# AST 426 : Economic and Environmental Impact of Precision Agriculture

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# Recap: Case Study II

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## Machine learning and fluorosensing for estimation of maize nitrogen status at early growth-stages

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# Recap: Case Study II

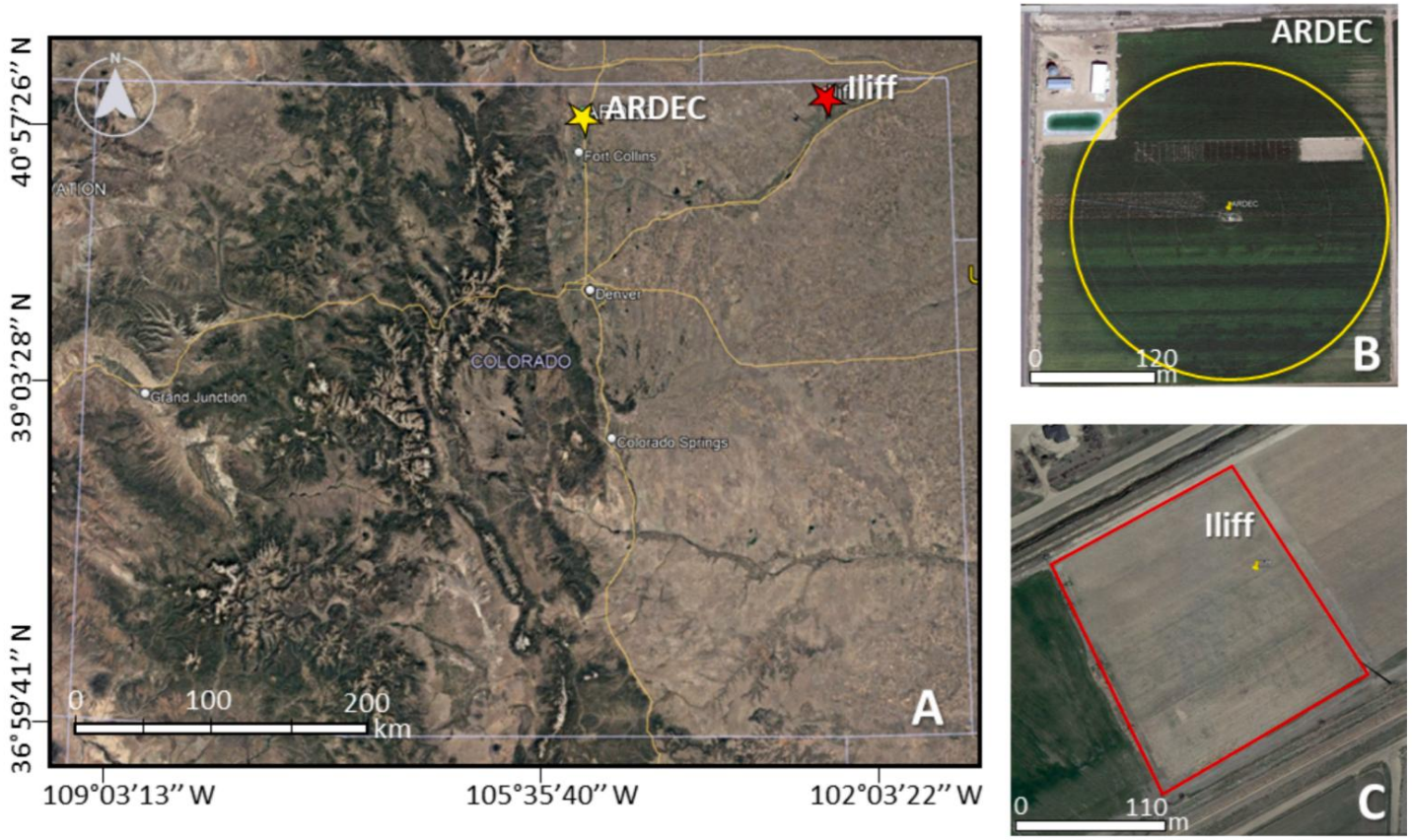


**Fig. 1.** Geographic location of the ARDEC and Iliff sites (star symbols) overlaid on a Google Earth imagery (A). An enlarged view of fields over two sites are highlighted in yellow (B) and red (C) polygons for ARDEC and Iliff respectively.

