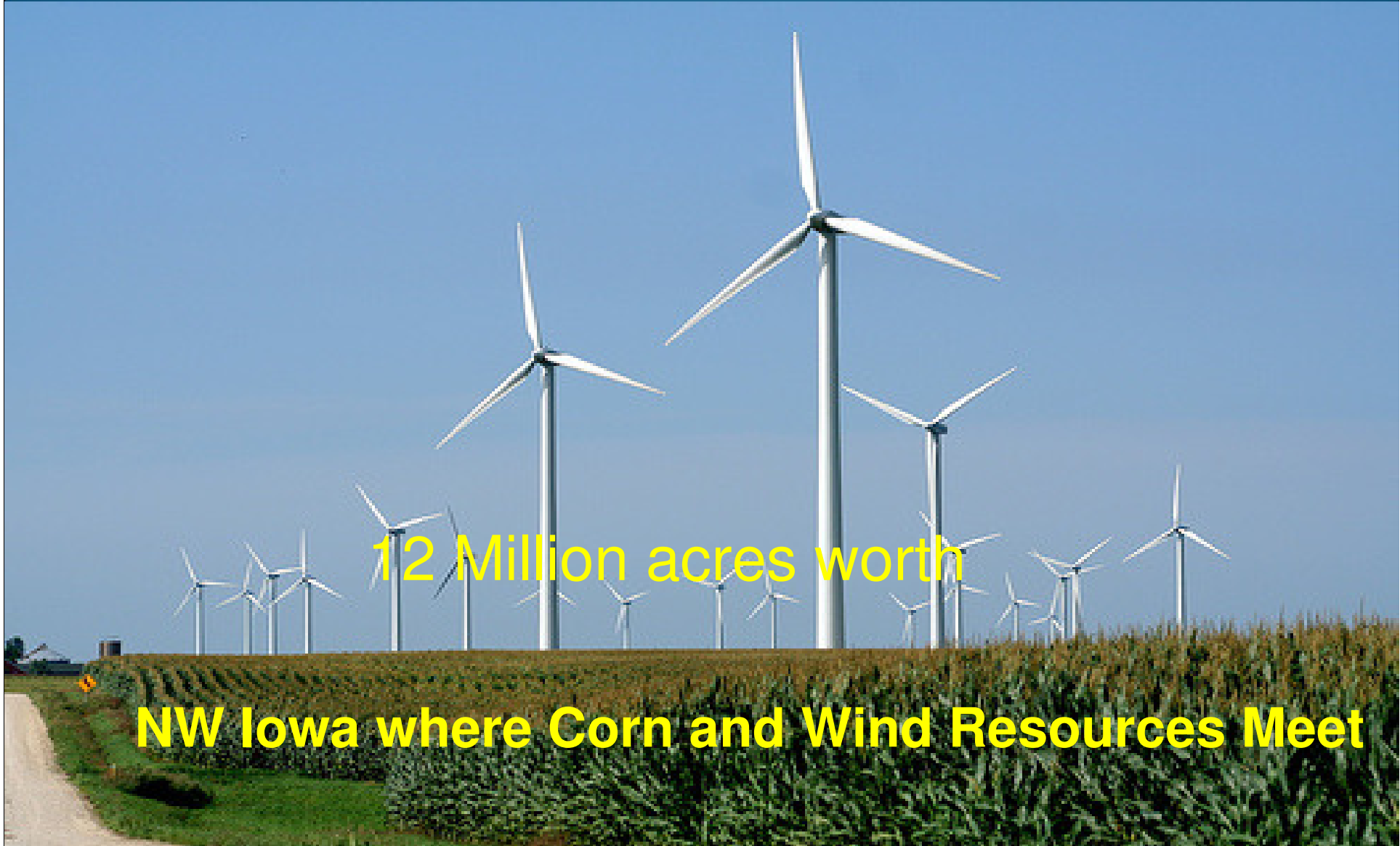
Why
Iowa?
Wind !!

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12 Million acres worth

NW Iowa where Corn and Wind Resources Meet



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Spirit Lake, Iowa

17 mph plus average wind speed

**First public use of wind driven
electrical generation**

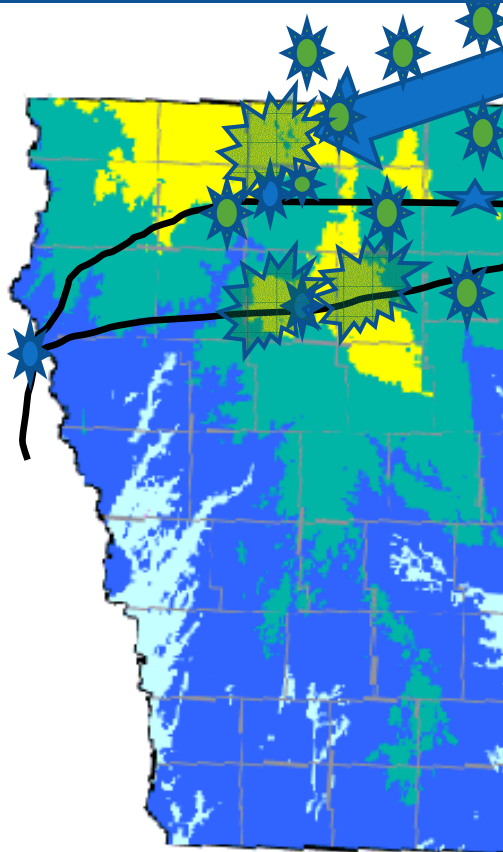
Spirit Lake Community School

1992

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•NW Iowa Home of Energy Independence ...Today



- 2 major ammonia pipelines
- 4 major ammonia terminals
- 9 ethanol plants combined output of over 350 million gallons
- 4 major wind farm installations with over 400 MW of total face plate
- At least four times today's installed MW's are being planned
- Home to Hydrogen Engine Center
- Home to Iowa Lakes Community College
The nations only Wind Turbine Technology and Biofuels production job training
- Modern ammonia handling equipment and a trained ammonia handling work force

Without the written consent of the
Iowa Energy Center.

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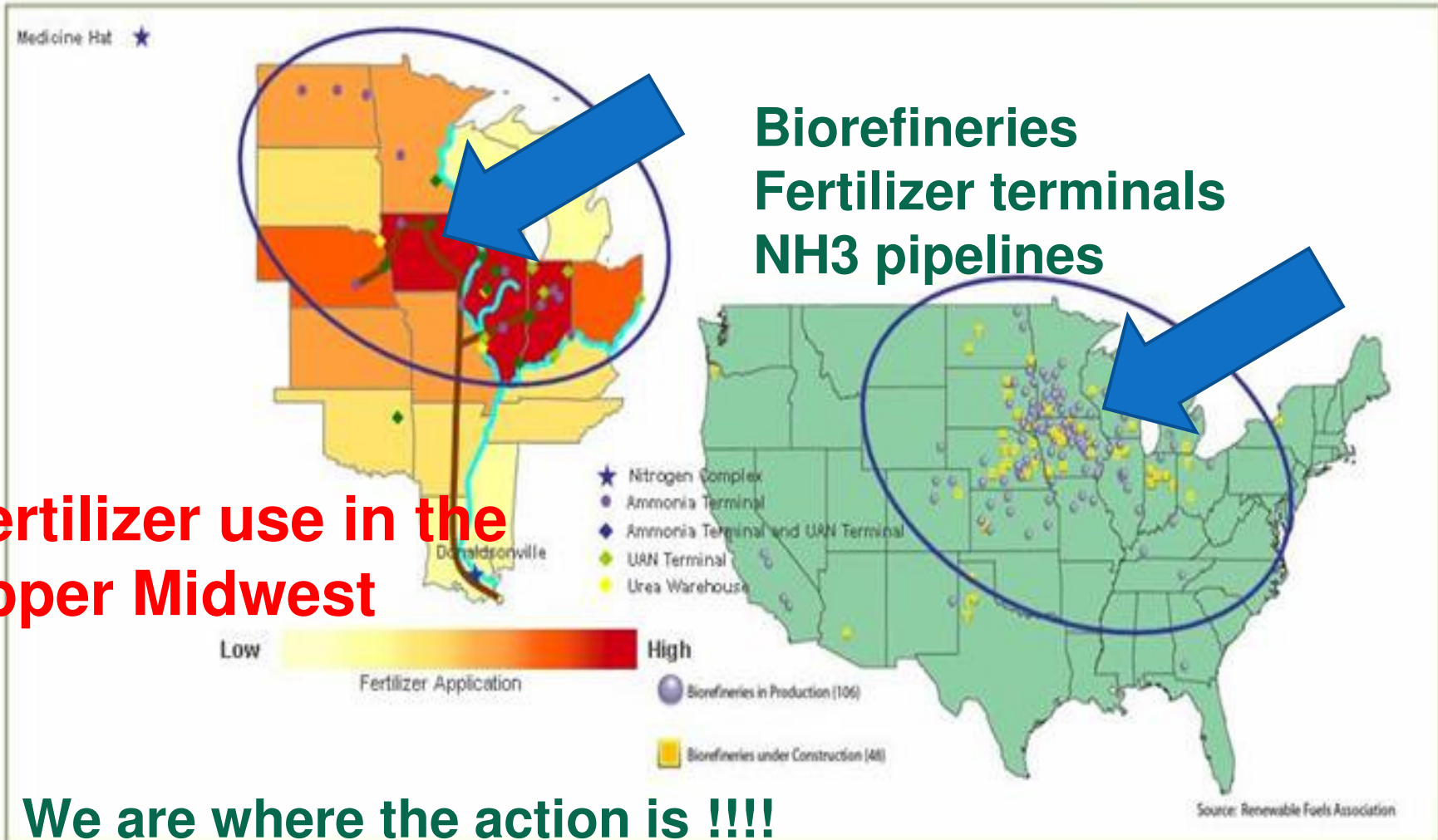


