Winter flooding effects on soil health and pathogens in rice farming systems

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RESEARCH & EDUCATION TO ADVANCE CONSERVATION & HABITAT

Louisiana-Mississippi MAV CDN: Advancing Fall Flooding
December 8, 2021

WILDLIFE, FISHERIES AND AQUACULTURE

Context:

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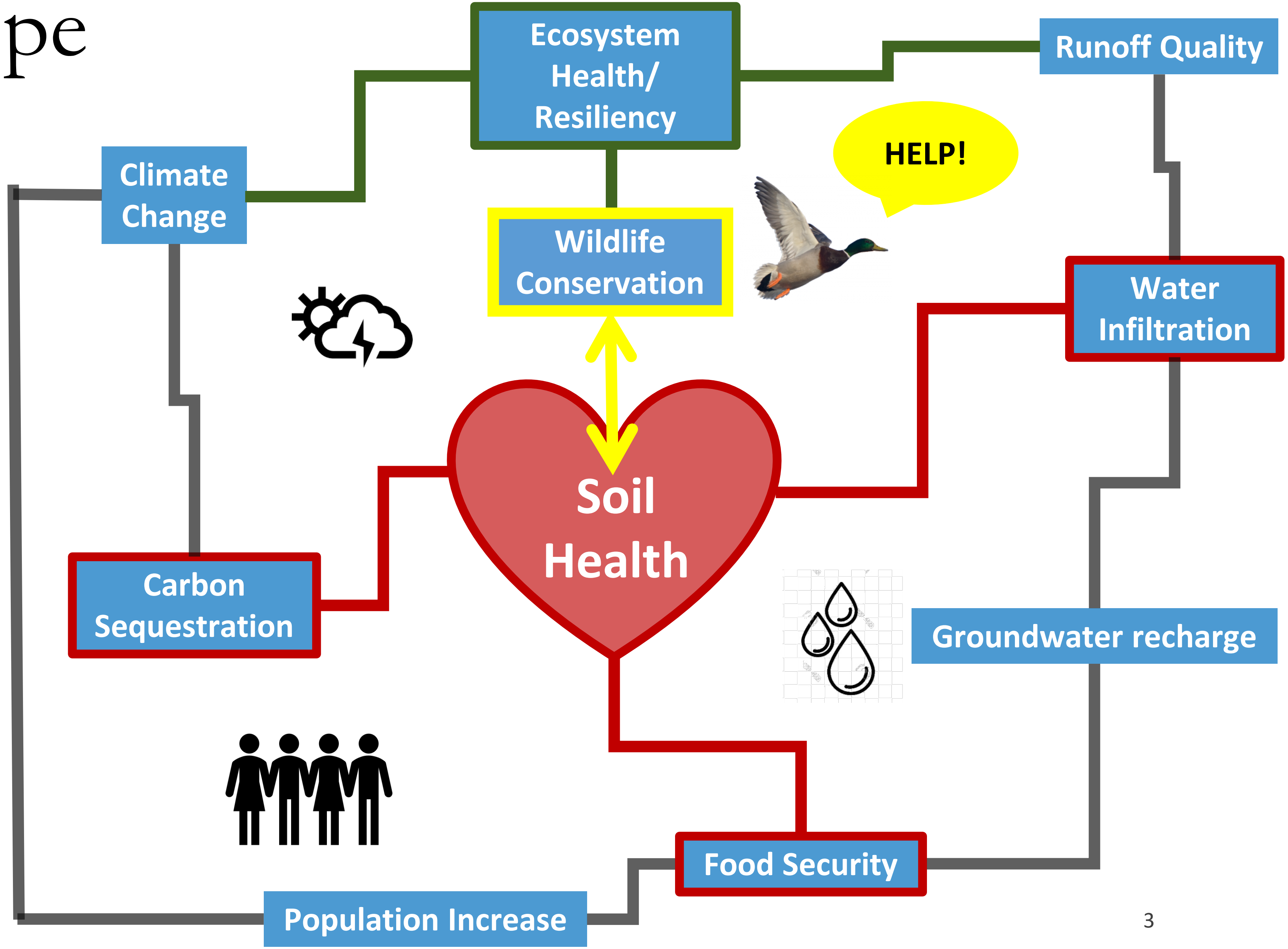
- Costs and benefits of implementing conservation practices in agricultural landscapes
- Effects on environmental integrity

➢ Conservation demonstrations on working farms
➢ On-farm research trials
➢ Outreach and education events.

Research Scope

» Carbon Sequestration

- Soil contains the largest store of terrestrial carbon (C)
- Potential to store 0.4-1.4 GT C/year
- Poor soil management depletes soil C by ~60%
- Climate change
  - Ag & Pasture lands= 32% CO_2 emissions globally
  - US Agriculture= 10% of global GHG emissions



A Case Study: Winter flooding for the birds

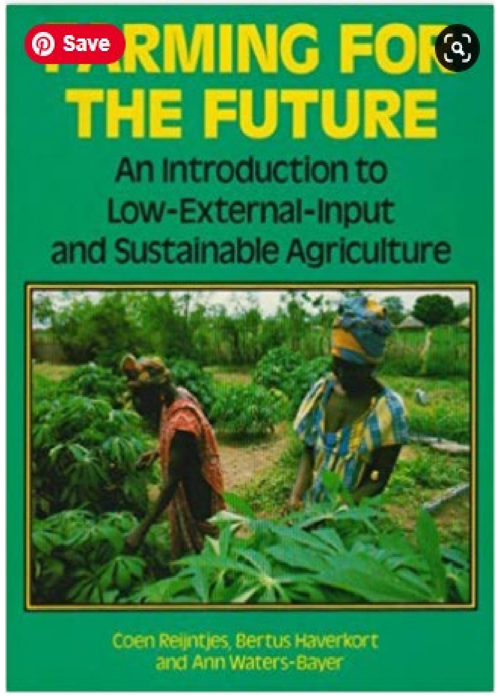
- Capture rain water over winter→ flood rice fields

