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Residue management and potential effects on P availability in a continuous corn system

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TODAYS TALK

- Importance of residue
- Why manage residue
- Alternative uses for residue
- Research on nutrient availability

IMPORTANCE OF CROP RESIDUE

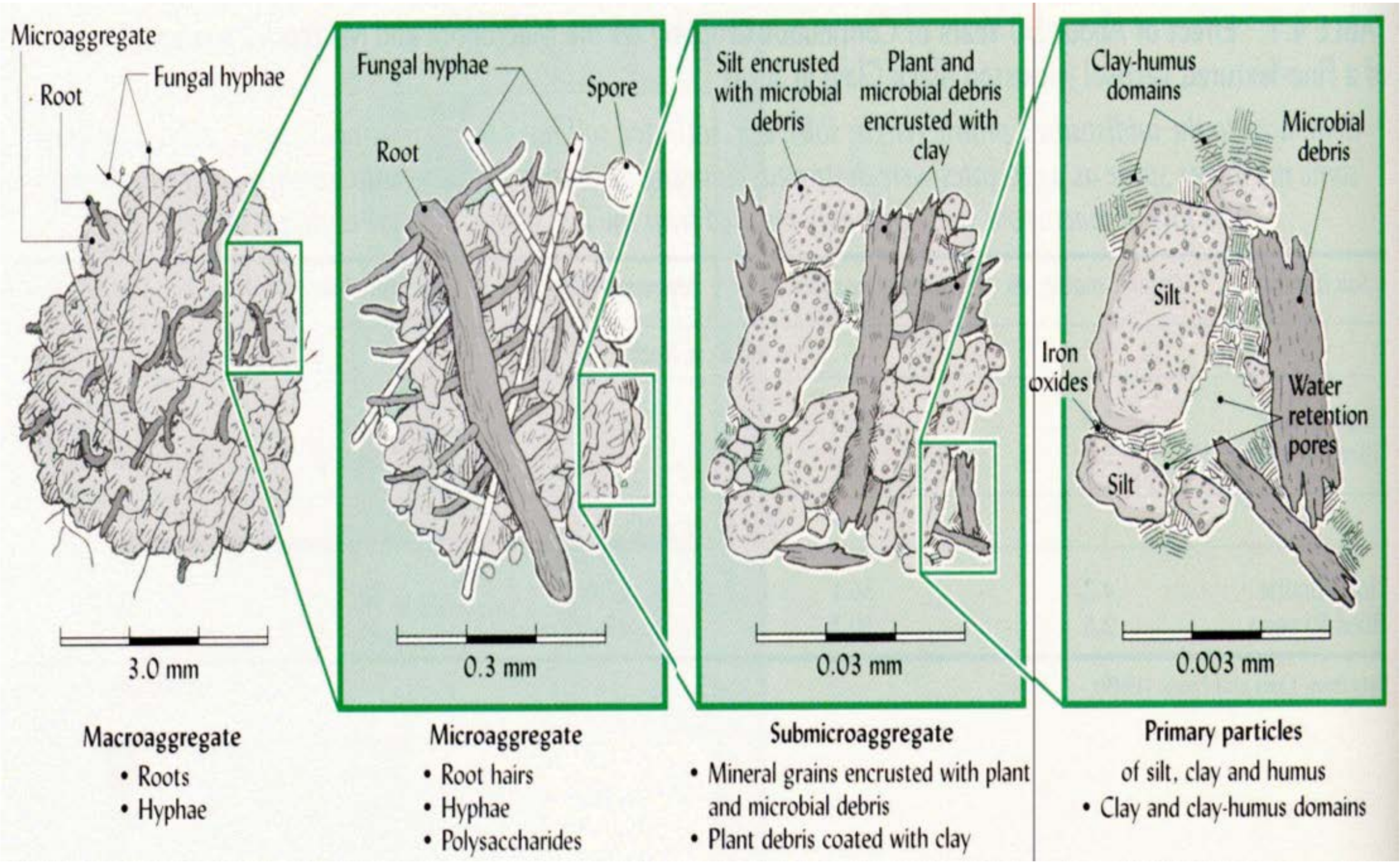
- Soil aggregate stability
- Penetration resistance
- Bulk density
- Volumetric water content
- Earthworm population
- Microbial biomass
- Soil nutrient mineralization

AGGREGATE STABILITY

- Soil aggregates are strongly influenced by the presence of organic acids – humic acids