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Fertilizer use in the upper Midwest

**Biorefineries
Fertilizer terminals
NH3 pipelines**



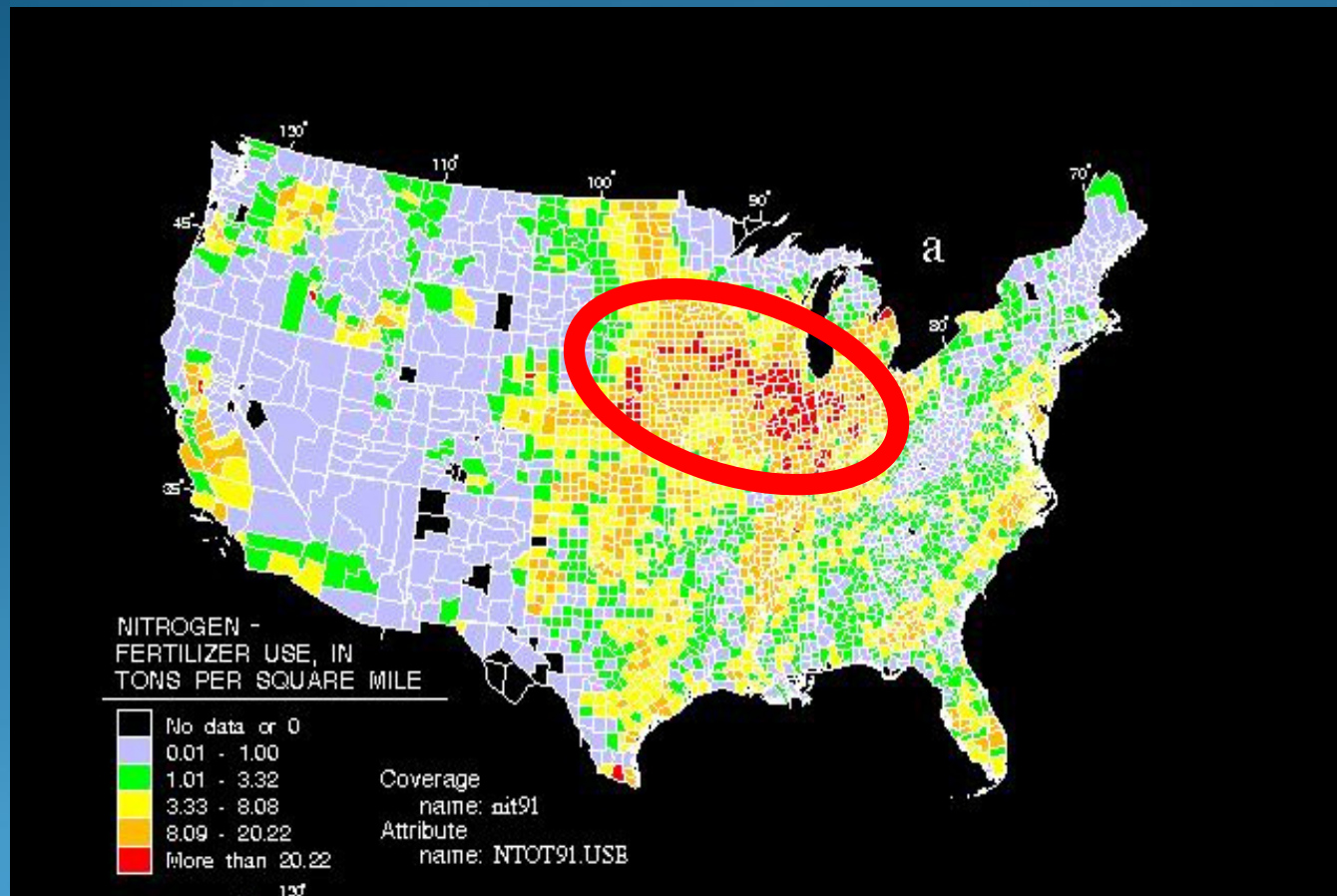
We are where the action is !!!!

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Nitrogen use
in the Upper
Midwest

8 to 20 plus
tons per
square mile



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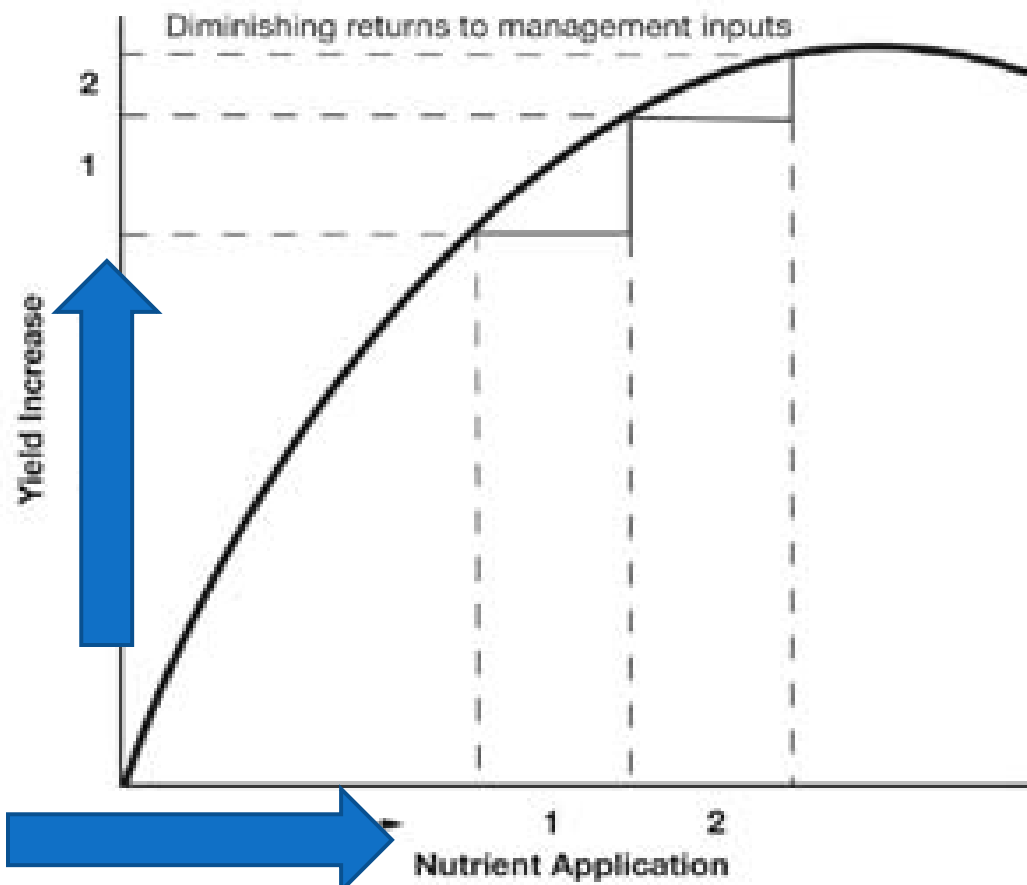
Anyone connected to agriculture knows how important fertilizer is to crop production.

It is the critical ingredient for modern production agriculture.

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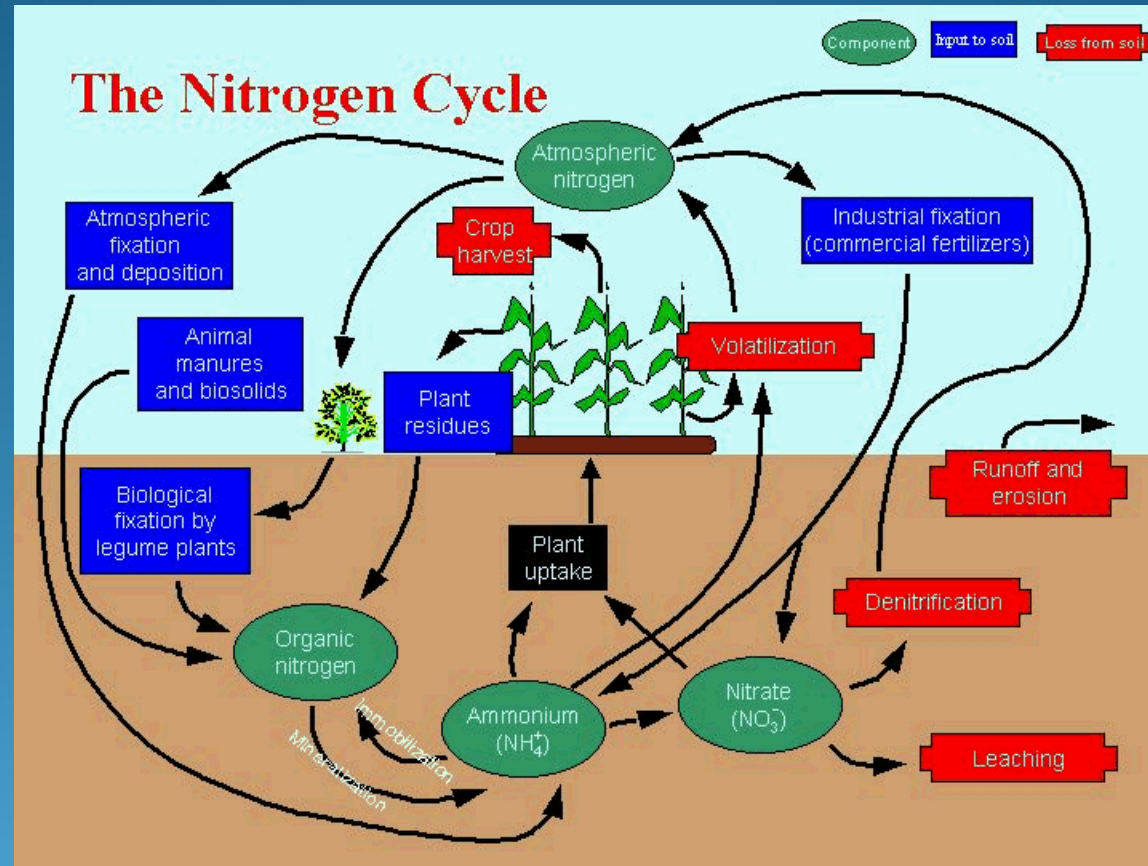
Figure 1. A typical response curve for nutrient application when nutrients are limiting.