# Recap: Case Study II

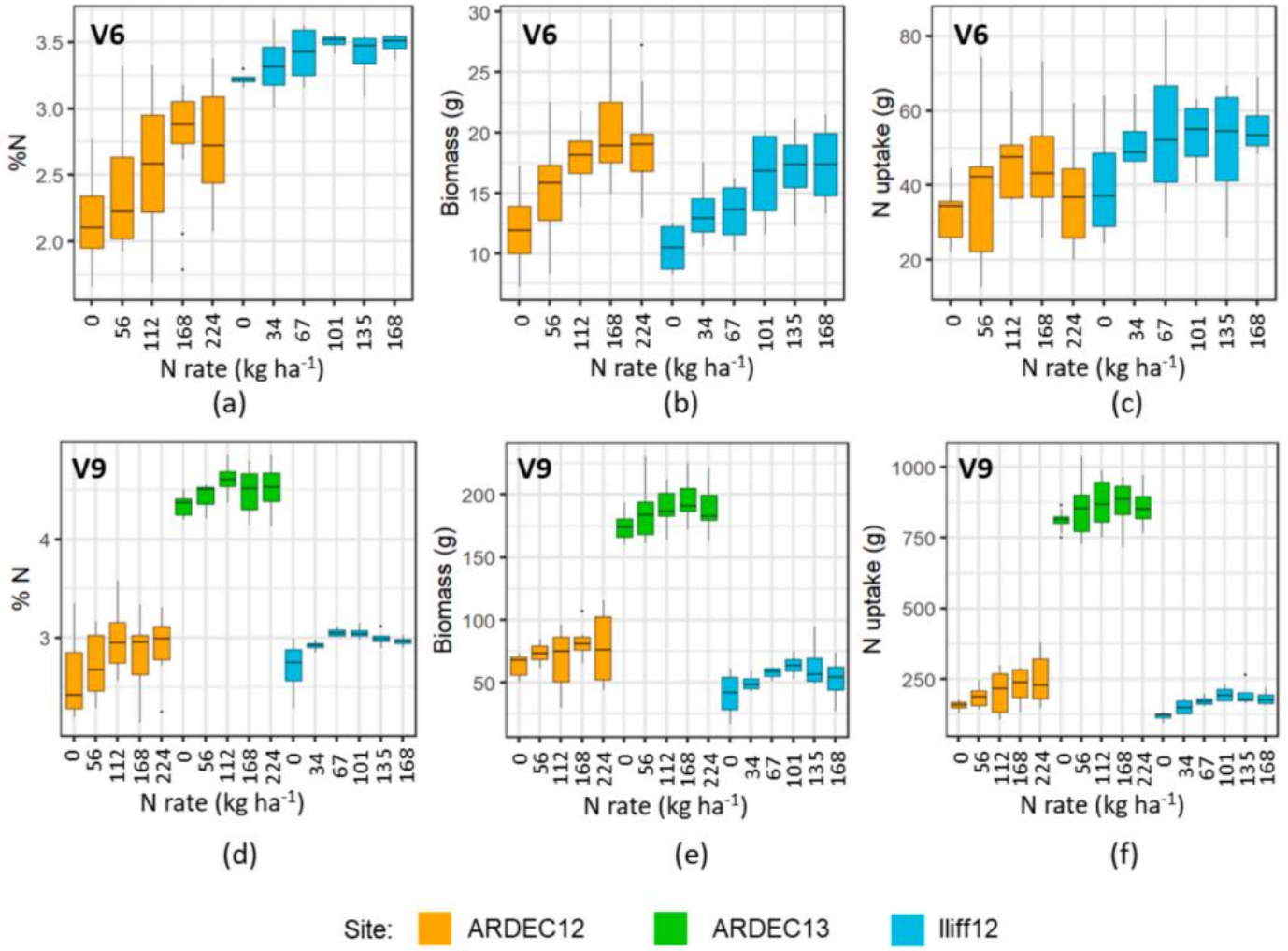


**Fig. 2.** Variability of %N, above ground biomass, and N uptake with N rate applications at V6 and V9 growth stages of maize for three site-years.

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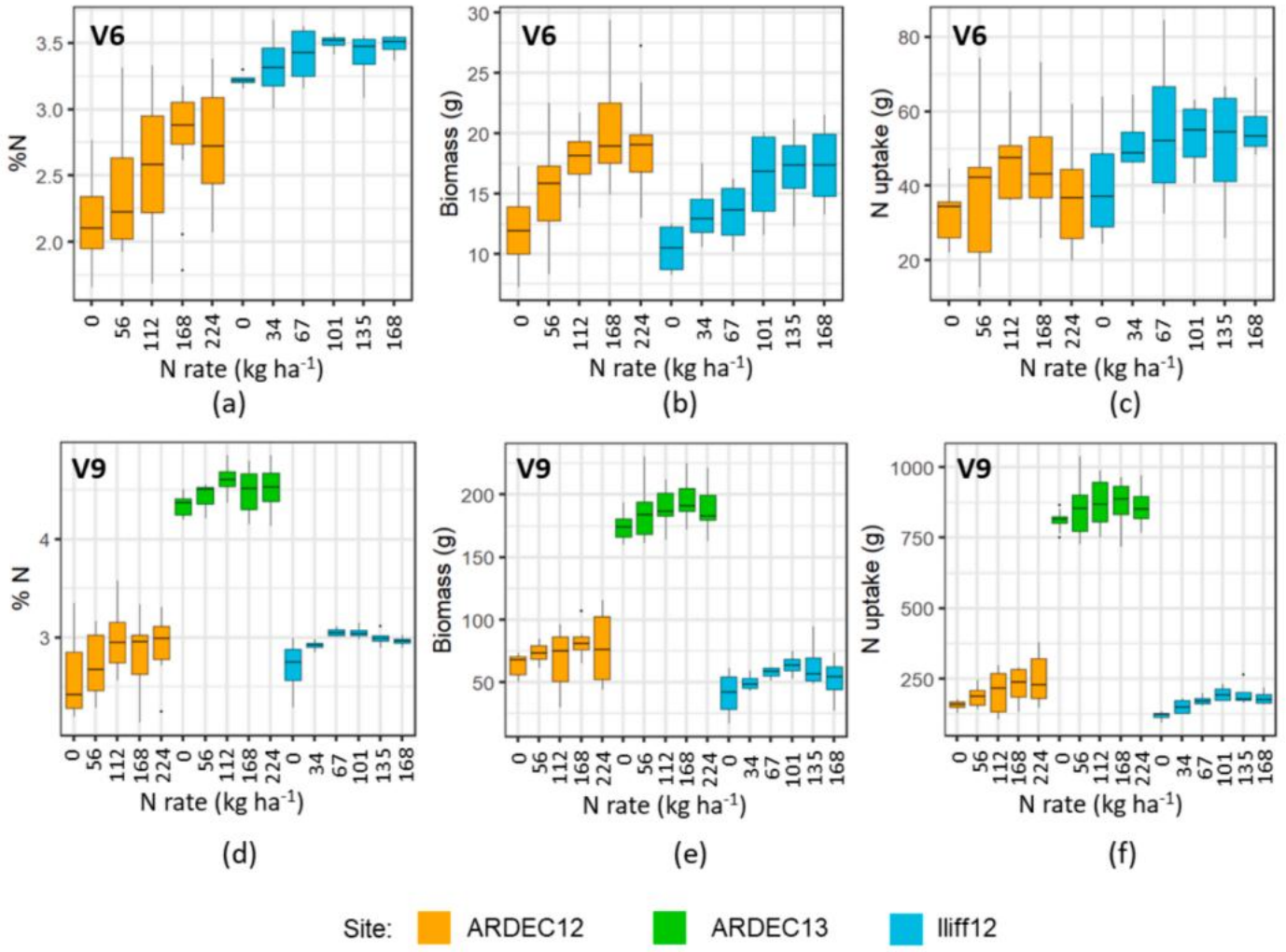



**Fig. 2.** Variability of %N, above ground biomass, and N uptake with N rate applications at V6 and V9 growth stages of maize for three site-years.