Picture source: NRCS

AGGREGATE STABILITY

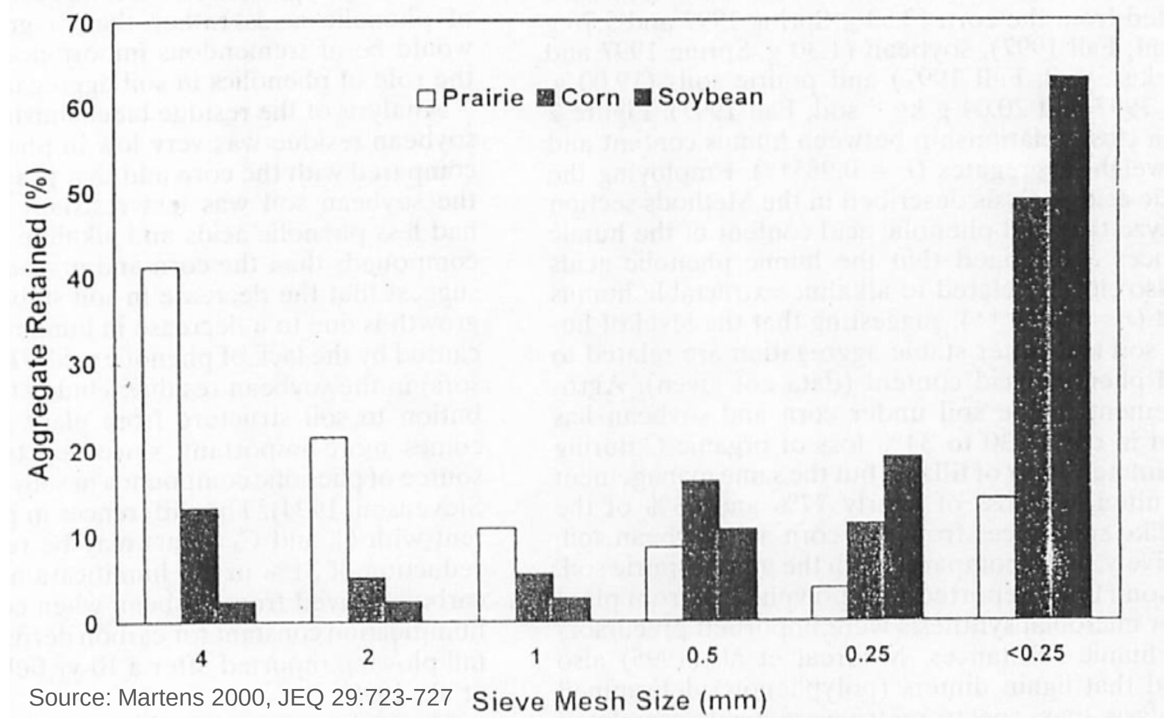


Tisdall & Oades, 1982. J. of Soil Sci.33: 141-163

AGGREGATE STABILITY

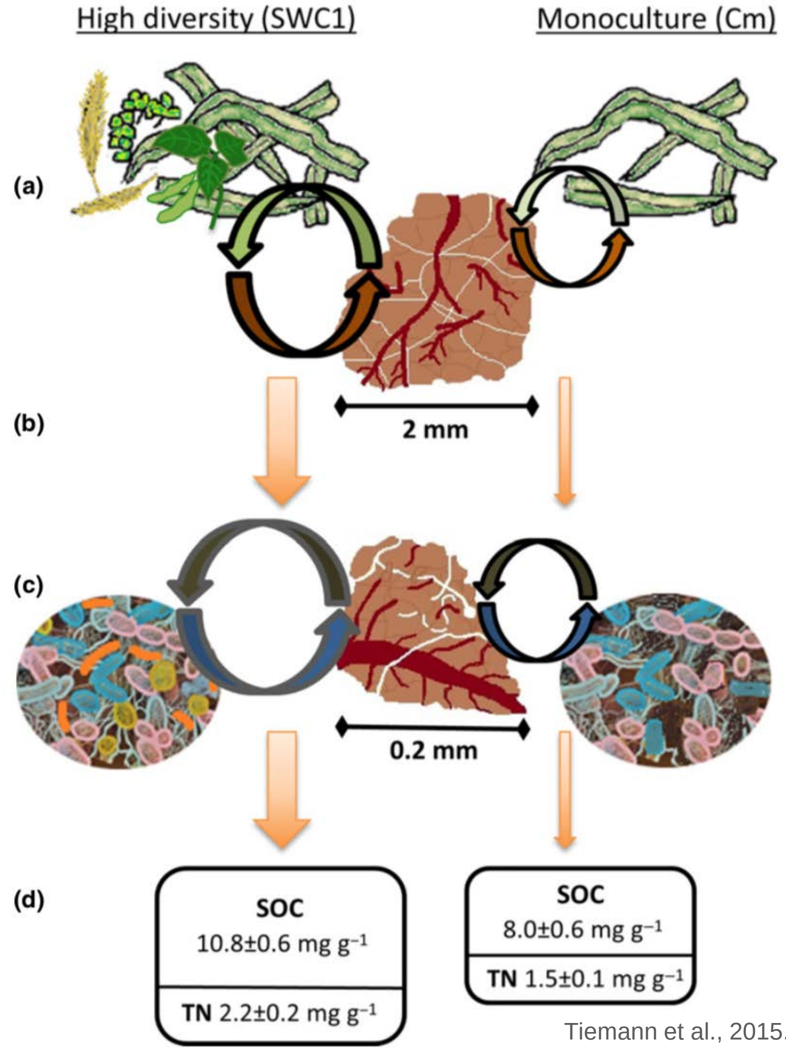
- Crop residue has high influence on the organic acid content of the soil
  – e.g. soybean residue has lower phenolic compounds than corn residue
- Prairie soil has much more phenolic compounds than corn or soybean residues

AGGREGATE STABILITY



Source: Martens 2000, JEQ 29:723-727

AGGREGATE STABILITY

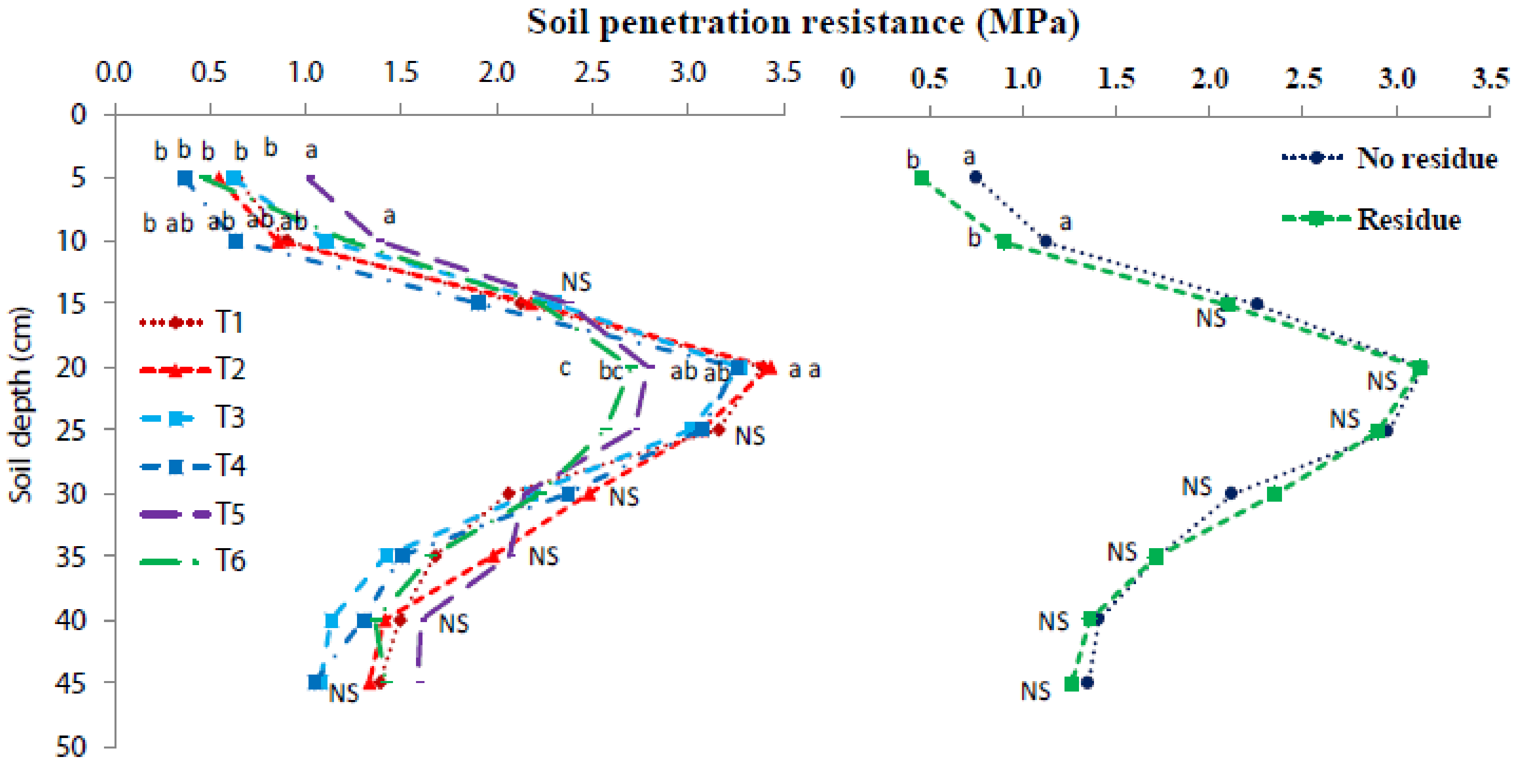


Tiemann et al., 2015. Ecology letter 18:761-771

PENETRATION RESISTANCE

- Removal of residue can significantly impact soil penetration resistance
  - Hard soil makes it difficult for roots to grow deep
  - Compaction layers minimize water flow and also water retention
  - Bulk density is also increased