Crop Yield Response to Fertilizer

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At Freedom Fertilizer we like to refer to NH_3 as the catalyst of plant production. Nitrogen is the first step in plant growth and NH_3 is the first step in the production of all sources of nitrogen fertilizer.

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With less NH_3 use crop yields plummet.
Without NH_3 we have no healthy plant production
No sugars and starches. No grains for livestock.
No food no fiber

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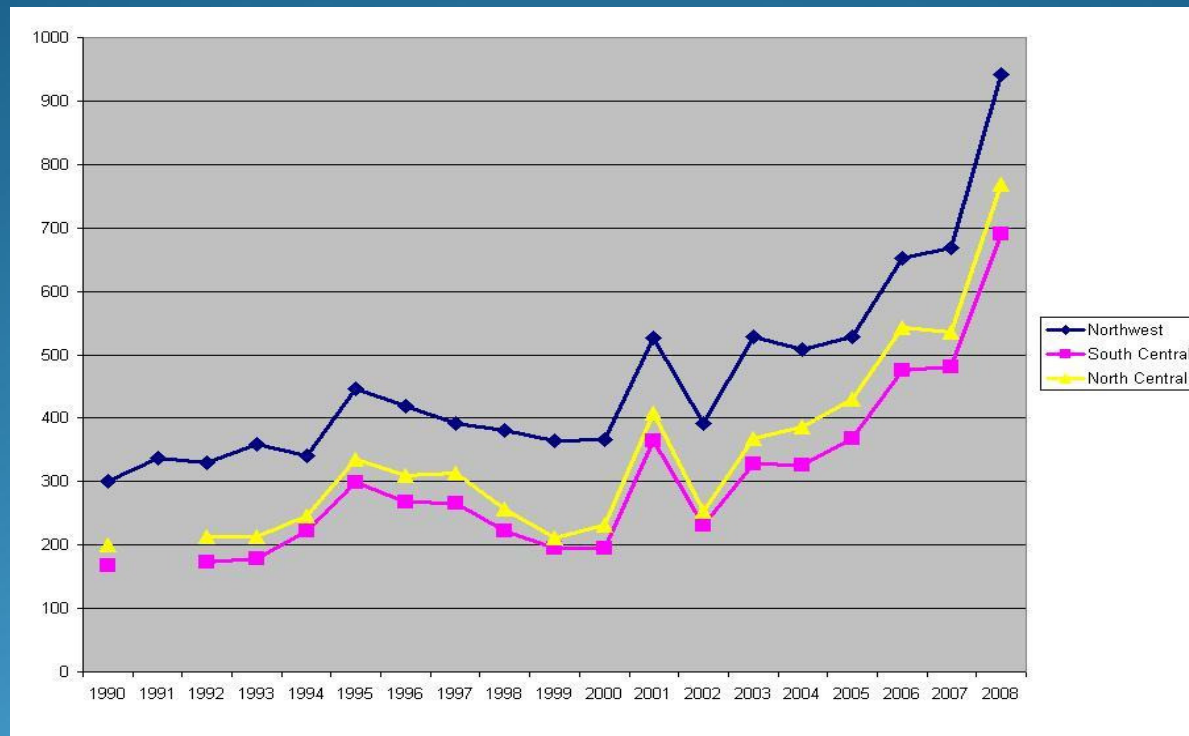
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With the advent of bio fuels, No NH_3 , no ethanol or bio diesel.
 NH_3 is the first step to all Ag production

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Now with ammonia's steadily increasing price it is a catalyst for inflation.

NH₃ pricing is a major determining factor in all food pricing and food availability around the world.

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Every 3.6 seconds a person
dies of hunger

75%
of them are children

Sadly without NH_3 use, a catalyst for hunger.

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As we all know concerns about fossil fuels, our economy and global climate change all go hand in hand.

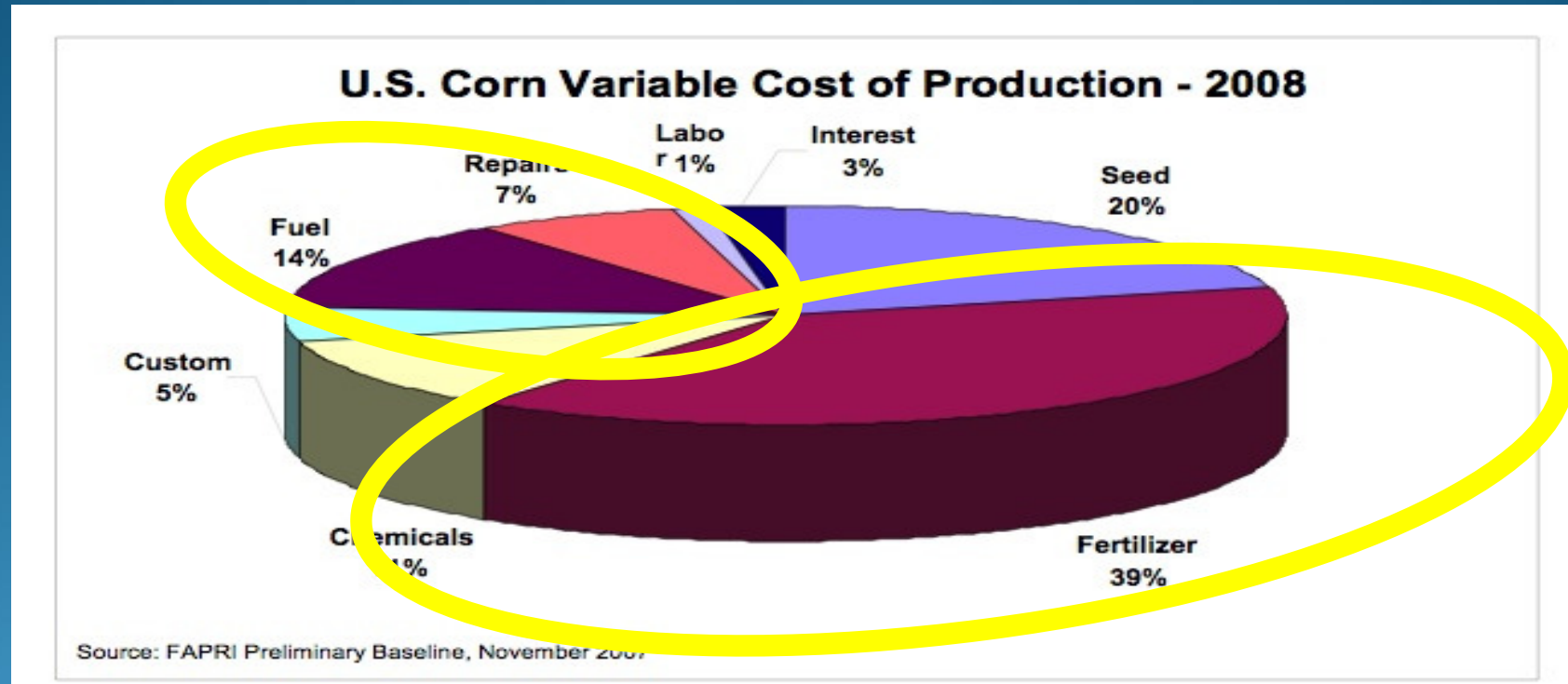
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- Producing a single ton of NH_3 made from natural gas produces 1.8 tons of CO_2 .
- If we were to use coal over 3 tons CO_2 would be produced along with many other unwanted pollutants.

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The largest percentage of fossil fuel consumed in growing an acre of corn is for the production of Nitrogen fertilizer. More energy is consumed to produce the 150 pounds of nitrogen that is required to sustain today's yields than all other aspects of production. More energy than tillage, planting, harvesting and delivery combined.

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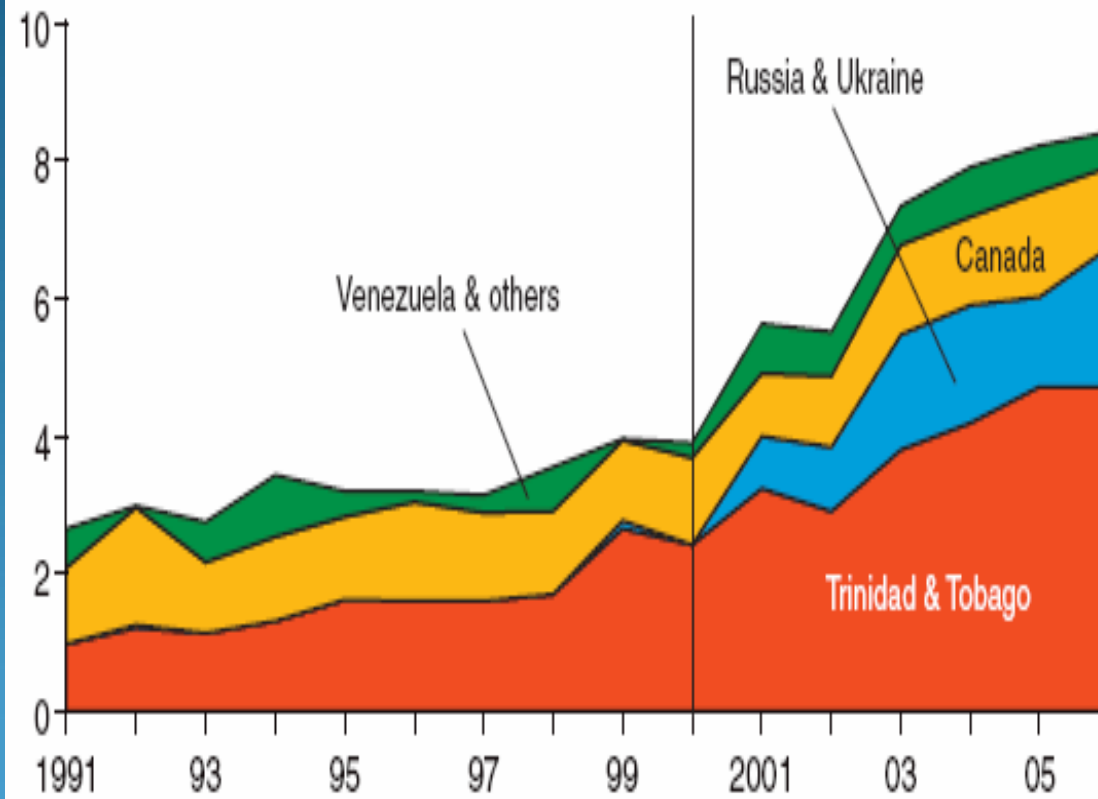
- Worldwide there are more tons of NH_3 produced annually than any other manmade chemical compound.
- Production of NH_3 consumes over 4% of the world's yearly fossil fuel production
- Hence a major greenhouse gas contributor.