- MS Migratory Bird Flyway → waterfowl use rice fields as surrogate wetland

- Fecal matter inputs from bird activity → increase soil health

SOUTHERN SARE

Sustainable Agriculture Research & Education



LEISA: Low-External-Input-Sustainable-Agriculture

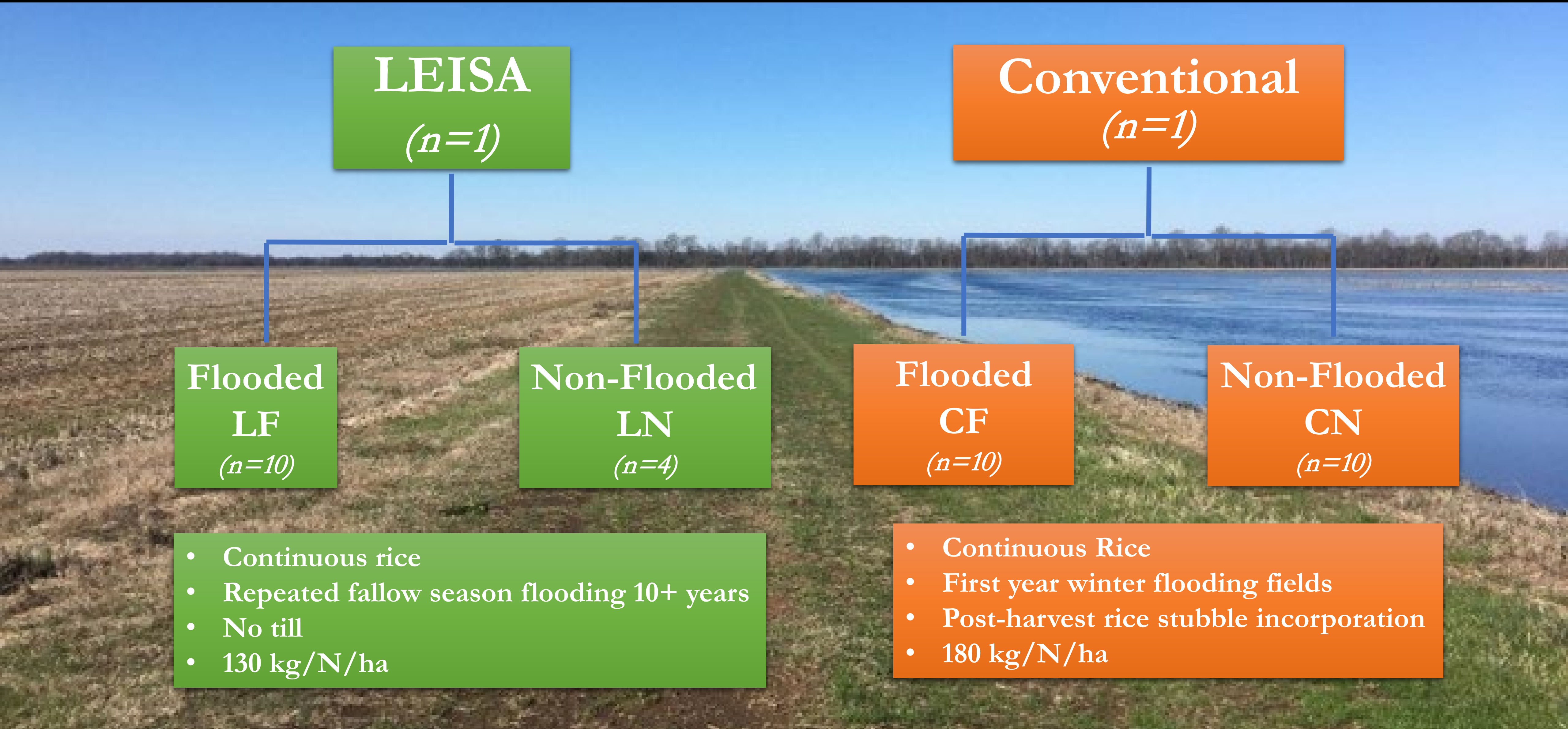
- Adapting and designing the agriculture system **to fit the environment** of the region
- Optimizing use of **biological and chemical/physical resources** within the agroecosystem
- Developing strategies that **minimize changes** to the natural environment and energy used manipulating the environment