PENETRATION RESISTANCE



Source	Analysis of variance (ANOVA)								
	5 cm	10 cm	15 cm	20 cm	25 cm	30 cm	35 cm	40 cm	45 cm
Replication	NS	NS	NS	NS	NS	0.001	0.004	NS	NS
Treatment (T)	0.002	0.008	NS	0.002	NS	NS	NS	NS	NS
Residue (R)	0.001	0.032	NS	NS	NS	NS	NS	NS	NS
T x R	0.018	0.010	NS	0.001	NS	NS	0.010	NS	NS

Gathala et al. J Ecosys Ecograph 2017, 7:3

CHALLENGE YOURSELF

- Do you have an area of a field that always have issues due to water logging?
  - Try to manage that area differently, add diversity
  - Plant corn *year 1*, soybean *year 2*, small grain interseeded with a cover crop *year 3*, alfafa years *4 and 5*
- Maybe the next corn year will be the best corn you have planted in the area

EARTHWORM AND RESIDUE

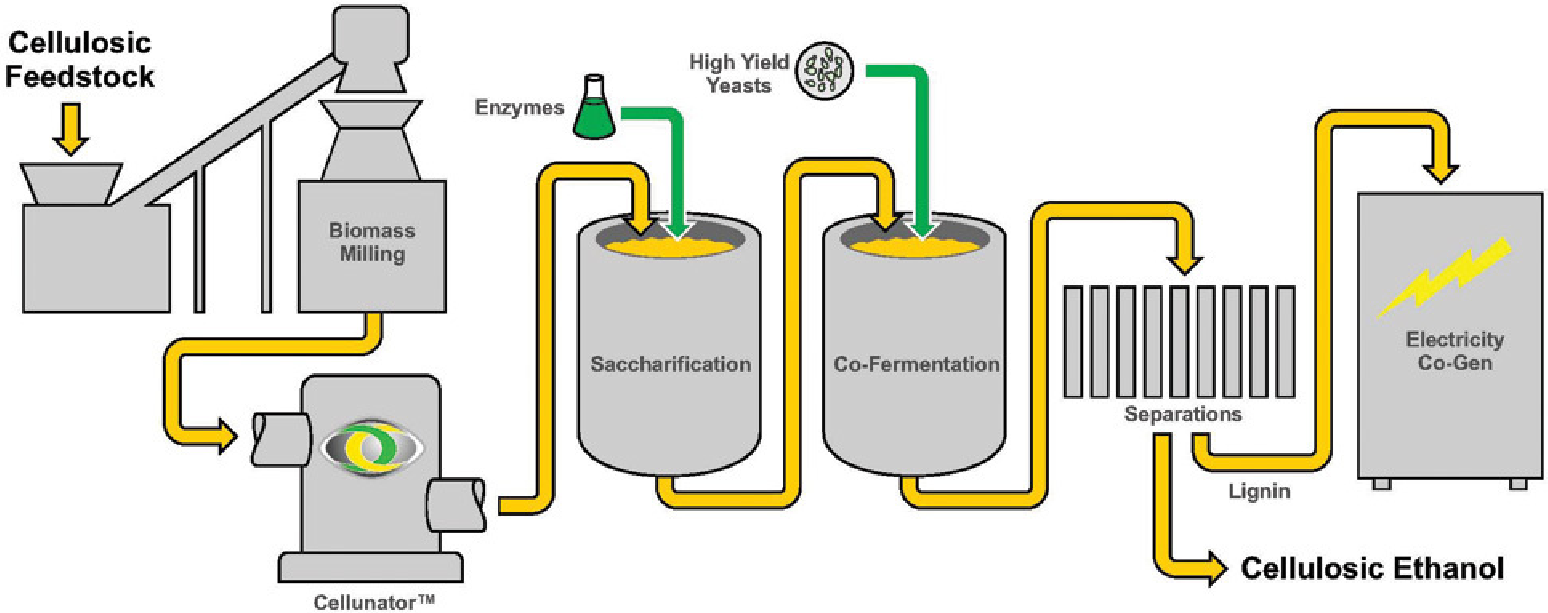
- Corn residue provides conditions that maximizes earthworm growth
- Amount of residue is more important than the quality of the residue
  - Nutrient content of residue does not seem to be as important as amount of biomass

ALTERNATIVE USE FOR RESIDUE

- Mostly used as bedding and low quality forage for beef cattle
- Potential alternative use includes:
  - Biochar production
  - Cellulosic ethanol production

CELLULOSIC ETHANOL PRODUCTION

- Processes of pre-treatment
- Enzymatic hydrolysis
- Fermentation
- Distillation