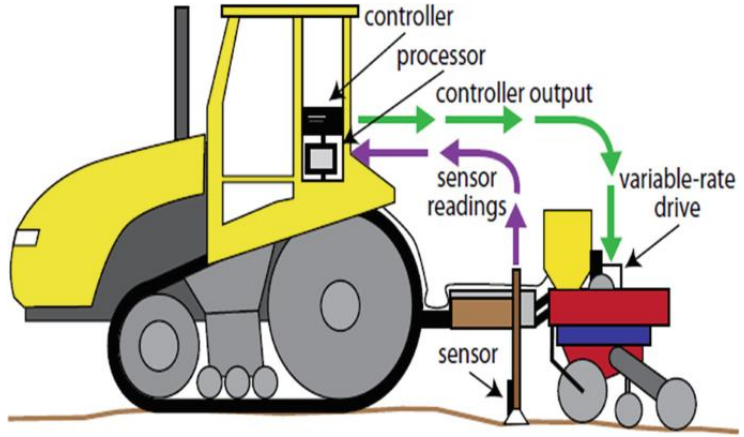
# Economic Impacts of Precision Agriculture

## RTK Auto-Steer (Efficiency Gains)

- Reduced tractor fuel costs by **10.4%**.
- Reduced overlap during planting and fertilizer application, saving on seed (**2.4%**) and fertilizer (**2.2%**).
- Increased machinery efficiency, allowing faster headland turns and reentry into fields, reducing overall operating time.

## Variable Rate Application (VRA)

- Optimized nitrogen application based on soil variability
- Reduced fertilizer use in areas with limited crop response.
- Increased application in high-response areas, boosting yields.
- Increased net returns by **0.9%**.




Schieffer, J., & Dillon, C. (2015). The economic and environmental impacts of precision agriculture and interactions with agro-environmental policy. Precision Agriculture, 16, 46-61.

# Economic Impacts of Precision Agriculture

## Automatic Section Control (ASC)

- Reduced overlapping pesticide applications, saving 10.5% on herbicides and insecticides.
- Decreased sprayer fuel use by **15.6%**.
- Increased net returns by **0.8%**.

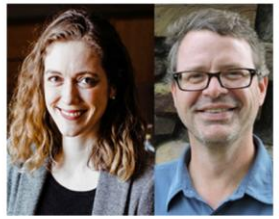

## Combined Technologies

- Integration of RTK, VRA, and ASC increased net returns by **2.9%**.
- Synergistic effects
- Enhanced input efficiency.
- Improved yields (corn yield +**1.8%**)

https://mytopcon.topconpositioning.com/ie/agriculture-smart-implements-and-harvest/sprayers/boom-height-control

# Economic Impacts of Precision Agriculture

## Benefits and Evolution of Precision Agriculture



Drs. Amanda Ashworth and Philip Owens are researchers in ARS's Poultry Production and Products Safety Unit and the Dale Bumpers Small Farms Research Center located in Fayetteville and Booneville, AR, respectively. Their precision agriculture work focuses on developing tractor guidance systems for better resource management on farms.

*Welcome Drs. Ashworth and Owens to* ***Under the Microscope:***

https://www.ars.usda.gov/oc/utm/benefits-and-evolution-of-precision-agriculture/

**UM –** *What are the potential economic and environmental impacts of the tractor guidance system you are developing?*

**AA –** Our team (along with Dr. Mike Popp at the University of Arkansas) developed a decision support tool called "Tractor Guidance Analysis," which helps optimize on-farm decision making for improved economic and environmental impacts using tractor guidance systems. We are also performing research to identify actual overlap and gap reductions when using tractor guidance, as well as the corresponding economic and environmental impacts. We are finding that this technology can reduce diesel, fertilizer, and other inputs, thereby resulting in greater environmental sustainability. Consequently, this technology can pay for itself relatively quickly, even for small-scale producers.

Aerial photo from a tractor-guidance study evaluating how topography and field shape variations influence crop management and growth. The green areas are depressions where the wheat crop is maturing slower. Knowing the exact locations of these areas can help farmers choose the best management strategies.

# Economic Impacts of Precision Agriculture

**A 2019 survey of 800 commercial farmers (1000 acres or larger in size) by Purdue's Center for Commercial Agriculture**

- Large proportion of farmers with 2000 or more operated acres collect yield monitor (approximately 75%), soil sample (approximately 85%) and imagery (close to 90%) data
  - Highest influence on fertilizer decisions, seeding rate decisions and drainage decisions
  - 72% report a positive yield impact from data-driven seeding rate decisions; 81% from fertilizer decisions and 85% from drainage decisions.

https://ag.purdue.edu/commercialag/home/resource/2021/02/the-value-of-data-information-and-the-payoff-of-precision-farming/

# Economic Impacts of Precision Agriculture

- Lowenberg-DeBoer and Erickson have provided an excellent review of the research that has been done internationally on the adoption of precision agriculture technology (Lowenberg-DeBoer and Erickson, 2019)