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U.S. imported ammonia

Mil. tons



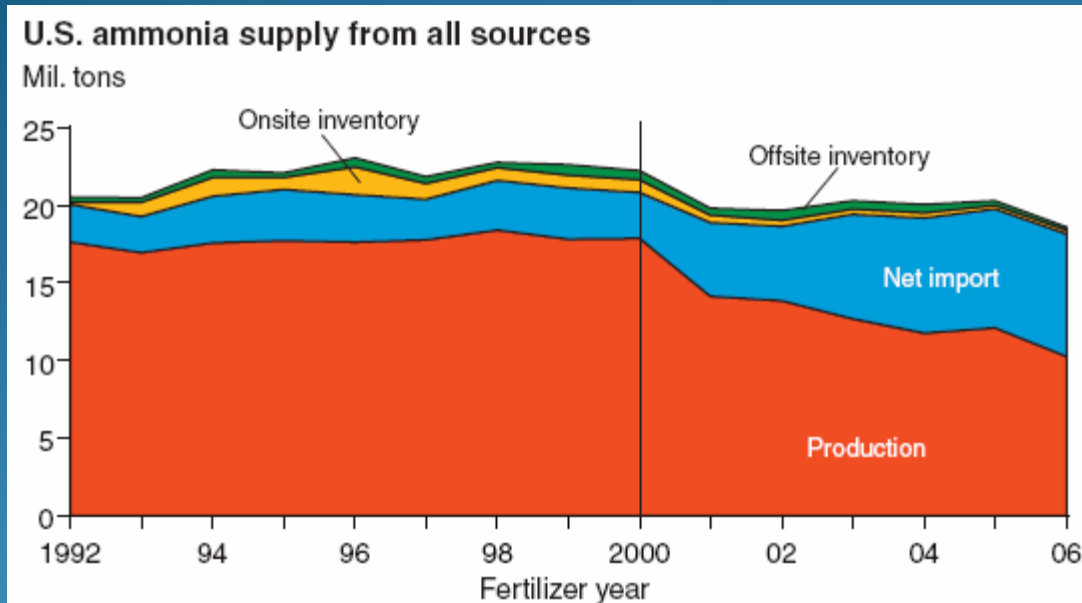
- Imported ammonia has become increasingly important to the U.S. ammonia supply.

- From 2000 to 2006, annual U.S. imports of ammonia increased from 3.9 to 8.4 million tons, an increase of 115 percent,

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NH₃ supplies from all sources is declining



Note: Fertilizer year runs from July of the preceding year to June of the year indicated in the chart.

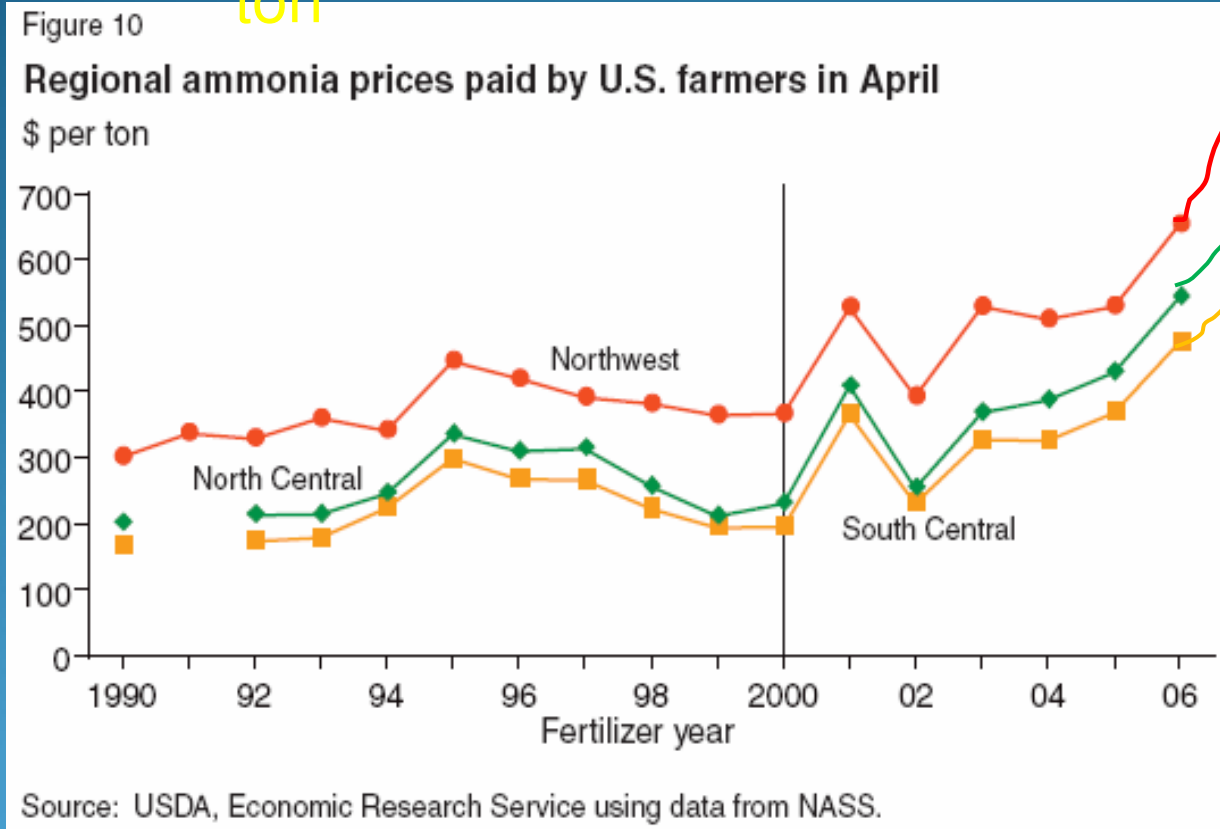
Source: USDA, Economic Research Service using production and onsite inventory data from DOC, net import data from ERS(d), and offsite inventory data from TFI (c).

- Currently the United States is importing a higher percentage of NH₃ than we do fossil fuel.
- More than 75% of the ammonia used in this country is imported.
- This is not only bad for our economy this puts the United States at risk.
- It is no longer just about food production. It is also about food security.

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Now over \$1100 per ton

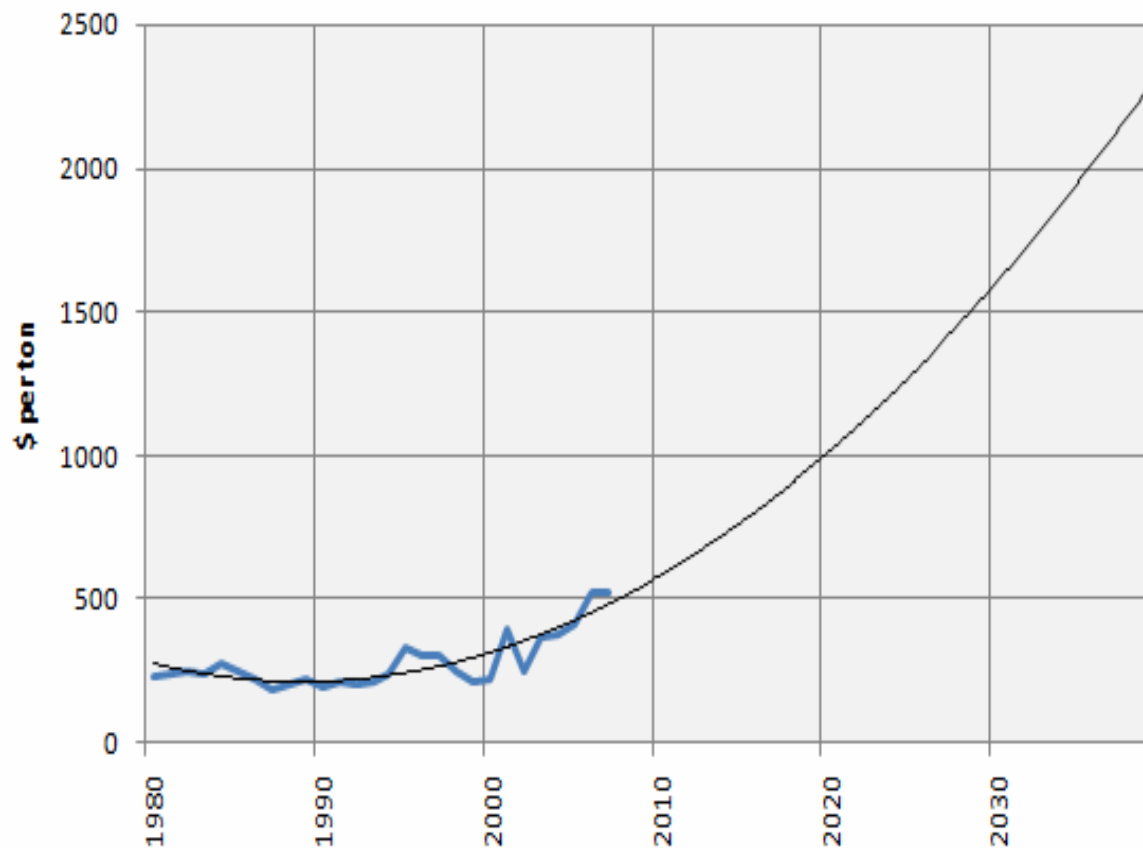


Ammonia prices paid by farmers continue to climb

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U.S. Fertilizer Price



- This graph shows the average U.S. fertilizer price over the last 25 years, and projected the trend out to 2040.