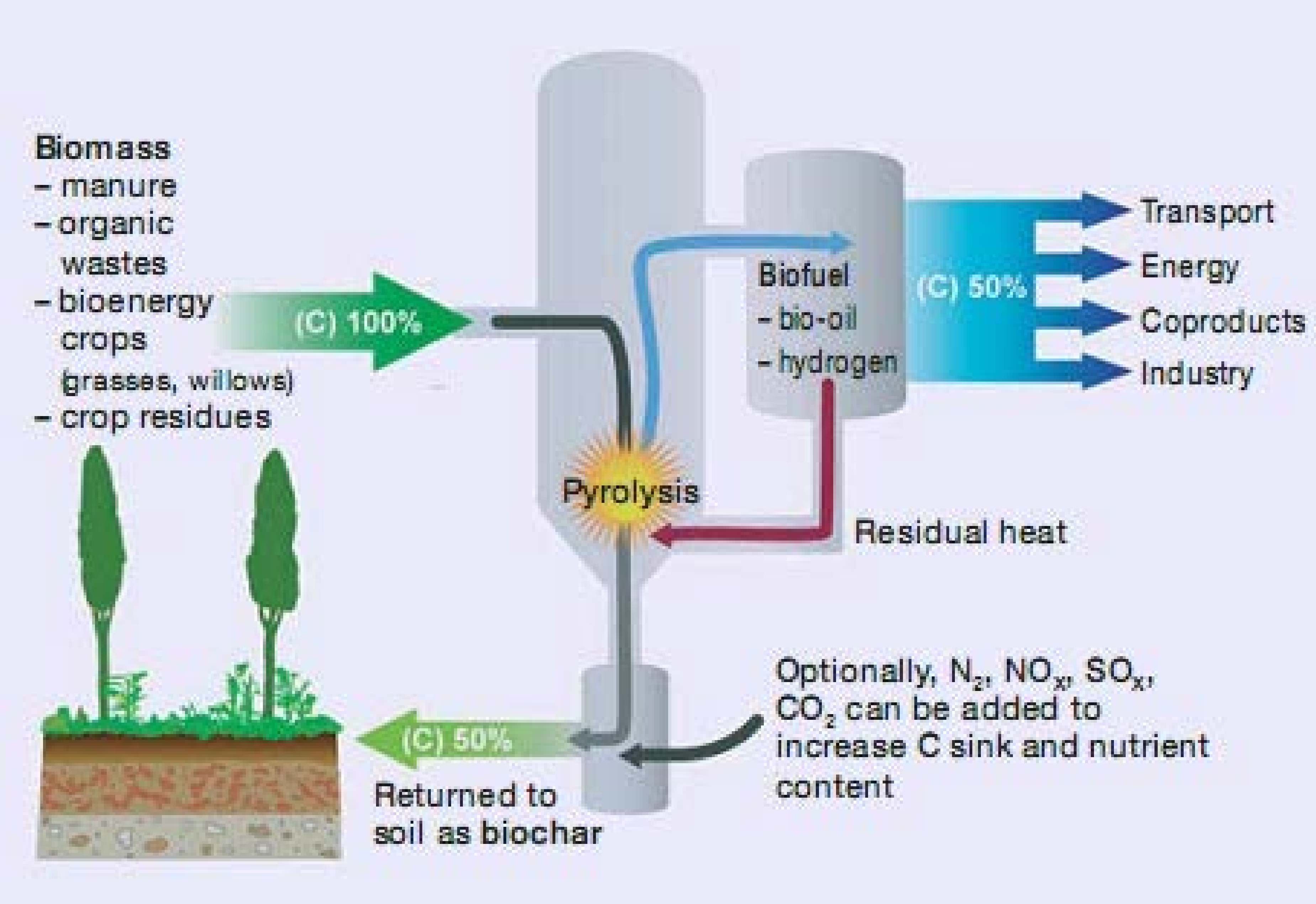


http://www.ethanolproducer.com/uploads/posts/magazine/2011/04/13028855516569.jpg

BIOCHAR PRODUCTION

- Provides stable C to soils
  - Increases soil porosity
  - Increases water holding capacity
- Increases soil pH
- Nutrient Availability

https://www.agmrc.org/media/cms/article1figure1_DB6B2EE6D7C09.jpg



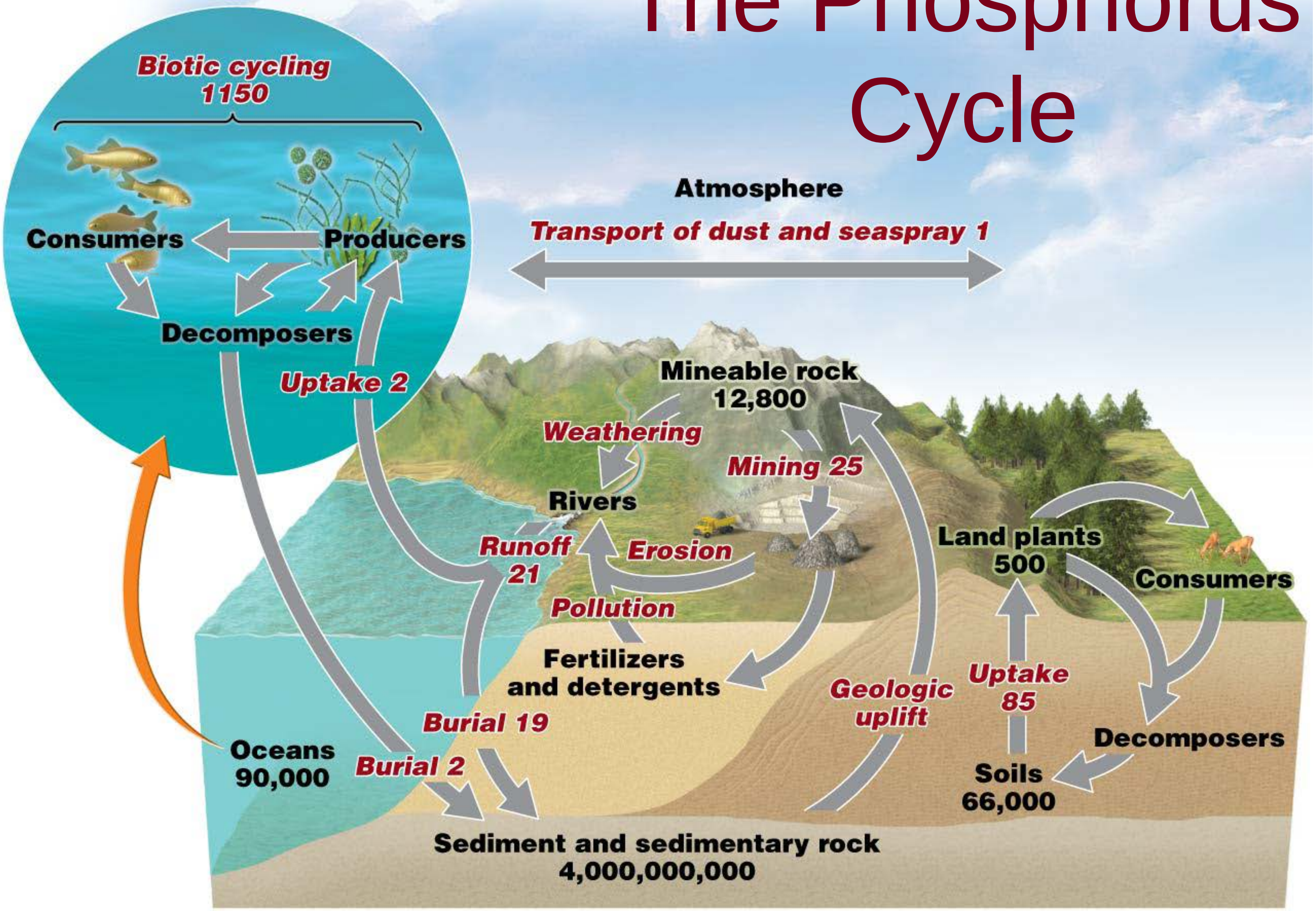
https://ahualoa.net/ag/biochar-chart.jpg