**"Historians of the future may look back and realize that the VRT equipment and services marketed starting in the early 1990s were a useful first step, but not the last word in spatial management of crop inputs. A new wave of technology may be required to apply the right input, at the right place, at the right time, and in the right manner. For example, it may require robots equipped with AI doing individual plant management."** Page 15

https://www.ars.usda.gov/oc/utm/benefits-and-evolution-of-precision-agriculture/

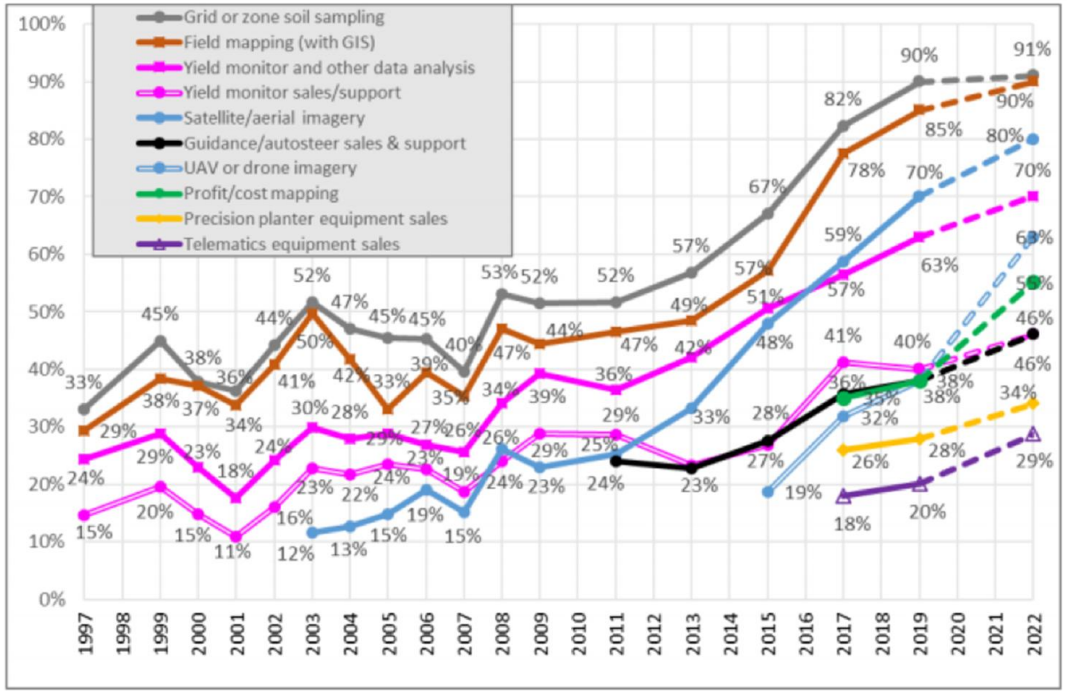
# Economic Impacts of Precision Agriculture

- Soil and yield maps, automated guidance systems, and variable input applications showed **2% increases in net returns**.
- Soybean farmers reported **$10–$20/acre benefits from digital tools**.
- Yield monitors, mapping, drones, agronomic systems, decision support technologies resulted in **net benefits: ~$90/acre, benefit-cost ratio of 9.7:1**

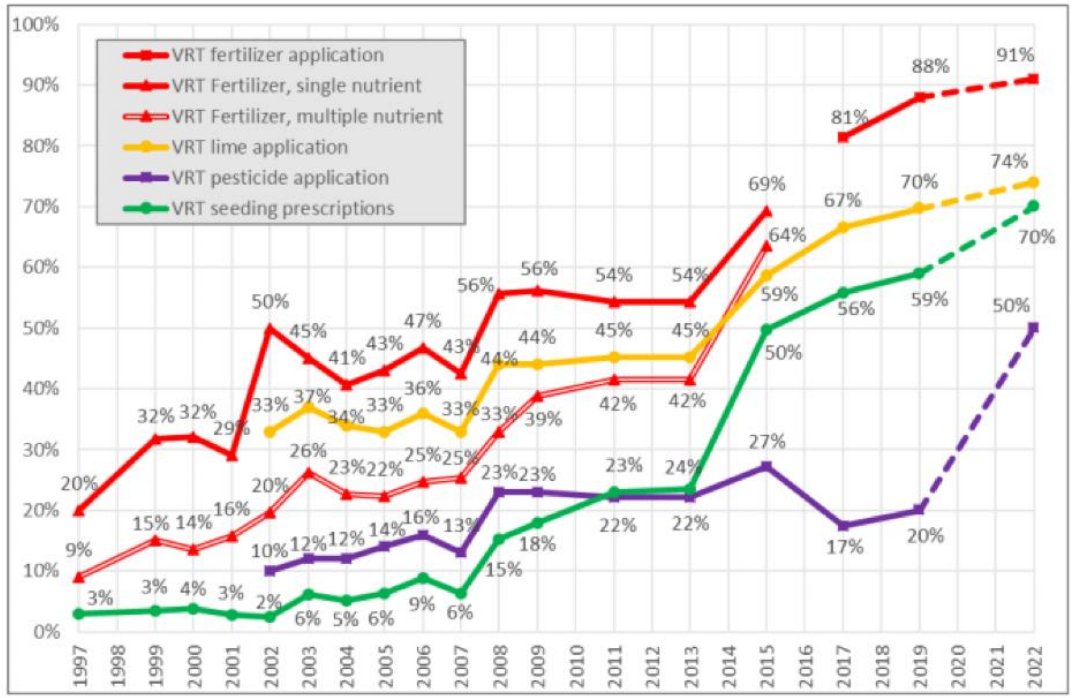
https://www.ars.usda.gov/oc/utm/benefits-and-evolution-of-precision-agriculture/