- This graph indicates a rise of almost 500% over the period.

- Very conservative given recent trends

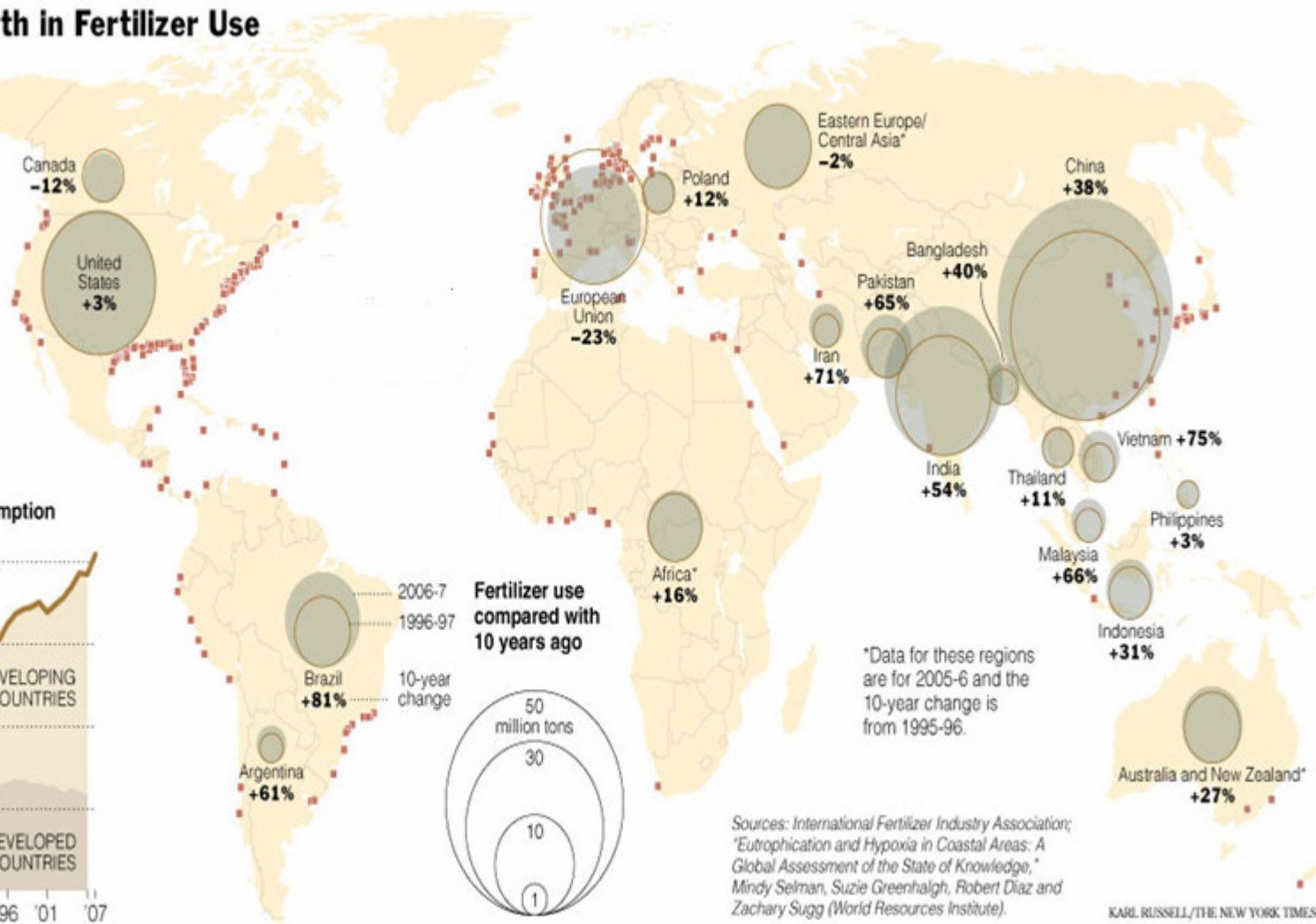
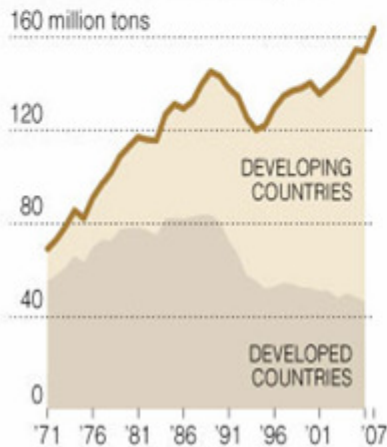
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Worldwide Growth in Fertilizer Use

Fertilizer use has been growing faster in developing countries than in the industrialized world in recent years. But rising demand has produced a big price jump.

Worldwide fertilizer consumption



Sources: International Fertilizer Industry Association; "Eutrophication and Hypoxia in Coastal Areas: A Global Assessment of the State of Knowledge," Mindy Selman, Suzie Greenhalgh, Robert Diaz and Zachary Sugg (World Resources Institute).

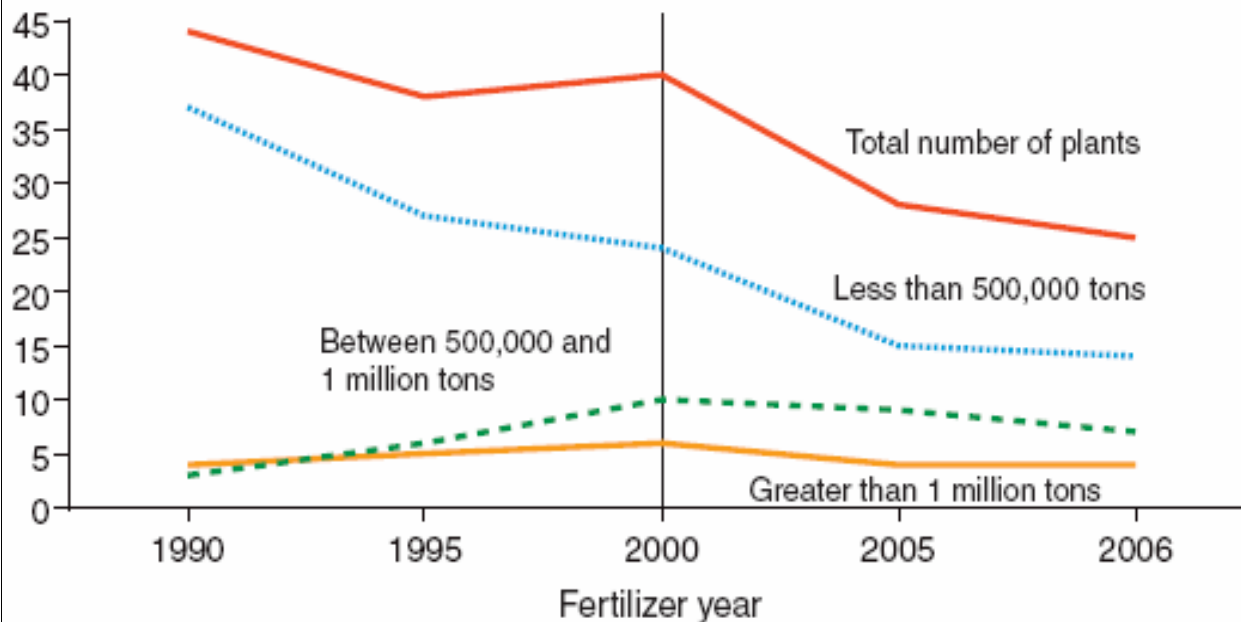
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Figure 6

Number of ammonia plants in three ranges of production capacity per year

Number of plants



Note: Fertilizer year runs from July of the preceding year to June of the year indicated in the chart.

Source: USDA, Economic Research Service using data from IFDC.