Does it work? → Test soil for soil health indicators

Can it be repeated? → Nearby farm floods fields

Are there drawbacks? → Pathogens & yield declines

Experimental Design



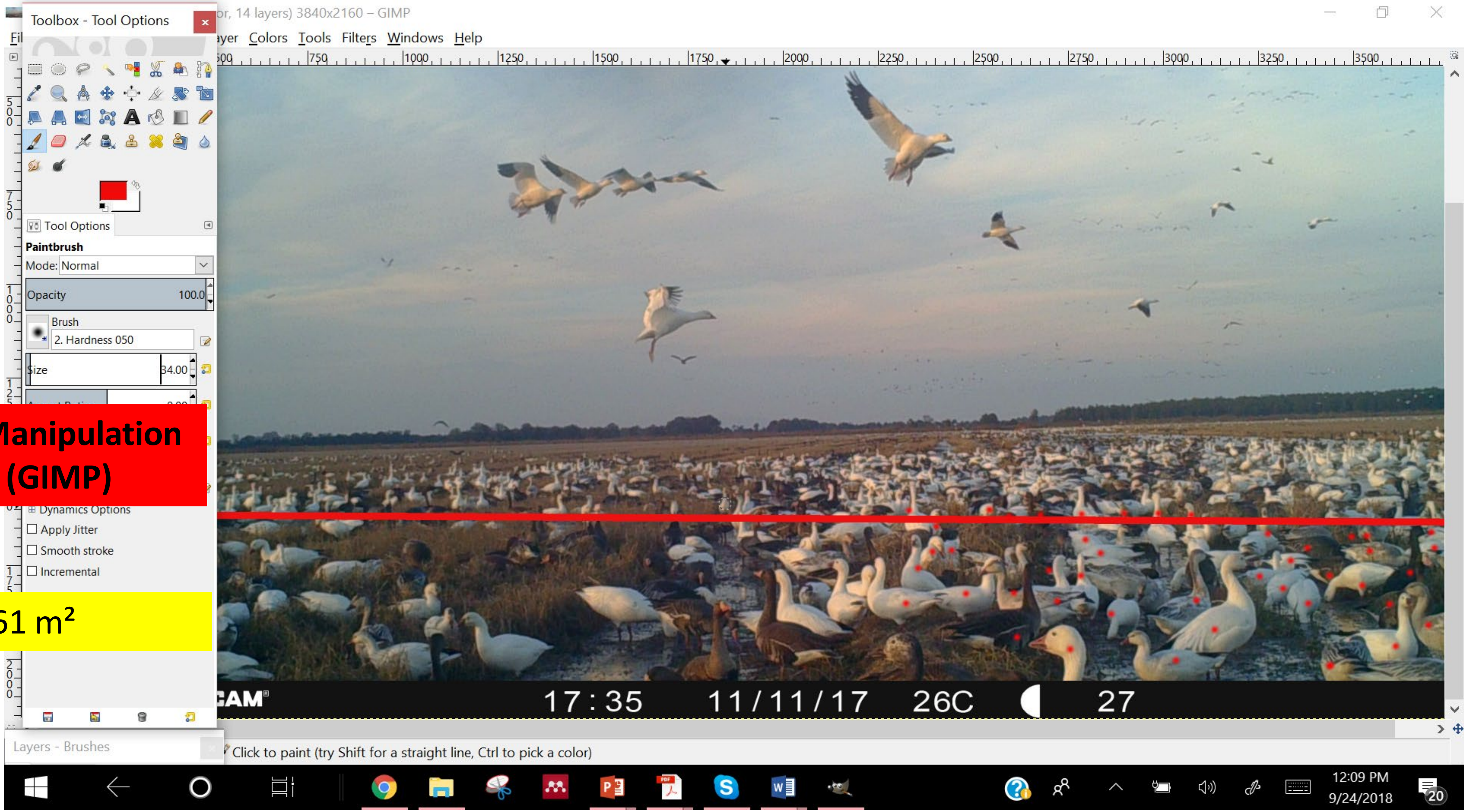
Fecal Matter Quantification

Fecal Matter Quantification

- No-glow infrared camera traps (Stealth Cam G42NG)
- Photograph once/hr during non-growing season

→ Estimate bird use

Fecal Matter Quantification



GNU Image Manipulation Program (GIMP)

242.361 m^2

Fecal Matter Quantification

- No-glow infrared camera traps (Stealth Cam G42NG)
- Photograph once/hr during non-growing season

→ Estimate bird use

↓ Literature to quantify fecal matter and nutrient additions to fields

Firth, A.G.; Baker, B.H.; Gibbs, M.L.; Brooks, J.P.; Smith, R.; Iglay, R.B.; Davis, J.B. Using cameras to index waterfowl abundance in winter-flooded rice fields. MethodsX 2020, 7.

Firth, A.G.; Baker, B.H.; Brooks, J.P.; Smith, R.; Iglay, R.B.; Davis, J.B. Low external input sustainable agriculture: Winter flooding in rice fields increases bird use, fecal matter and soil health, reducing fertilizer requirements. *Agric. Ecosyst. Environ.* 2020, *300*, 106962.

Soil Sampling

Two sampling periods:

November, Post-harvest

March, Pre-drawdown

Soil Health Tests

Nutrients

pH, OM, CEC
N, P, K, C
Ca, Na, Mg

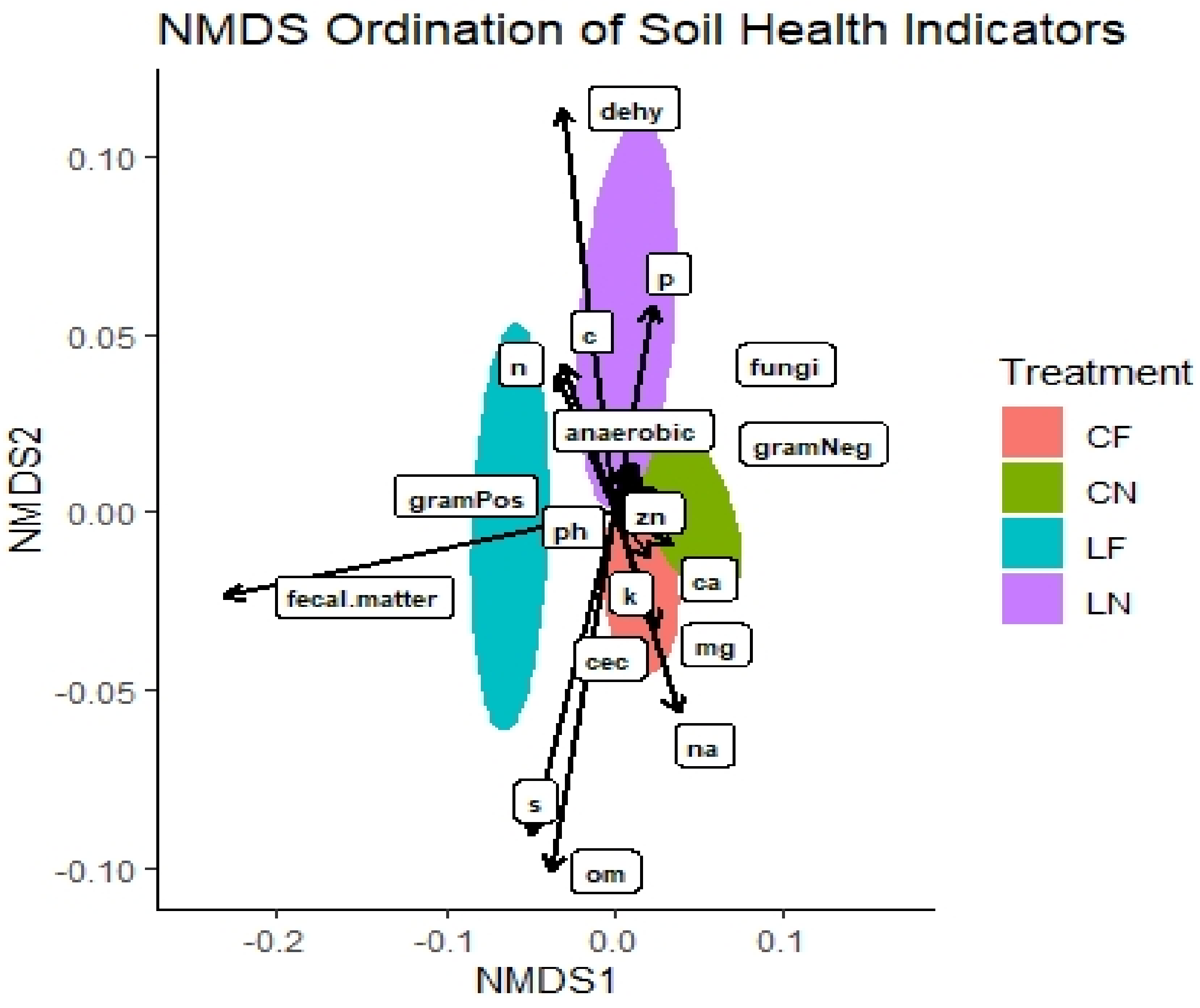
Microbes

Gram +, Gram-,
fungal diversity,
microbial activity

Pathogens

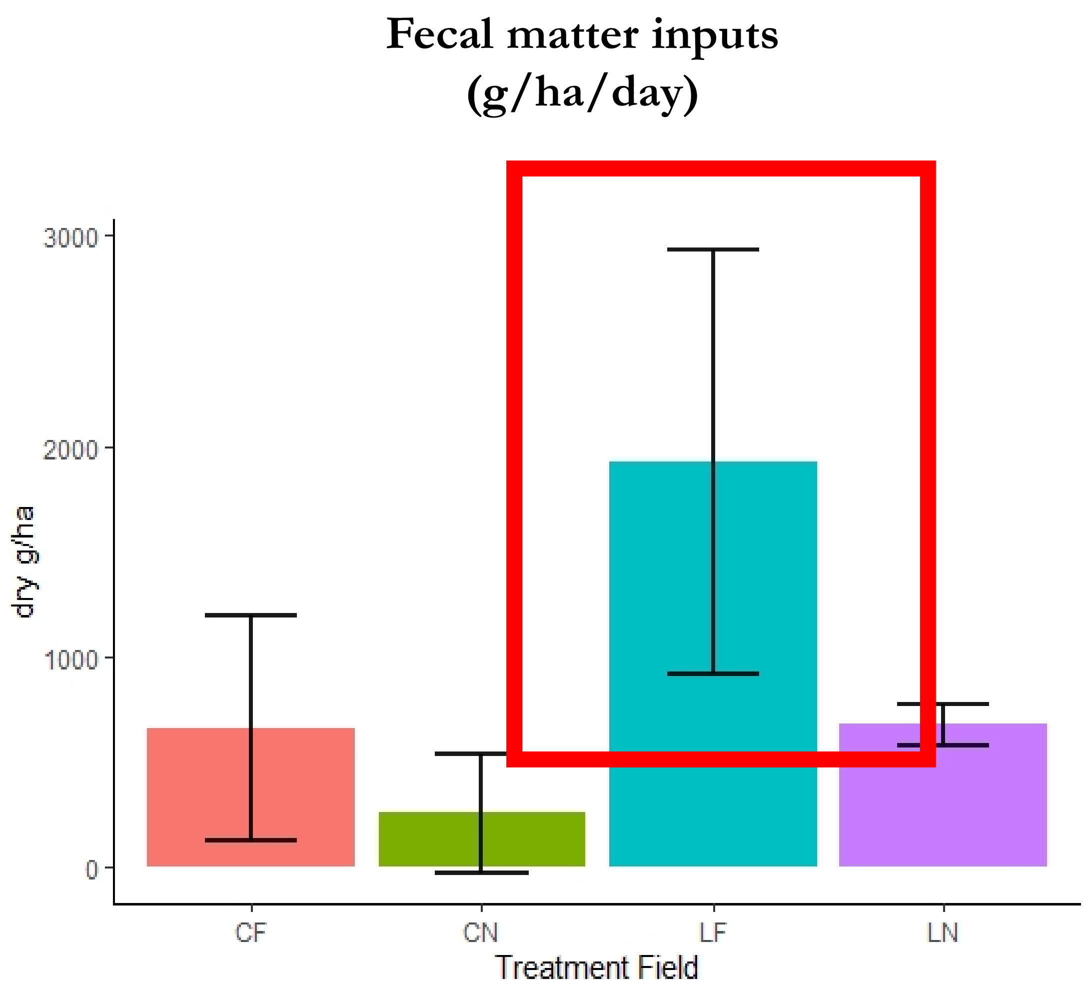
Salmonella,
Campylobacter,
E. coli,
C. perfringens,
Enterococci

Results



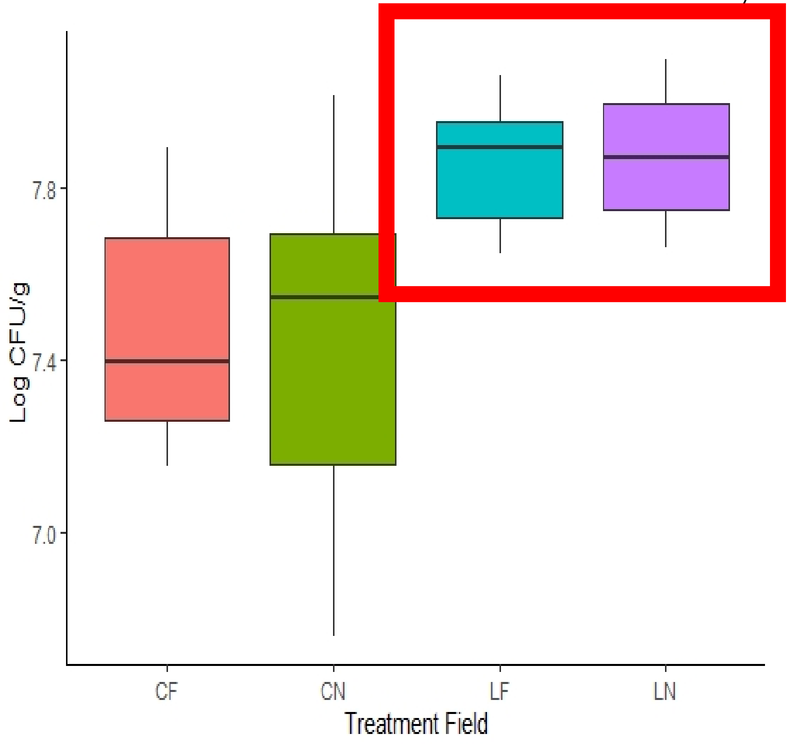
- LEISA fields have clear differences
- LEISA fields have more variability