# Economic Impacts of Precision Agriculture

**Dealer offering of precision services over time, sensing technologies. 2022 are projections.**



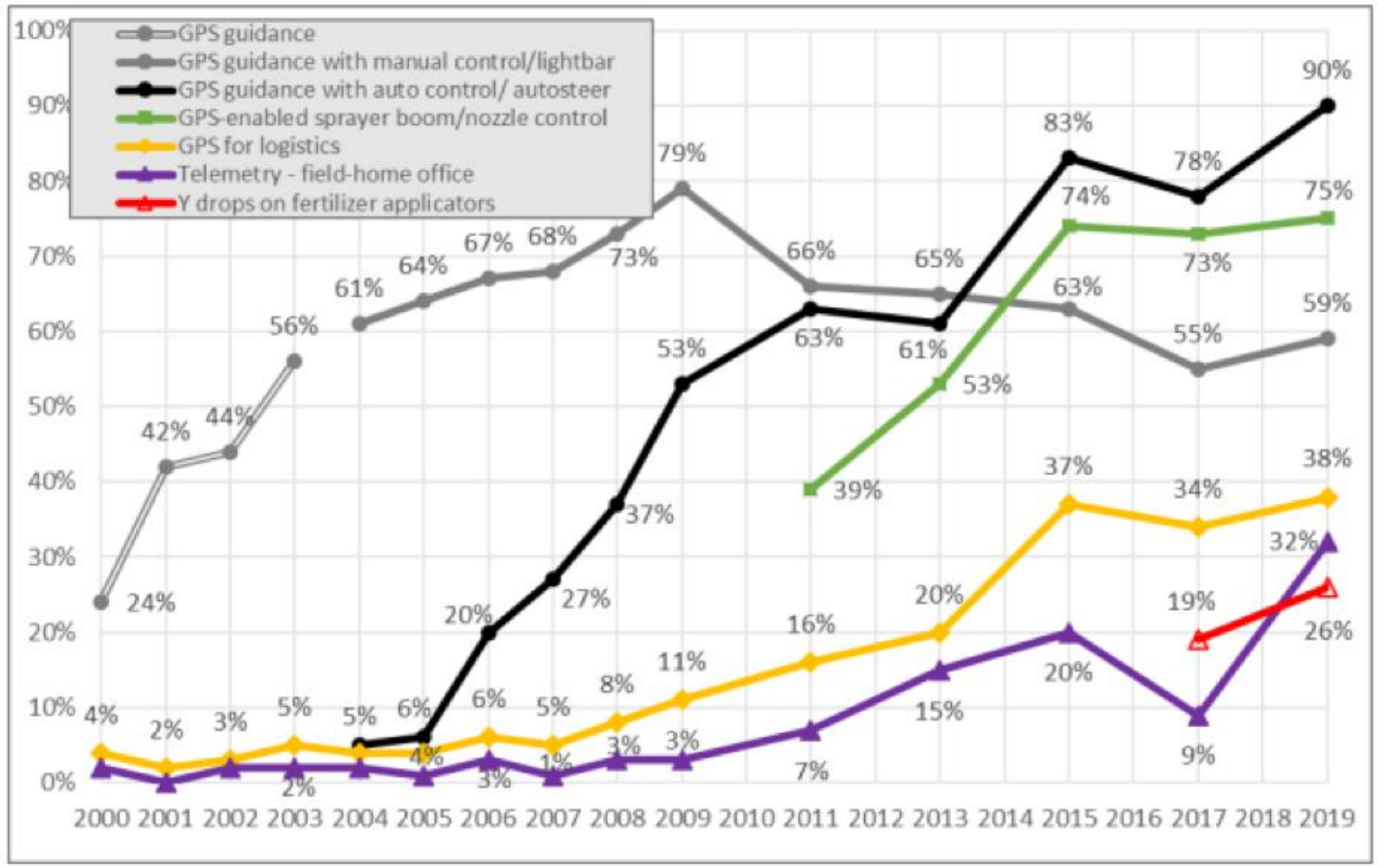

**Dealer offerings of precision services over time, variable rate technologies.**




https://ag.purdue.edu/commercialag/home/resource/2021/02/the-value-of-data-information-and-the-payoff-of-precision-farming/

# Economic Impacts of Precision Agriculture

**Use of precision technology over time by retailers, automated technologies.**

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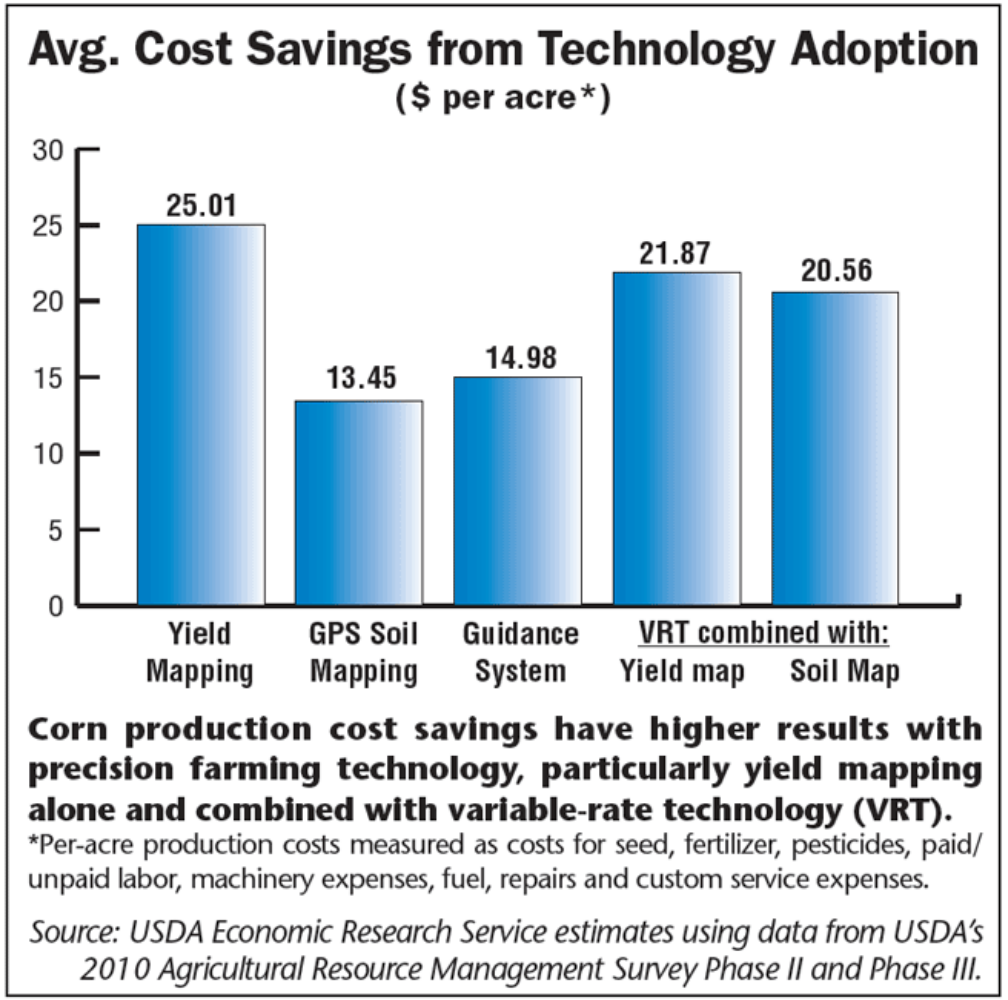
# Economic Impacts of Precision Agriculture