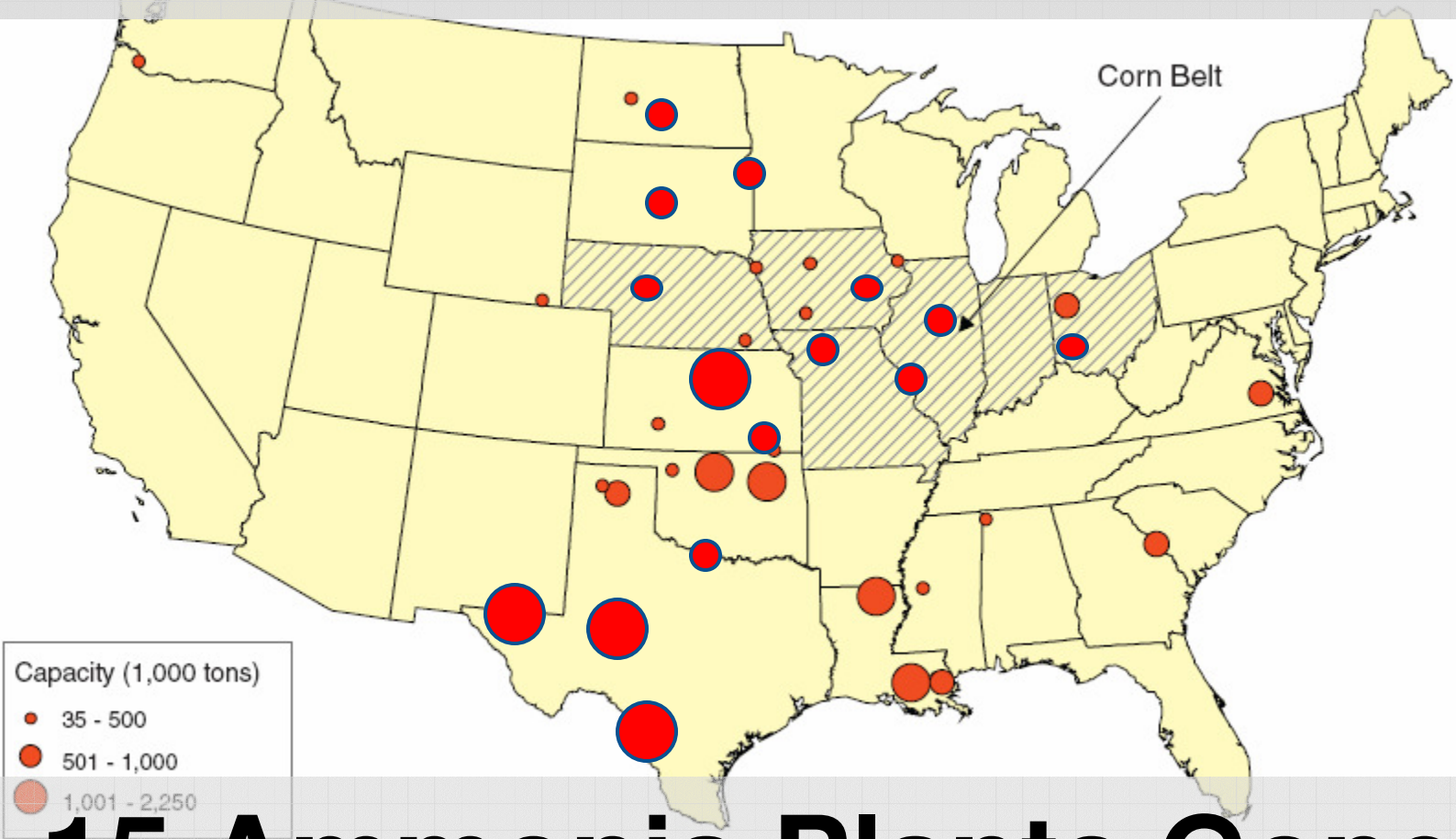
- The number of ammonia plants is declining
- Ammonia plants dropped from 40 to 25.
- The largest decline has been in small plants with annual production capacity of less than 500,000 tons.

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U.S. ammonia production plants, 2005-06

1994 – 40+ Ammonia Plants



15 Ammonia Plants Gone

Source: U.S. Economic Research Service (http://www.ers.usda.gov)

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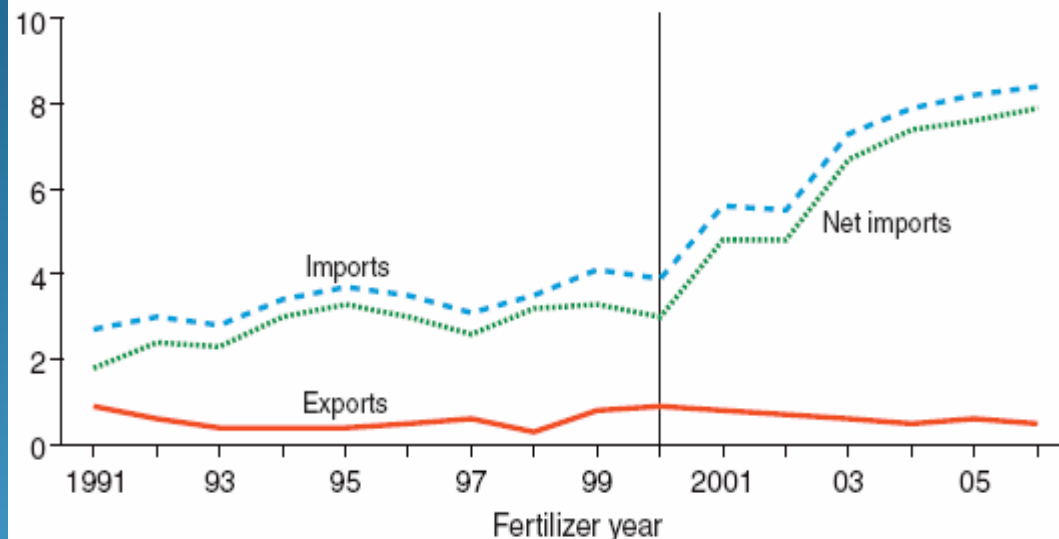
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- 7 million tons NH₃ imported

Figure 7

U.S. ammonia imports, exports, and net imports

Mil. tons



Note: Fertilizer year runs from July of the preceding year to June of the year indicated in the chart.

Source: USDA, Economic Research Service (d).

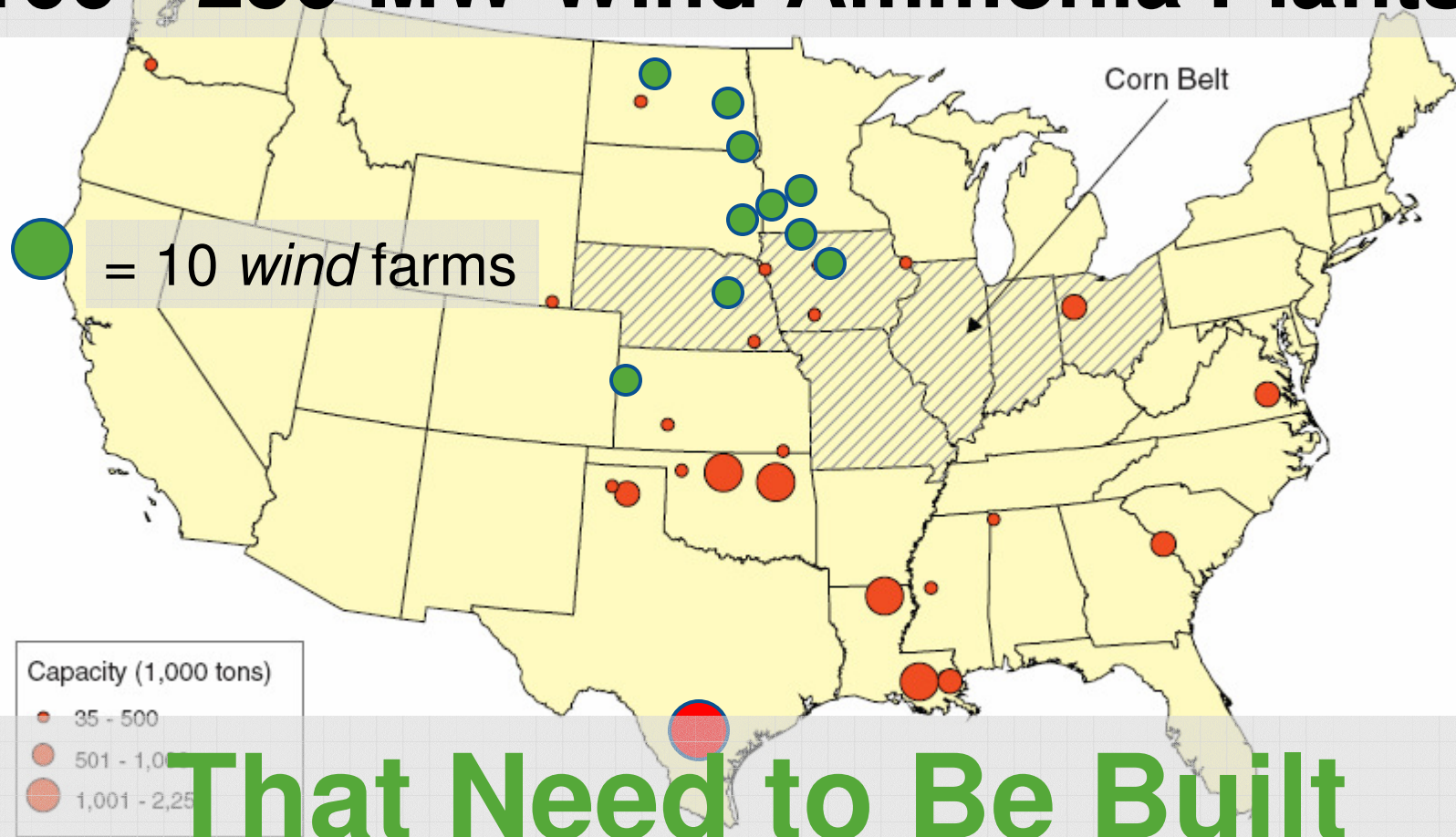
- Just a little more NH₃ than what the entire 75 million acre U.S. corn crop requires
- To produce 7 million tons NH₃ would require 84 Thousand GW
- 9600 - 2.5 MW Turbines located with in 17mph wind speed would replace these imports

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U.S. ammonia production plants, 2005-06