Results: Fecal Matter Inputs

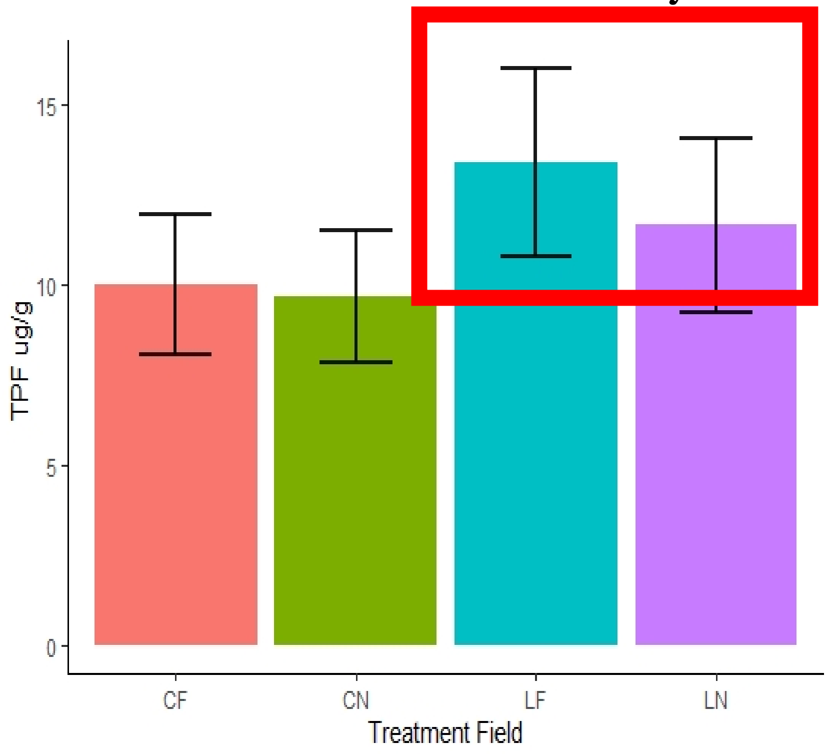


Results: Microbes

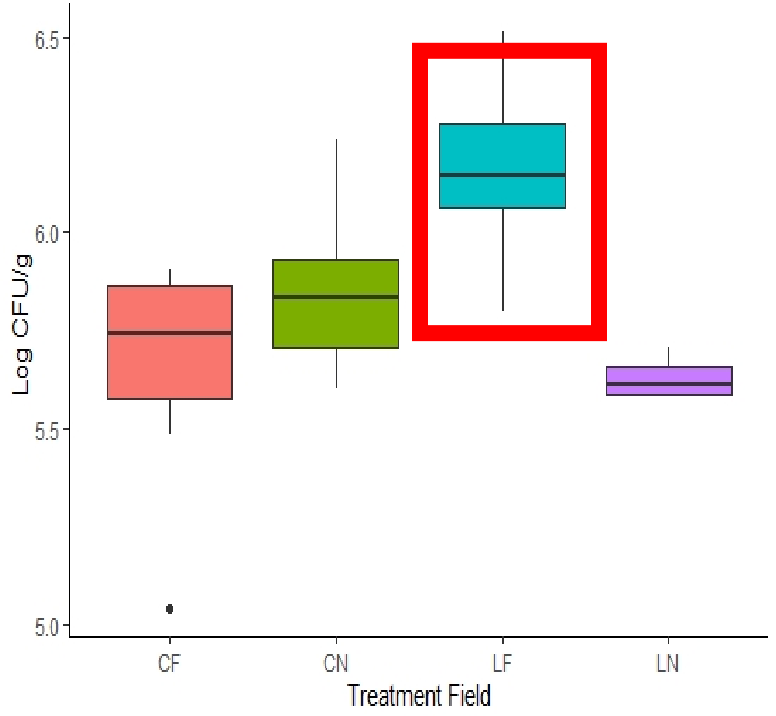
Anaerobic Bacterial Diversity



Microbial Activity

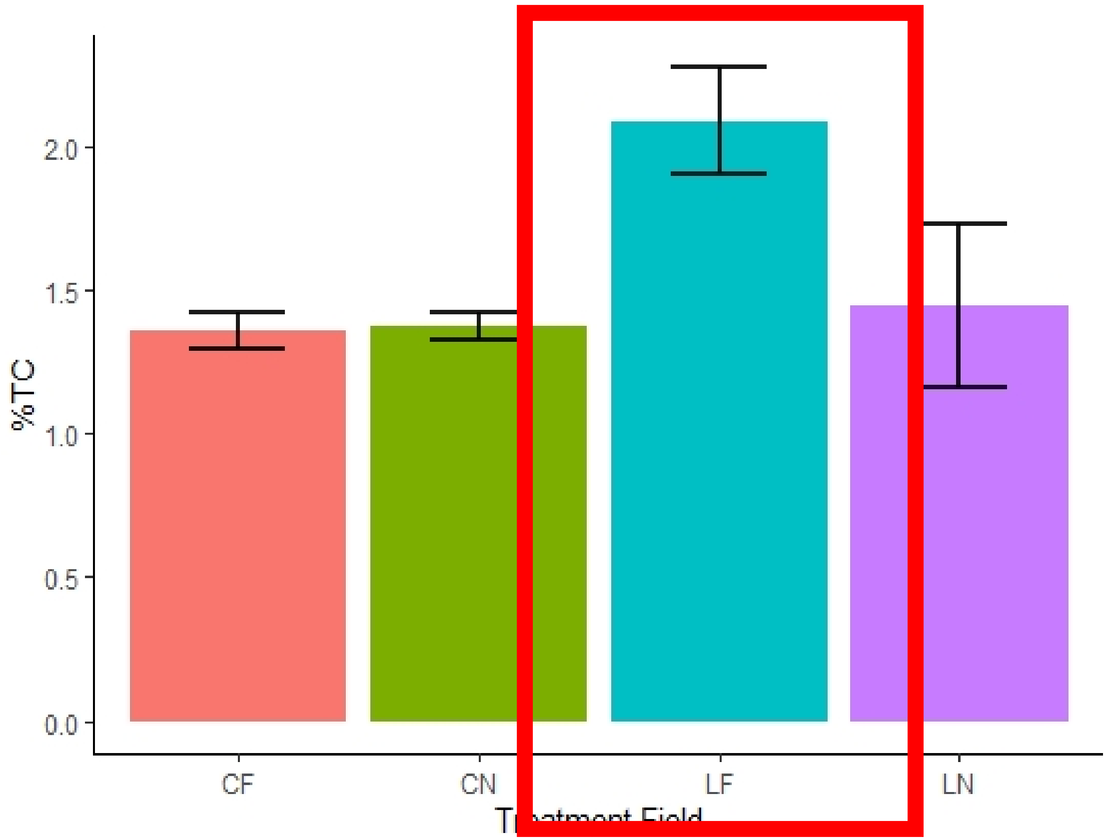


Gram + Bacteria

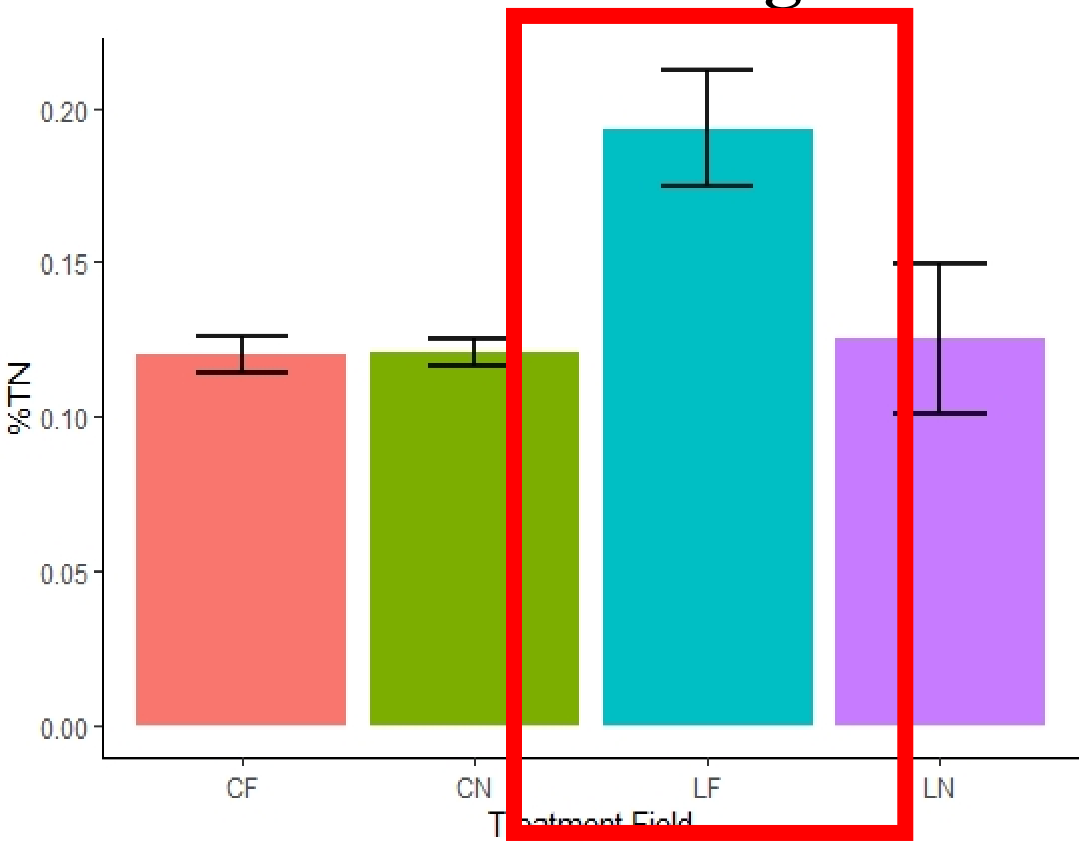


Results: Carbon & Nitrogen