BIOCHAR

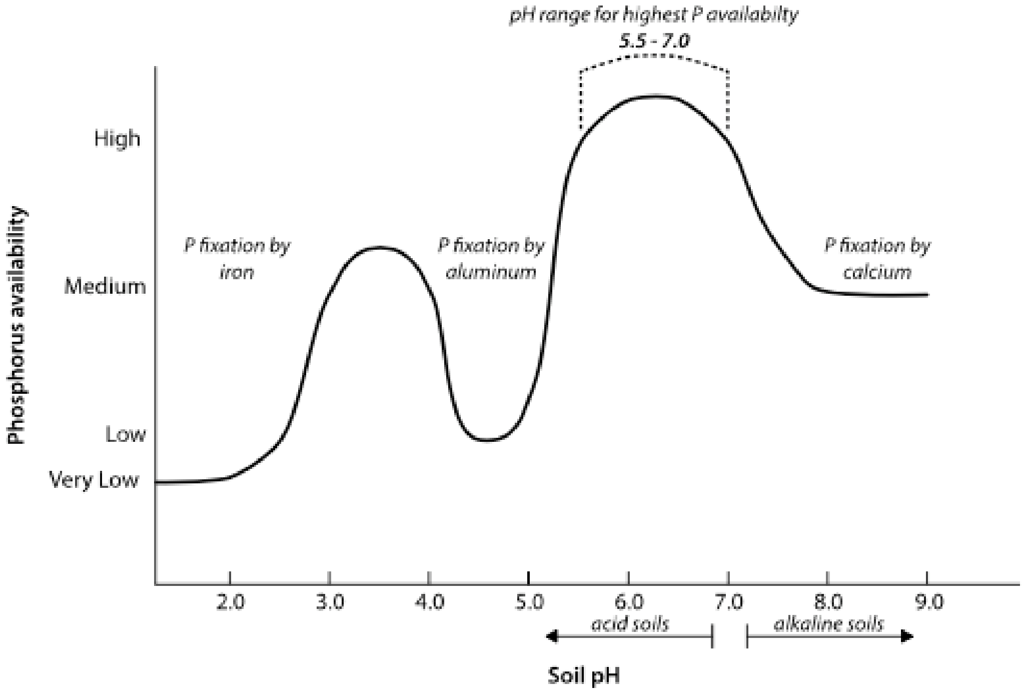
http://biochar.ucdavis.edu/files/3913/6148/5832/biocharwheel_SJP.jpg