100 - 250 MW Wind Ammonia Plants



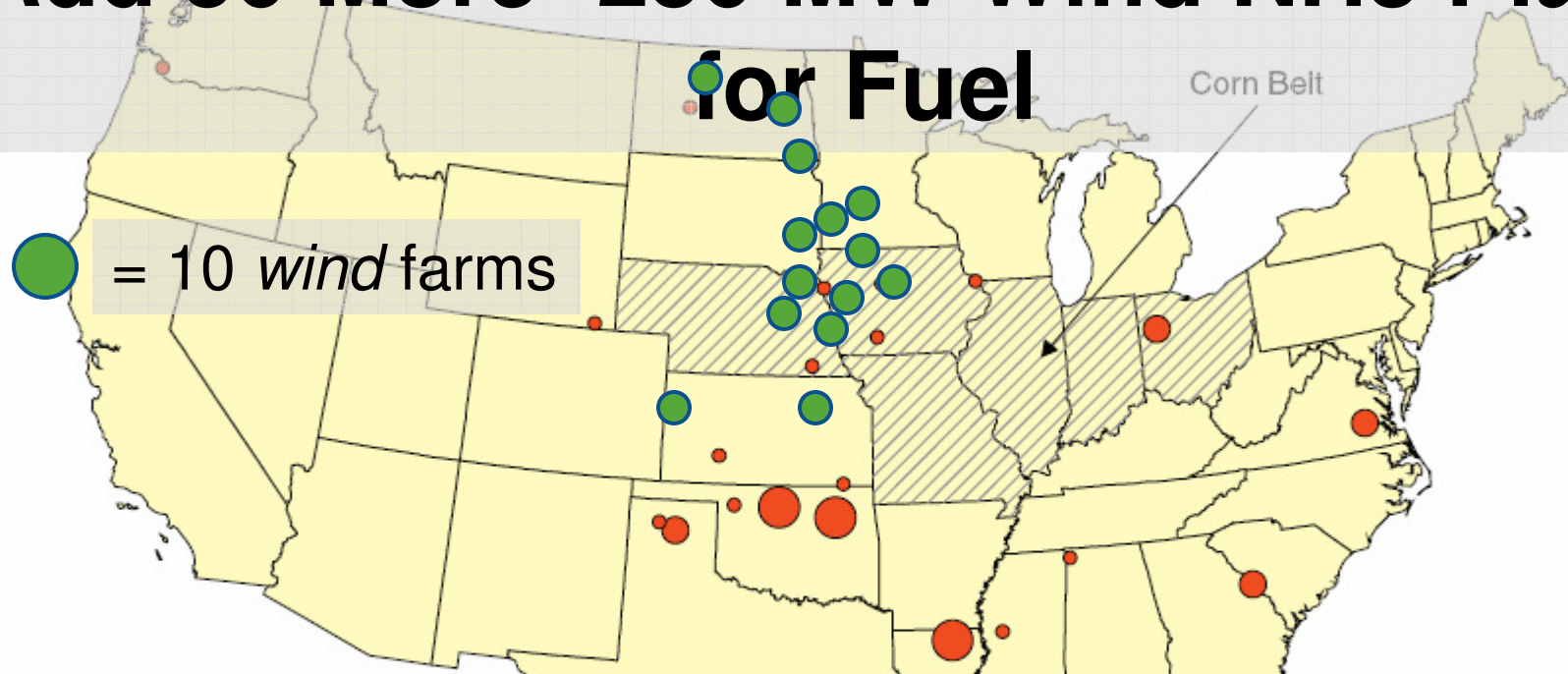
Source: USDA, Economic Research Service using data from IFDC.

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U.S. ammonia production plants, 2005-06

Add 50 More- 250 MW Wind NH3 Plants for Fuel



Capacity (1,000 tons)

501 - 1,000

1,001 - 2,250

Source: USDA Economic Research Service, using data from EIA, DC.

American Corn Production Would be 100% Green

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U.S. ammonia production plants, 2005-06

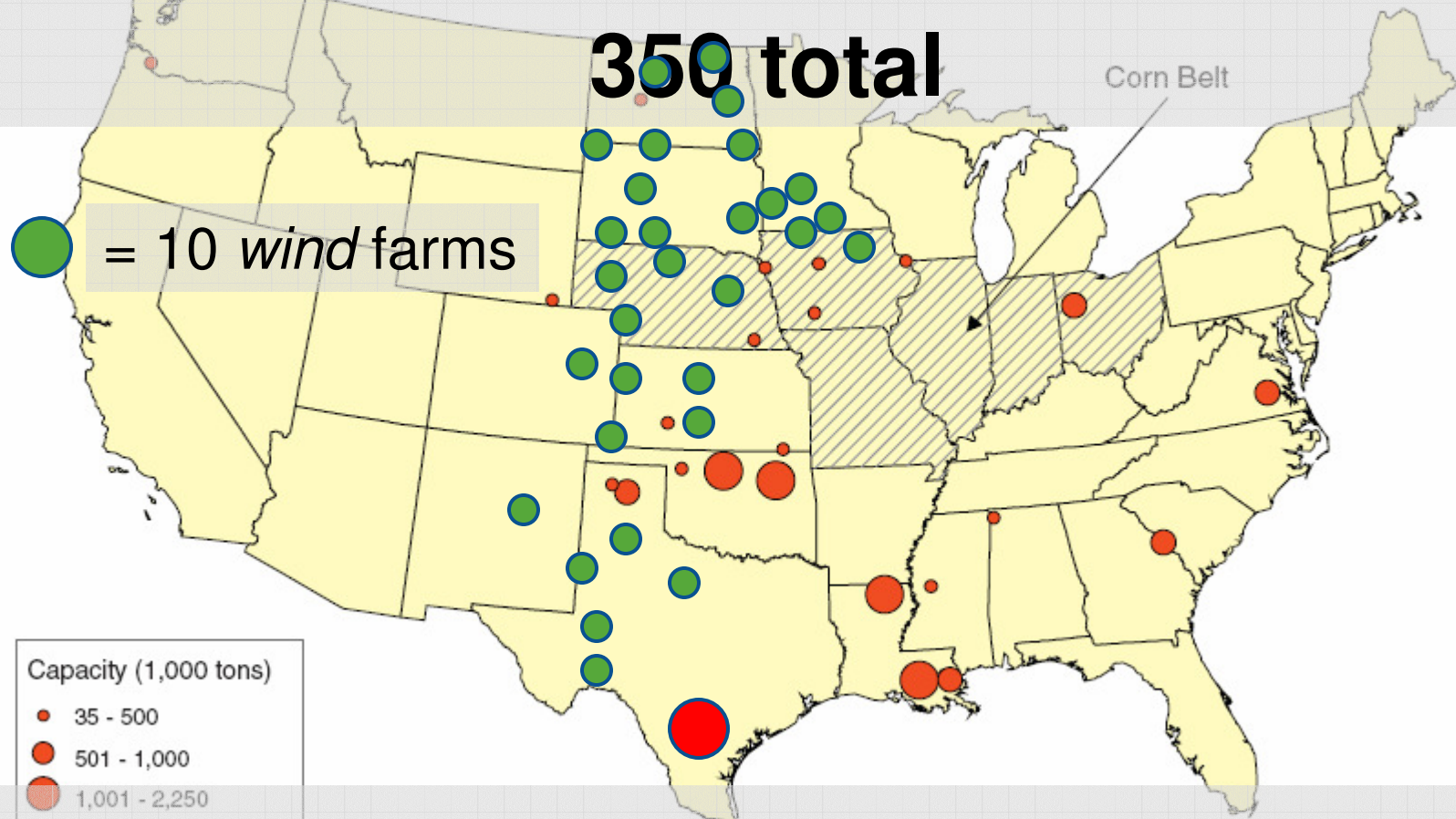
200 More Wind Ammonia Plants

350 total

 = 10 wind farms

Capacity (1,000 tons)

-  35 - 500
-  501 - 1,000
-  1,001 - 2,250



Would make all our NH₃ Green

Source: USDA Economic Research Service, www.ers.usda.gov from IFDC

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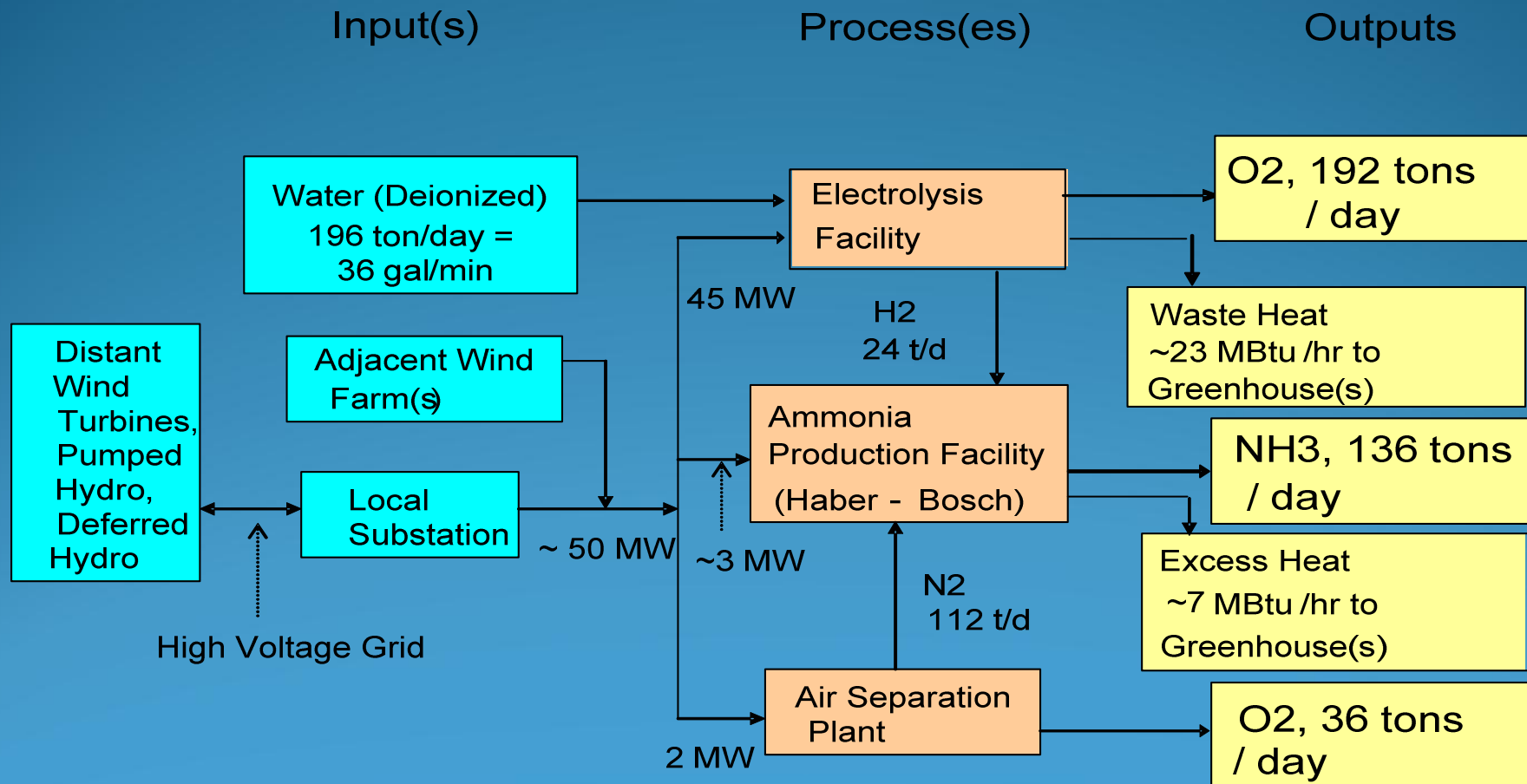
- Freedom Fertilizer answers the energy/production challenge facing the U.S. Ag-economy by capturing and converting stranded wind power into anhydrous ammonia
- NH_3 Fertilizer is critical to sustain corn production and and if produced with green methods a biofuel capable of delivering the advantages of hydrogen based energy using existing diesel technology