- VRT paired with yield mapping shows higher savings due to better input placement based on dense data.
- Combining GPS mapping, auto-guidance, and VRT provides synergistic benefits, improving operational efficiency and boosting profits.
- Even with higher input costs to achieve yield goals, **increased yields and profits justify the investment in precision agriculture technologies**.




https://www.farm-equipment.com/blogs/6-opinions-columns/post/13649-economic-benefits-of-using-precision-farming

# Environmental Impacts of Precision Agriculture

## Reduced Chemical Runoff

- Optimized application of fertilizers, pesticides, and herbicides reduces contamination of water bodies.

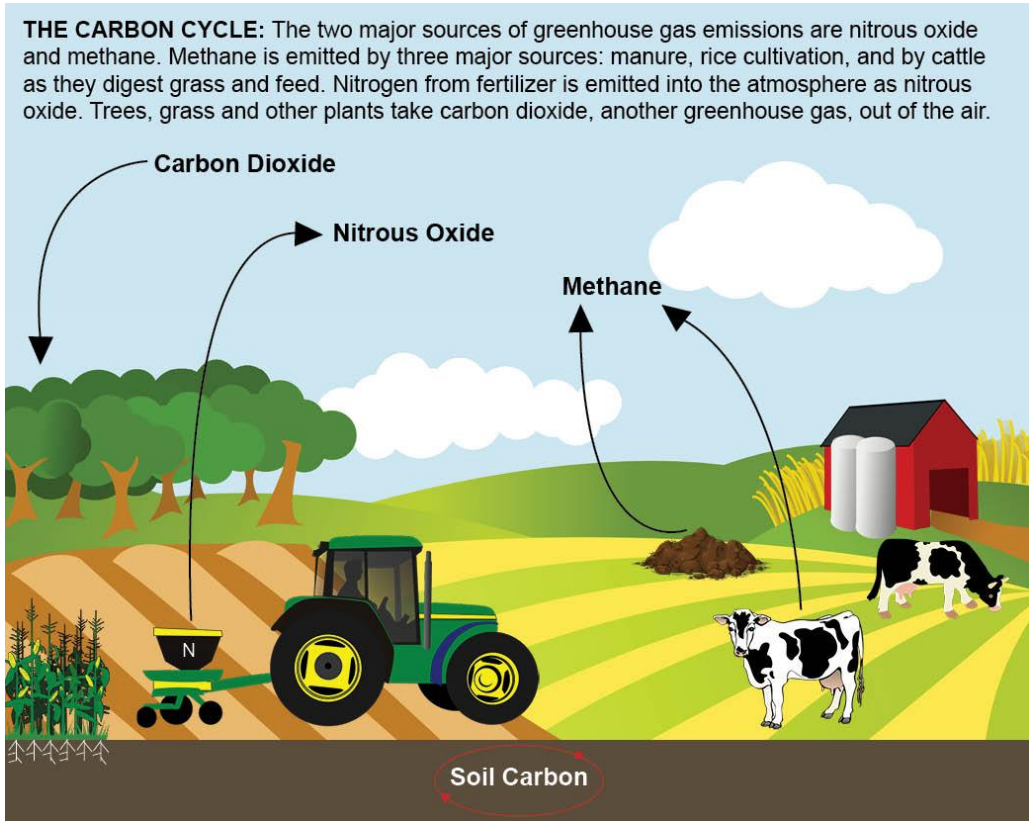
- When crops do not fully absorb nutrients like nitrogen, phosphorous, etc., they get washed off from the fields and lead to environmental issues in the surrounding ecosystem.
- **Agricultural runoff is considered bad** because it **disrupts the natural nutrient balance** in the environment.