RESEARCH AND SOIL P

The Phosphorus Cycle

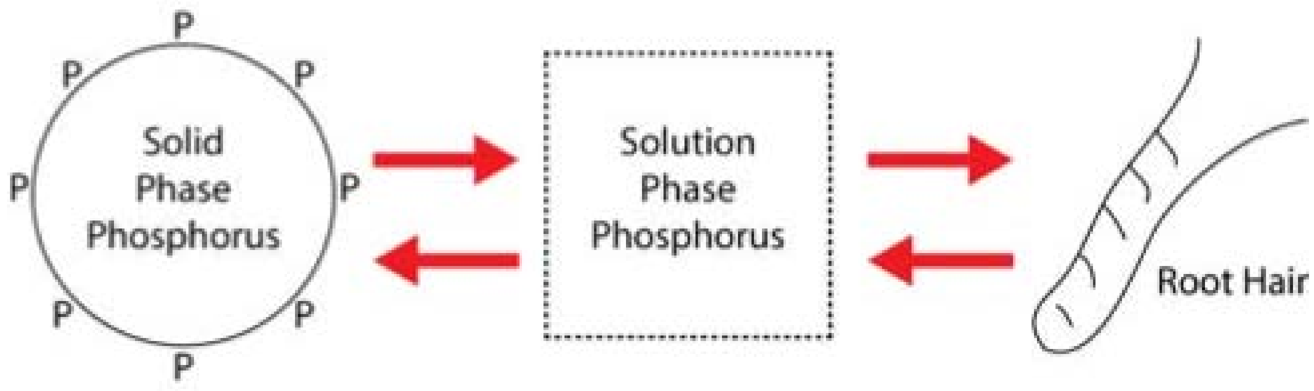


P BACKGROUND

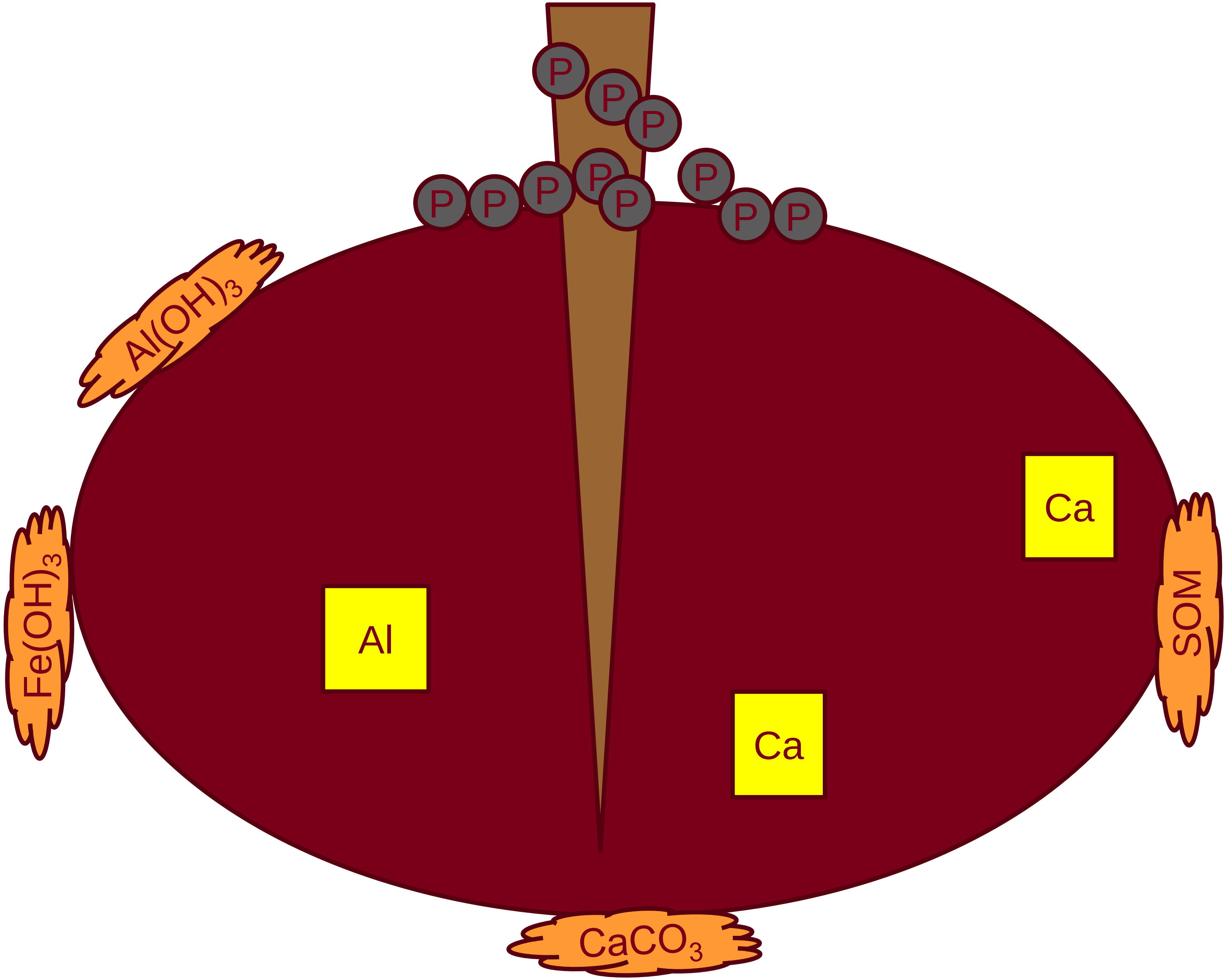


P UPTAKE

About 500-850 ppm in the solid phase



About 0.5 ppm in solution


P
P
P
P
P
P
P
P
P
P
P
Al(OH)3
Fe(OH)3
Al
Ca
Ca
SOM
CaCO3

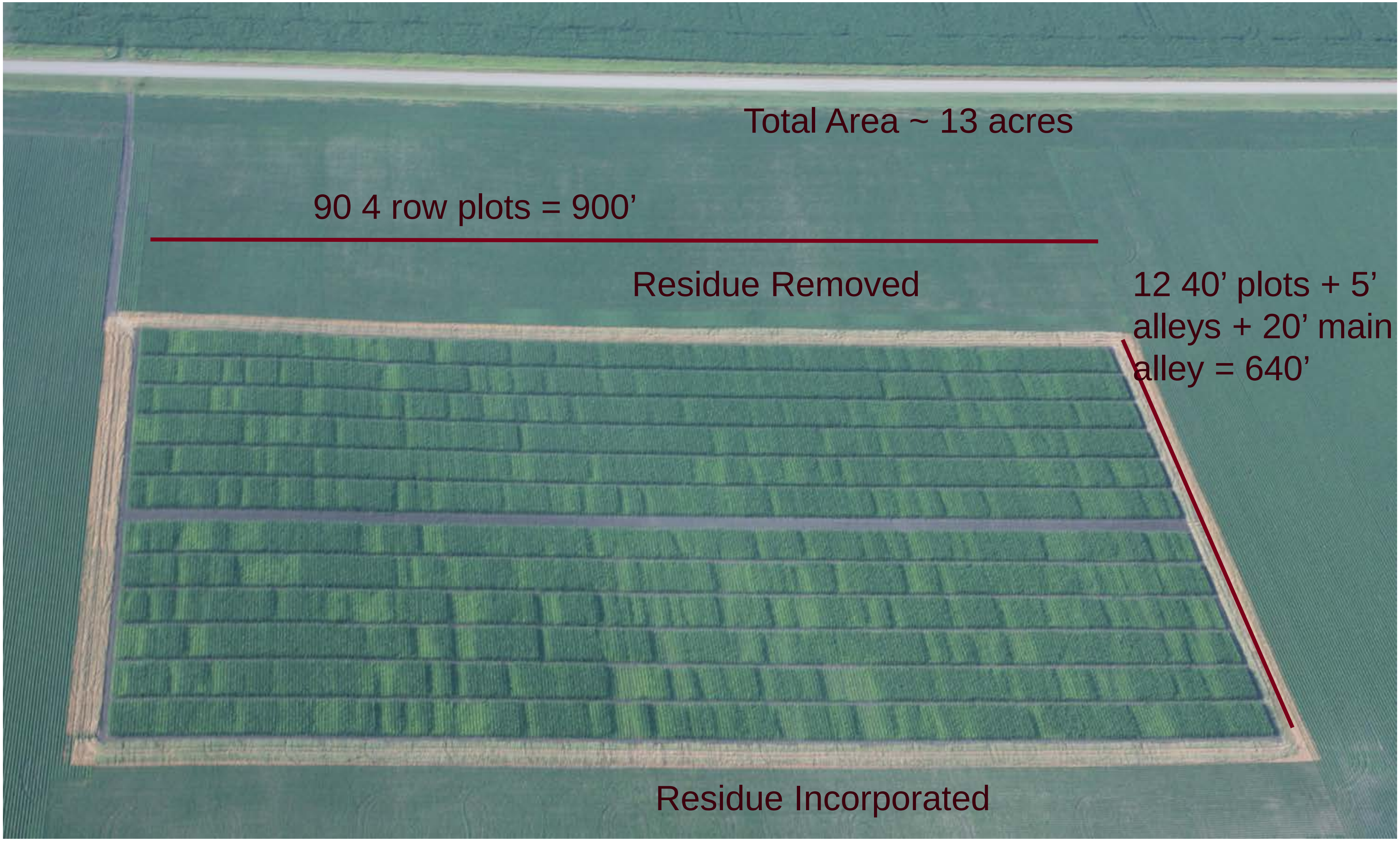
EXPERIMENTAL SET UP

- This study was carried out from 2012 to 2015 on continuous corn

Treatments:

- Residue removed or Incorporated after harvest
- N, P, and S broadcast and incorporated
  - 0 to 200 lbs N ac^{-1} (Urea)
  - 0 to 100 lbs P_2O_5 ac^{-1} (TSP)
  - 0 to 15 lbs S ac^{-1} (K_2SO_4)

FIELD LAYOUT



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EXPERIMENTAL SET UP

2012 and 2013

- Site was selected; Experiment area was delineated; Soil background information was collected in June/July 2012

Treatments:

- Residue removed or Incorporated after harvest
- N, P, and S broadcast and incorporated
  - 0 to 200 lbs N ac^{-1} (Urea)
  - 0 to 100 lbs P_2O_5 ac^{-1} (TSP)
  - 0 to 15 lbs S ac^{-1} (K_2SO_4)

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PHOSPHATE SUGGESTIONS FOR CORN PRODUCTION IN MN

		Soil test P (ppm)									
		v. low		low		medium		high		v. high	
Expected	Bray:	0-5		6-10		11-15		16-20		21 +	
Yield	Olsen:	0-3		4-7		8-11		12-15		16 +	
		Broadcast	Band	Broadcast	Band	Broadcast	Band	Broadcast	Band	Broadcast	Band
bu./acre	— P_2O_5/acre to apply (lb./acre) —										
< 100		60	30	40	20	25	20	10	10-15	0	10-15
100-124		75	40	50	25	30	20	10	10-15	0	10-15
125-149		85	45	60	30	35	25	10	10-15	0	10-15
150-174		100	50	70	35	40	30	15	10-15	0	10-15
175-199		110	55	75	40	45	30	15	10-15	0	10-15
200-220		130	65	90	45	55	30	20	10-15	0	10-15
220-240		145	75	100	50	60	30	20	10-15	0	10-15
240 +		160	80	115	60	70	35	25	10-15	0	10-15