% Total Carbon

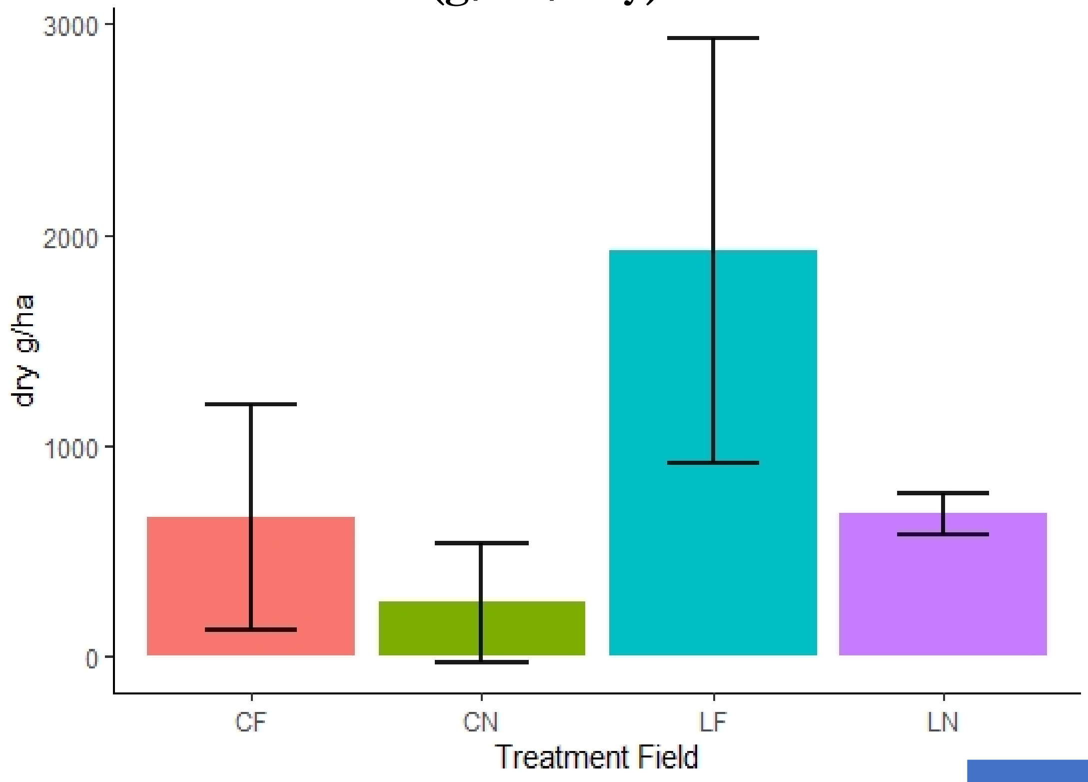


% Total Nitrogen



Bird Contributions

Fecal matter inputs (g/ha/day)



- MSU Extension Service recommends 180-235 kg N/ha for rice (median: 208 kg N/ha)

Fecal Inputs Kg N/ha/season	Low estimate	High estimate	Median
LF	6.1	48.9	27.5
CF	1.9	14.8	8.4