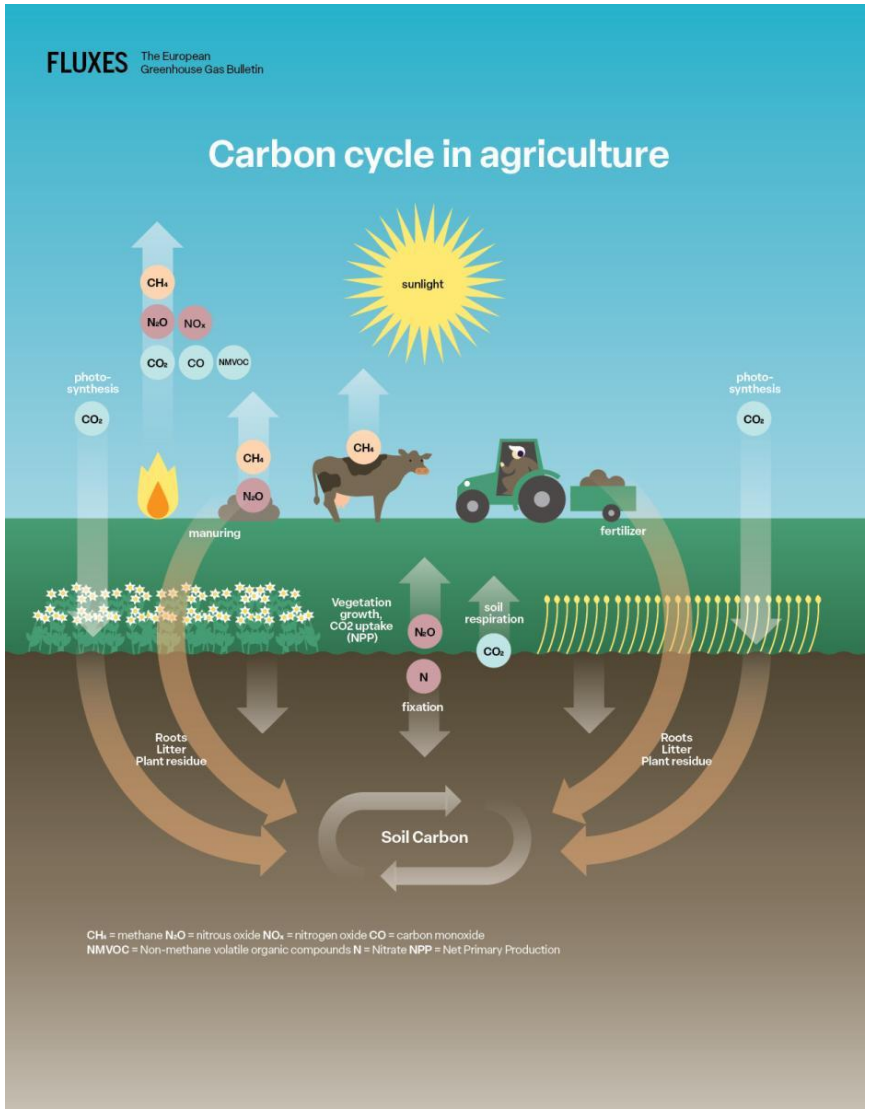
https://www.ars.usda.gov/oc/utm/benefits-and-evolution-of-precision-agriculture/

# Environmental Impacts of Precision Agriculture

## Lower Carbon Emissions

- Reduced fuel usage through efficient machinery operations and optimized input application.

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# Environmental Impacts of Precision Agriculture

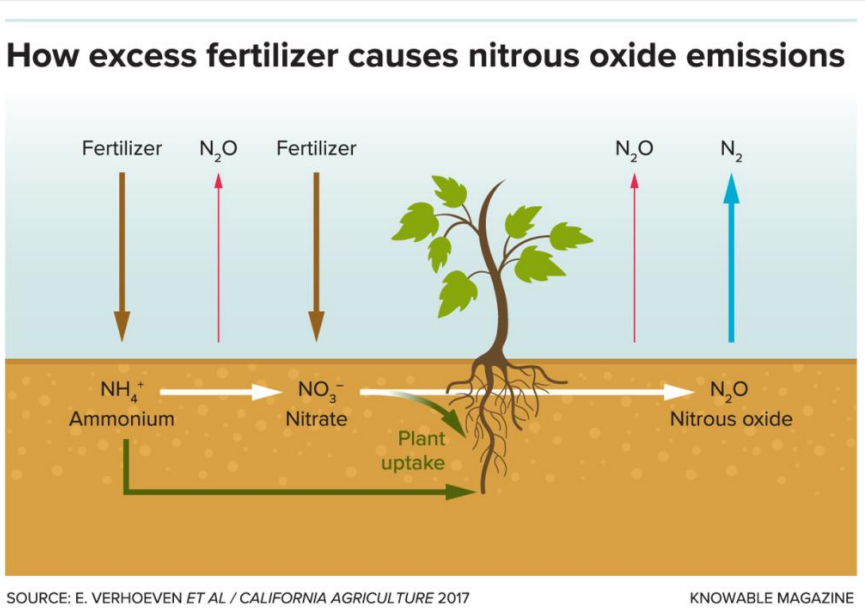
The World Economic Forum estimates that, **if 15-25% of farms adopted precision agriculture**, **global yield could be increased by 10-15% by 2030**, while **greenhouse gas emissions and water use could be reduced by 10% and 20%, respectively.**

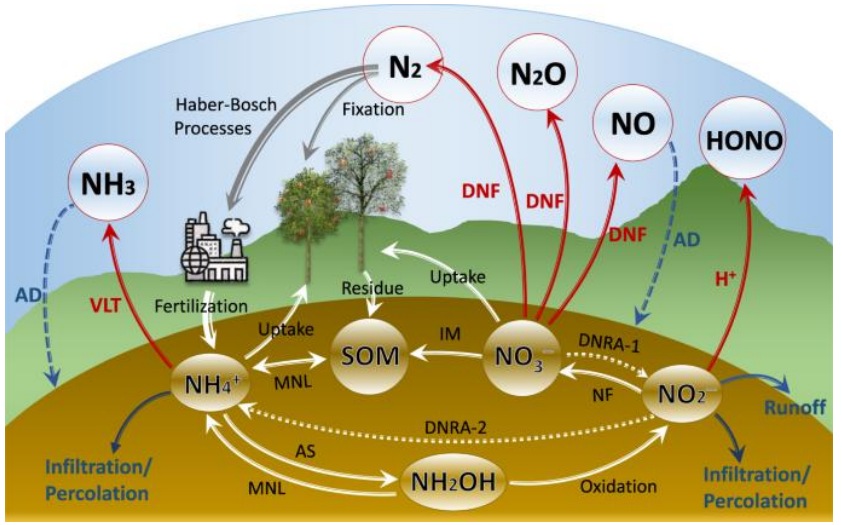
https://agfundernews.com/why-precision-agriculture-is-essential-in-combating-climate-change