* *Use one of the following equations if a P_2O_5 guideline for a specific soil test value and a specific expected yield is desired.*

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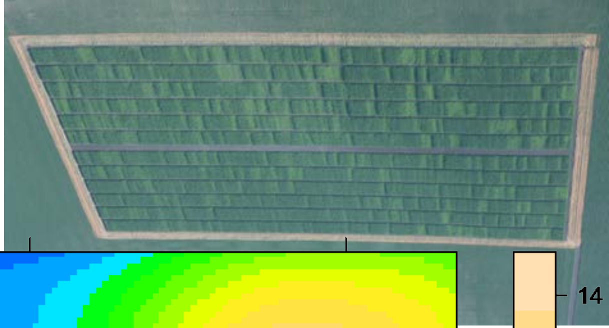
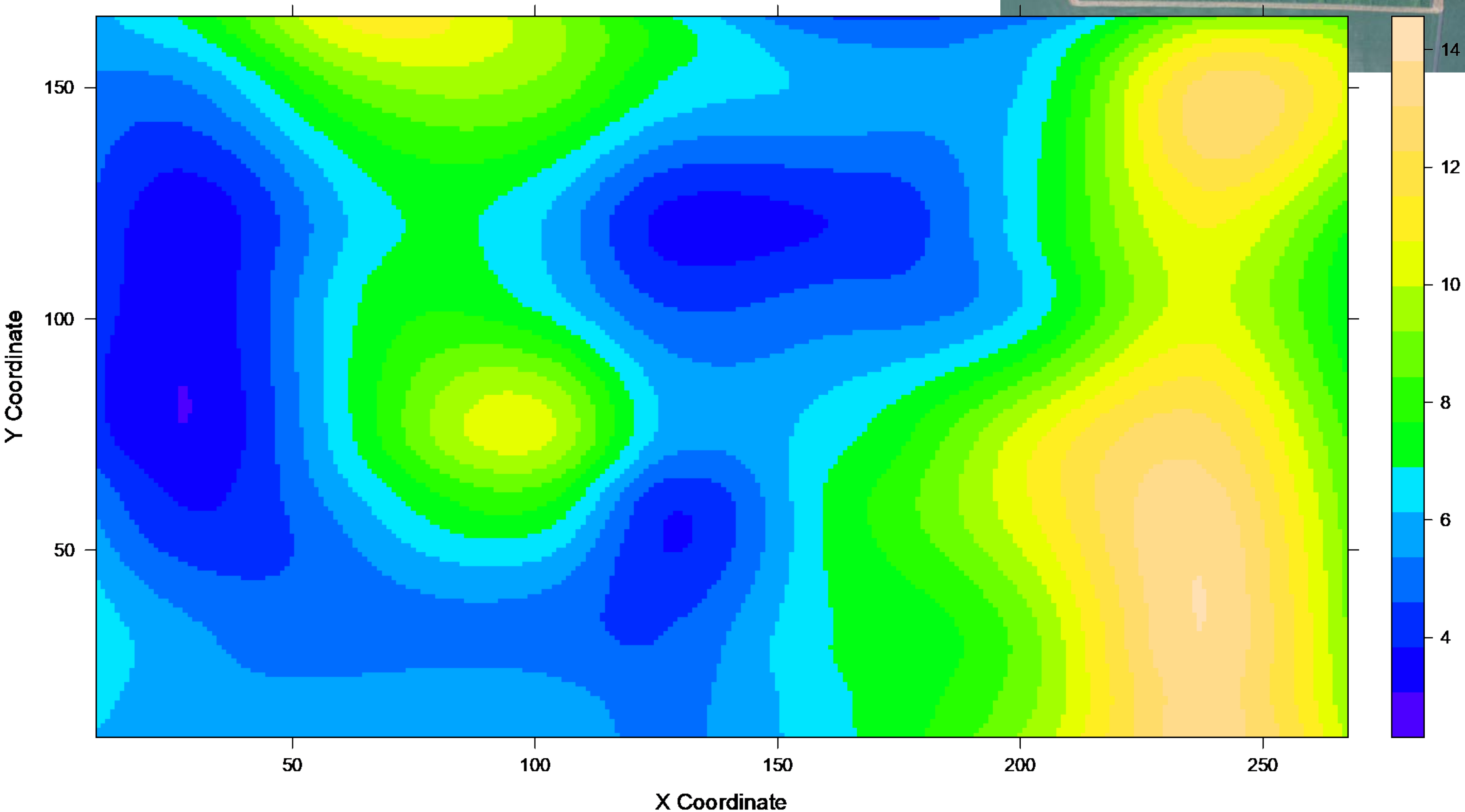
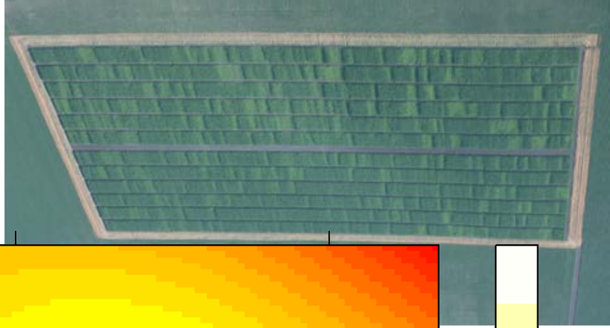
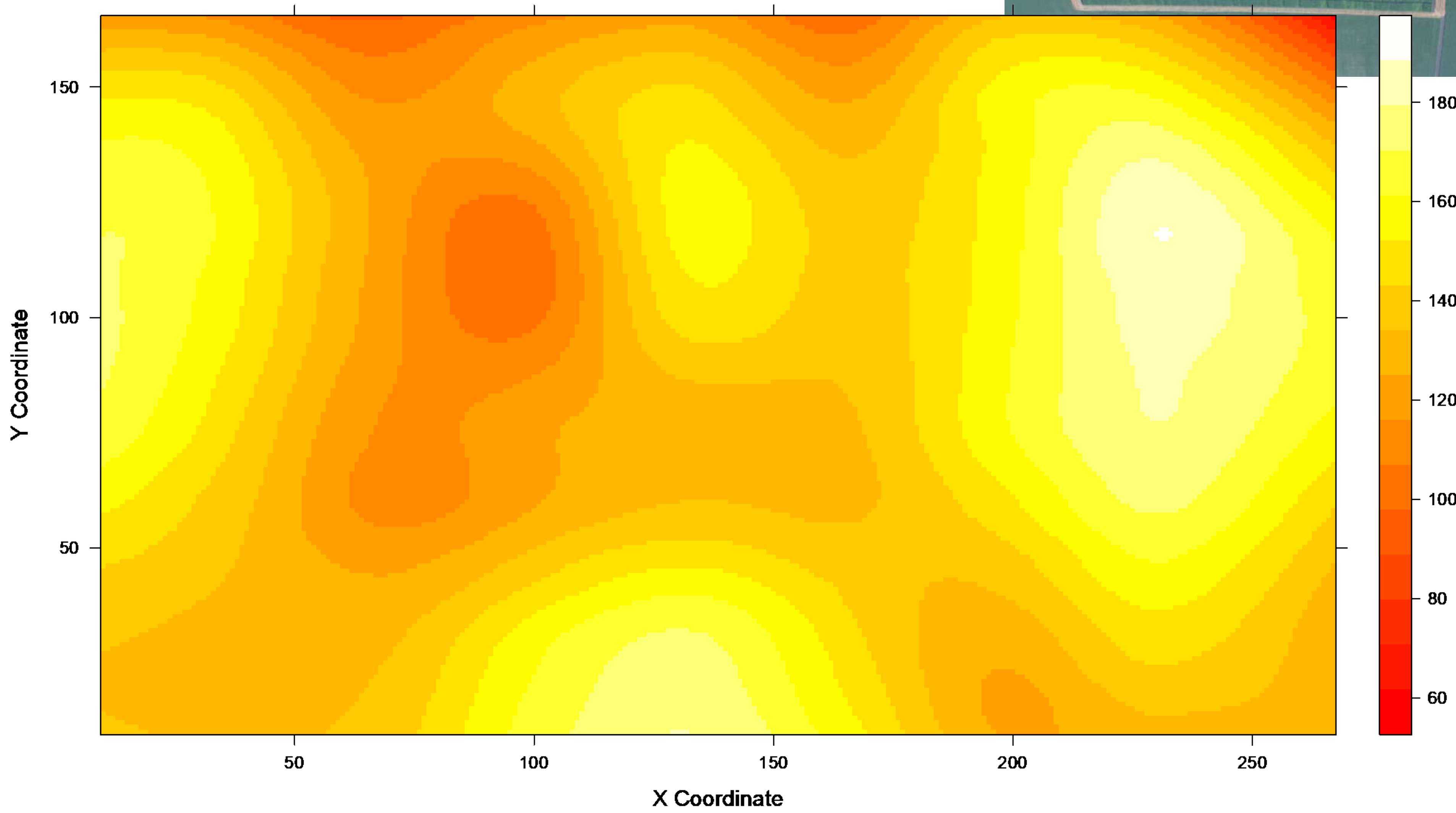
Soil Available P-Olsen