Reduction N fertilizer
LF: 23%
CF: 8.2%

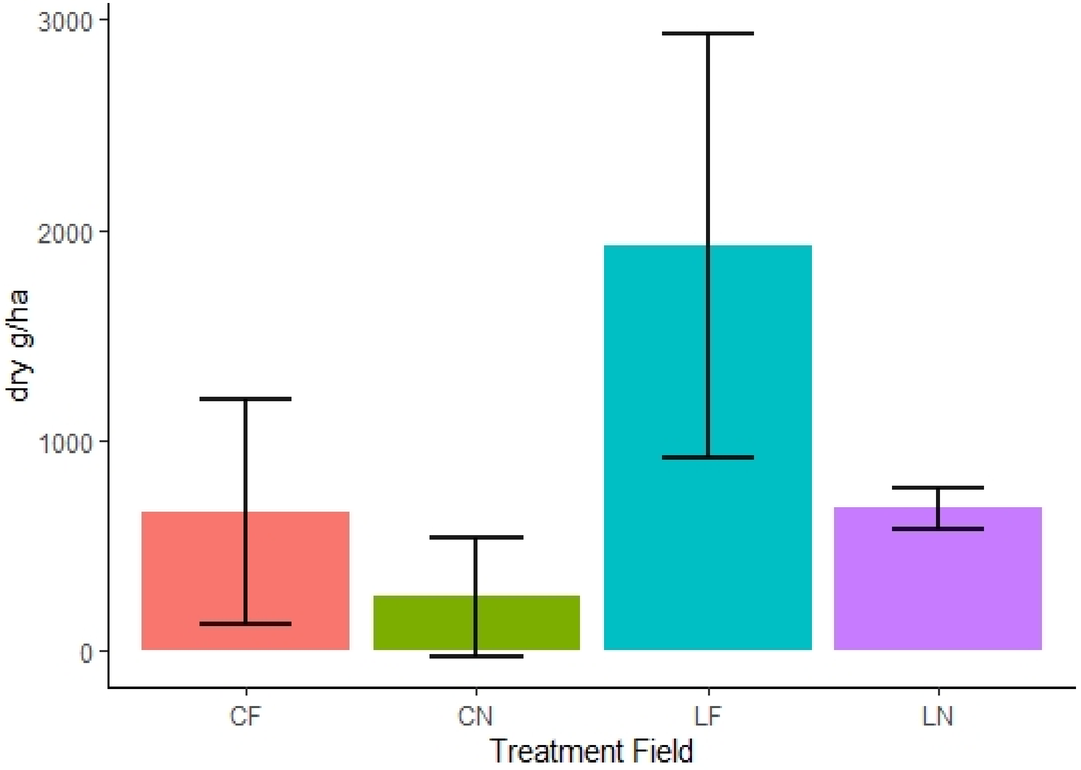
Reduction N fertilizer
LF: 13%
CF: 4%

- **LESIA: 133 kg N/ha**

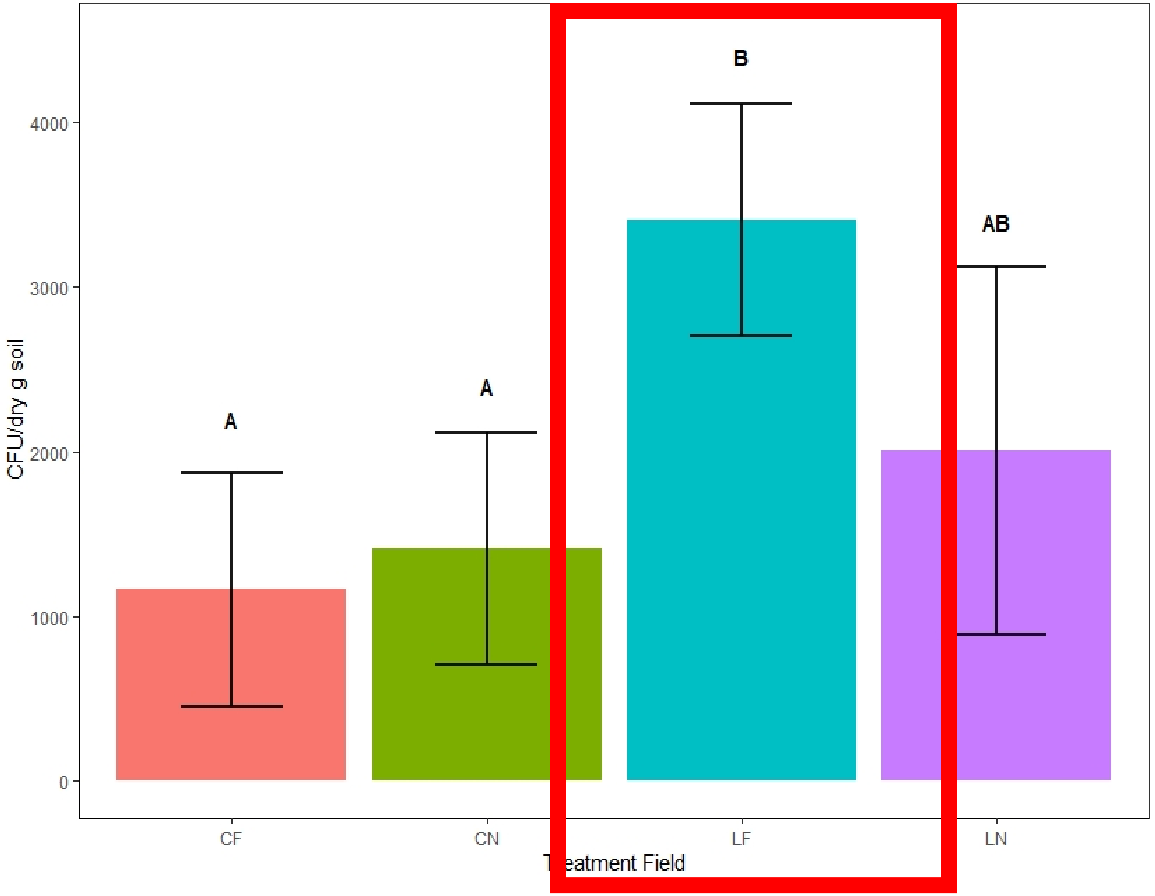
~30% Reduction in fertilizer

Potential Drawbacks: Pathogens

Fecal matter inputs (g/ha/day)



C. perfringens



Potenti

LEISA: 150 bu/acre

Conventional : 192 bu/acre

Expense	LEISA	Conv
Fertilizer, chemicals, seed, application	$110.25	$376
Equipment operation	$90	$134.92
Labor	$35	$18.83
Total expense per acre	**$235.25**	**$530**

	LEISA: 150 bu/acre @ $4.60/bu	Conv: 192 bu/acre @ $4.60/bu
Yield Income	$690	$883.20
Expenses	$235.25	$529.75
Net Total $/acre	**$454.75**	**$353.45**

Conclusions

- Winter flooding **<u>as part of a larger system strategy</u>** has the potential to increase soil health and lower need for N fertilizer
- BUT results may not be seen after one year
- Bird use impacted soil pathogen levels, but without risk to human health
- Regular monitoring is recommended