The following graphic provides an overview of the Freedom Fertilizer process:

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Green Fertilizer and Fuel for the Future

The following graphic provides an overview of the Freedom Fertilizer process:



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- Inputs
- 50 MW of electrical power on a constant feed
- Outputs of the process include:
 - 192 tons per day of Oxygen (O_2) from Electrolysis
 - 36 tons per day of Oxygen (O_2) from Air Separation
 - 136 tons per day of Ammonia (NH_3) from Haber-Bosch
 - ~23 MBtu/hr of heat from Electrolysis
 - ~7 MBtu/hr of heat from Haber-Bosch

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**Norsk Hydro
Electrolyzers
2 MW each**

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- Once capital costs are retired, ammonia production costs will be limited to labor and plant maintenance.
- A near term cost advantage of \$200/ton is achievable, with a long term differential projected at \$500/ton or more.
- Price advantage and pressure on natural gas supplies will drive customer demand.

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- Customer base will be local Ag producers reducing transportation costs.
- 250,000 ton/year ammonia facility can be expected to satisfy the typical needs of 3 to 4 thousand farmers
- Resulting in a delivery radius from the plant of roughly 60 miles
- Providing fertilizer for 5000 square miles of corn.
- Fluctuation in demand for ammonia fertilizer can be offset by demand for ammonia as a fuel.

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- Distribution will be through the existing robust ammonia infrastructure currently in place.
- Iowa is the natural center of the nation's 3,100 mile ammonia distribution pipeline system and has over eight hundred filling stations already in place.
- The State of Iowa would require just 4 - 250 MW plants to supply fertilizer for its approximately 12 million acre of corn

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- Project funding will be developed through a mix of government grants and venture capital investment.
- Project development and construction estimate would require 24-28 months from initial funding to first ammonia production.
- Intrinsic to Freedom Fertilizer's long-term profitability will be the choice of subsidiary enterprises interconnected with the ammonia generation plant.
- The two primary byproducts of ammonia generation are heat and medical grade oxygen.

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- A 50MW plant will provide sufficient heat to sustain a 5+ acre greenhouse year round.
- Recent technological innovations in the production of algae based biodiesel may establish that as a more profitable subsidiary enterprise utilizing waste heat.
- Oxygen can be used to sustain cellulosic methanol production, which could be another co-located independent enterprise.

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- Wind based ammonia generation offers immediate quantifiable benefits to Ag producers.
- An opportunity for immediate use of carbon free hydrogen based fuel and will serve as a nexus for other sustainable enterprises via co-location and use of byproducts.
- The need for carbon free energy and a reliable source for ammonia will drive customer demand and profitability, while moving our nation closer to a sustainable future.

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The Past History of Renewable Ammonia Fertilizer

FOOD FROM THE AIR

Projected Dams and Hydro-electric Stations

By DR. ROBERT CALVERT,
Chemist, University of Southern California, Los Angeles.

FOOD from air" was the optimistic prediction of a chemist twenty years ago. Food from air is a reality today, in Norway, in Germany and at Niagara Falls, Canada. Food from air is Henry Ford's idea for the Government plant at Muscle Shoals, Alabama. It should be one of our leading industries when great dams and hydro-electric sta-

does not grow, as do potatoes. Particularly is this true of nitrate of soda. With the growing appreciation of the value of nitrate fertilizer, the complete exhaustion of the Chilean beds is a matter of a few decades only. Then what? Will we turn to Germany and pay tribute in dollars and self-respect to her wisdom and genius in drawing from the atmosphere an inexhaustible source of nitrogen? Or will we harness the power of our turbulent seas and add to it human ingenuity and some of the hundreds of millions of dollars yearly that would otherwise be lost?

Nitrogen From the Air,

as a hundred years ago, with nitrogen still in its infancy, an Englishman, Cavendish, found that the spark could be used to combine nitrogen with the oxygen of the air. The invention of Cavendish lay unused for a hundred years, until cheap electricity became available in Norway. Dr. Samuel Eyde supplied the backing and the enthusiasm of the Government. He built five factories from 1905 to 1912, he was shipping ammonia around the Strait of Magellan to Seattle on the West Coast in combination with nitrate from the West Coast of Chile.

The New York Times

Published: March 5, 1922

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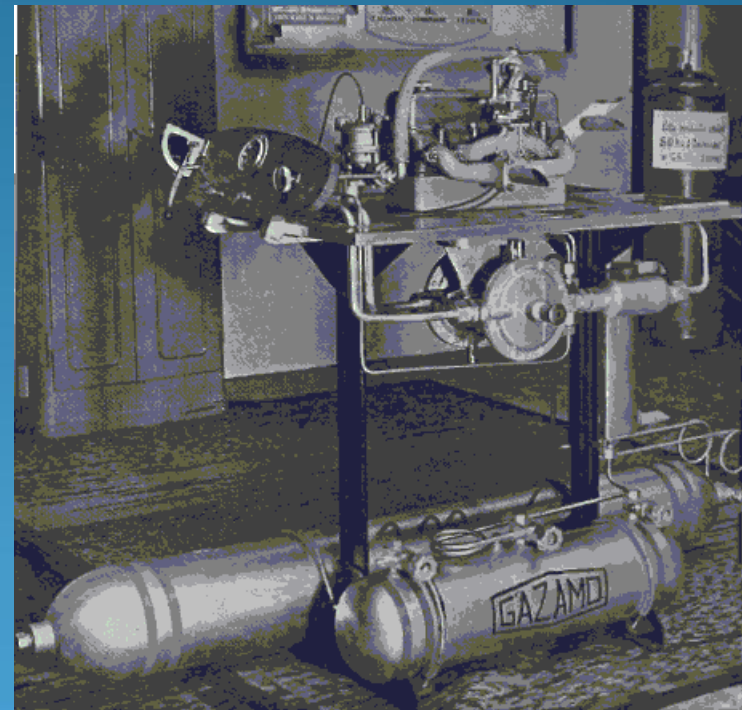
The Past History of Ammonia as Fuel



FIG. 3.

AMMONIA-EQUIPPED MOTOR BUS. AMMONIA CONTAINERS ARE FIXED ON THE FRONT OF THE VEHICLE AND THE GAS CYLINDERS ON THE TOP.

Brussels, Belgium
NH₃ Powered Buses
During WWII



Gazamo NH₃ Fueling System circa 1943

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The Future of Renewable Ammonia

Not since the first steam powered tractor, over 100 years ago has American Agriculture been 100% renewable and sustainable. Before for that time America's HP (horse power) was born raised and fed off the same land that these draft animals helped plant, cultivate, fertilize and harvest. Once energy from outside the circle was introduced and fossil fuels became part of this picture the circle has been broken.

Self sustenance and renewability was lost to the more efficient and labor saving internal combustion engine tractor. What was once a circle is now a flat line. Held in place by fossil fuel



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The Future of Renewable Ammonia

Many have advocated that we try and return to this type of renewable agriculture but how can we? As we all know.... You can never go back. The inefficiencies of horse drawn agriculture would never allow for amount of food that needs to be produced for a world population as large and hungry as it is today.

But we have an opportunity before us. One that will allow us to return to a 100% renewable and sustainable agriculture. We can once again have the fertilizer to feed the crop and fuel for the machines that is required to plant, cultivate and harvest the crop produced renewably in the same fields as the crops themselves. Green NH₃ produced from renewable wind energy to grow the crops. These same crops tended by machines that use the same green NH₃ as fuel.

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The Future of Renewable Ammonia

Renewable NH_3 made from wind power would not only make Agriculture once again sustainable but this would allow the growing crops to clean the atmosphere of the billions of tons of excessive CO_2 produced from burning fossil fuels. Farming without fossil fuel would make production agriculture a gigantic consumer of CO_2 . In turn making food production a huge negative carbon footprint. The way that nature intended the sustainable circle to work.

Think of the amazing possibilities of green NH_3 being produced around the world from resources like wind, hydro, ocean current and solar. This opens the door to producing NH_3 in remote areas with stranded resources. Areas that may not be connected to the grid, roads or pipeline. Areas like Central Africa and Asia where Nitrogen fertilizers maybe hard to come by.

This could mean modern green production agriculture around the world. Feeding hungry people and creating another source of income by harvesting these stranded renewable resources for the creation of food and NH_3 fuel.

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