# Environmental Impacts of Precision Agriculture

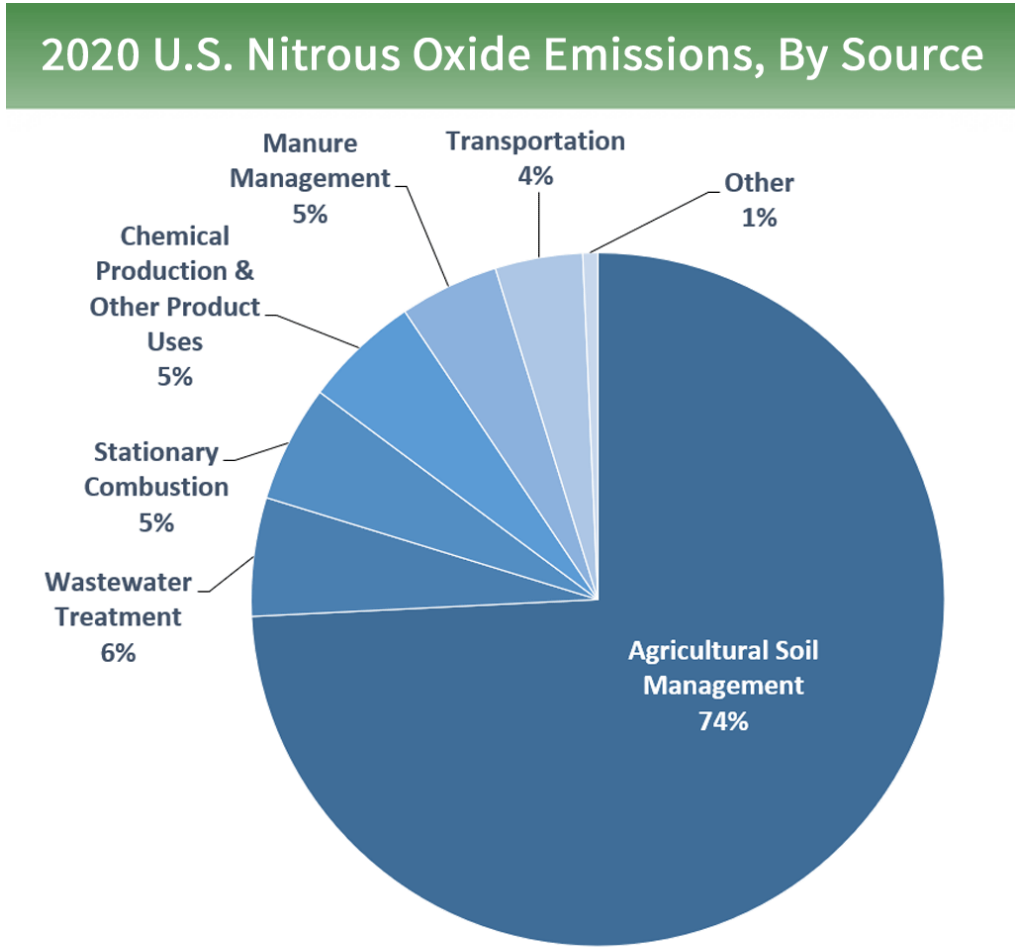
- When soil microbes come into contact with nitrogen fertilizer, they emit nitrous oxide ($N_2O$)
- A pound of this greenhouse gas can warm the atmosphere almost 300 times more than the same amount of carbon dioxide!
- **Agricultural soil management** is the largest source of nitrous oxide in the atmosphere
- In the US, for example, it accounts for **almost 80% of all $N_2O$** emissions
- Excessive use and mismanagement of fertilizers also lead to water degradation and pollution of habitats
- **VRA technology** helps identify which areas have a fertilizer deficiency and which have just enough
- This, in turn, **decreases $N_2O$ emissions** and **minimizes fertilizer runoff**, while also **increasing yields** and **saving farmers money**.

https://www.ars.usda.gov/oc/utm/benefits-and-evolution-of-precision-agriculture/



# Environmental Impacts of Precision Agriculture




U.S. Environmental Protection Agency (2022). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020

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# Environmental Impacts of Precision Agriculture

- Automatic section control reduces carbon footprint by 1.7% through efficient input use
- RTK auto steer system reduces time in field which in turn lowers fuel consumption and hence carbon footprint
- Technologies like soil moisture sensors and aerial imagery help tailor water applications.
  - Results in water conservation by applying just the required amount.
- Adoption of VRT reduced nitrogen use by 1.1% and decreased carbon emissions by 3.4%


https://www.ars.usda.gov/oc/utm/benefits-and-evolution-of-precision-agriculture/

# Quiz

**What is the primary environmental benefit of GPS-based auto-steer systems?**

a) Increases planting speed

b) Reduces overlap during field operations

c) Enhances pesticide effectiveness

d) None of the above

# Quiz

**You are a farmer using yield maps and GPS auto-steer systems. Which two ways can these technologies directly reduce your farm's carbon footprint?**

- Reduced fuel use by minimizing overlap.
- Optimized input application decreases emissions from excess fertilizers.

# Next Lecture

- Guest lecture by Dr. Daniel Martin, USDA-ARS, College Station, TX