Exemplifies how conservation and agriculture can work together with the progressive nature of modern farmers towards land stewardship.

Acknowledgments

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STATE WILDLIFE, FISHERIES AND AQUACULTURE

USDA

SOUTHERN SARE Sustainable Agriculture Research & Education

The fantastic Delta Rice Farmers!

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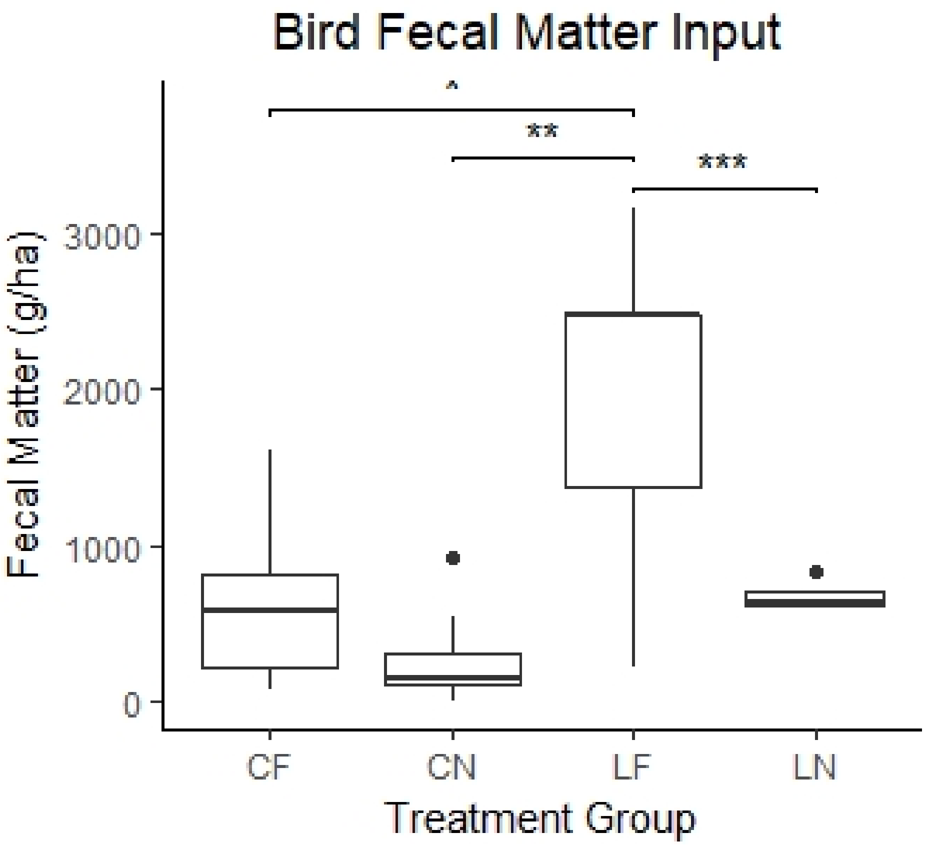
Results & Discussion: Fecal Inputs

Rank-Based ANCOVA ($F=11.99$, Robust $R^2= 0.54$, $p<0.05$)



Average Fecal Inputs per Field Type per Day (g/ha)			
	avg g fecal	95% Lower CI	95% Upper CI
CN	258.51	156.83	673.84
CF	659.07	243.73	1074.41
LN	677.67	20.96	1334.39
LF	1924.62	1509.27	2339.95

3 X

7 X

- LF had significantly higher fecal inputs than other treatment groups ($P<0.05$)
- Notable difference of LN and CF compared to CN
- Current best estimates
- Refinement of methods will give greater resolution