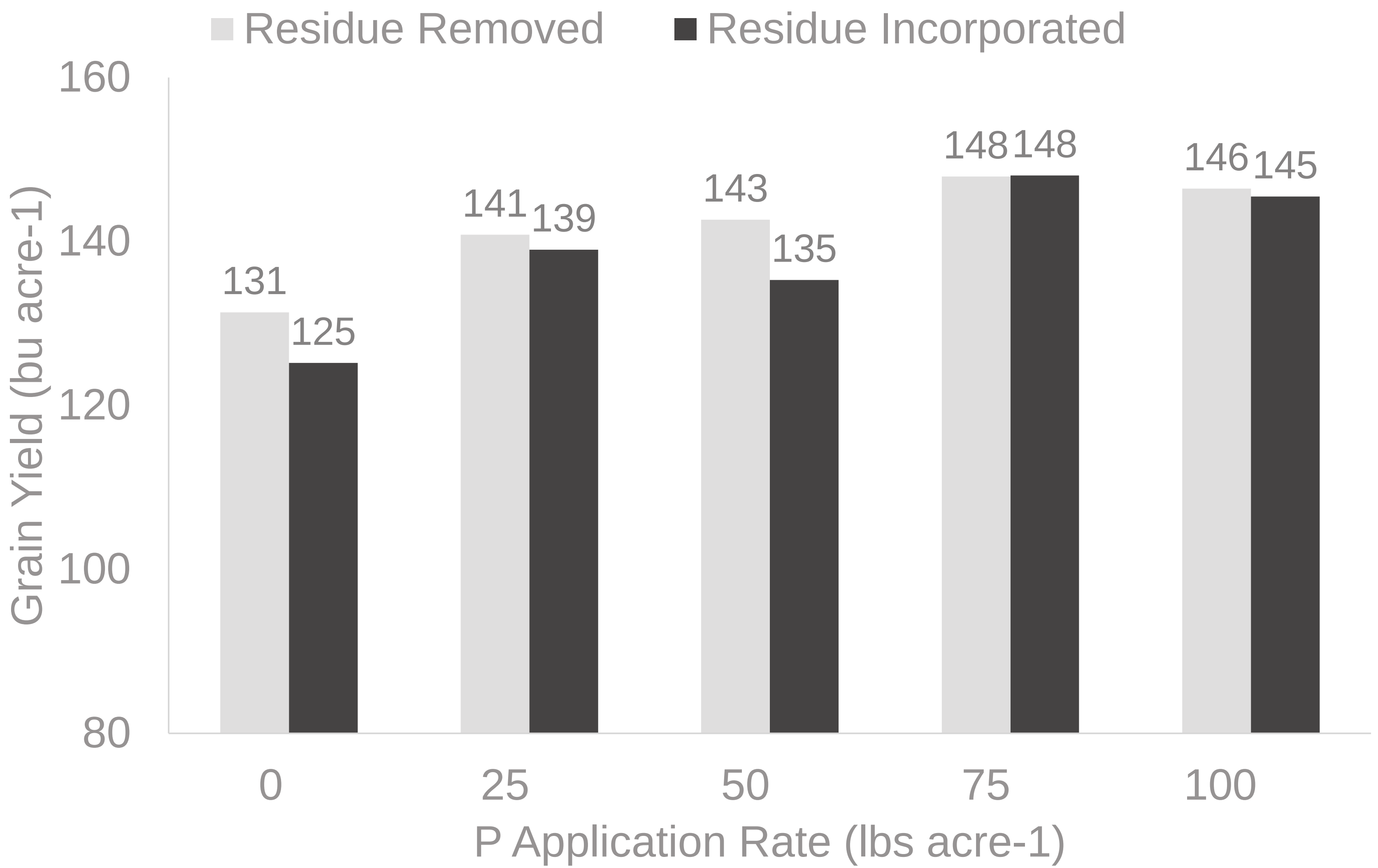




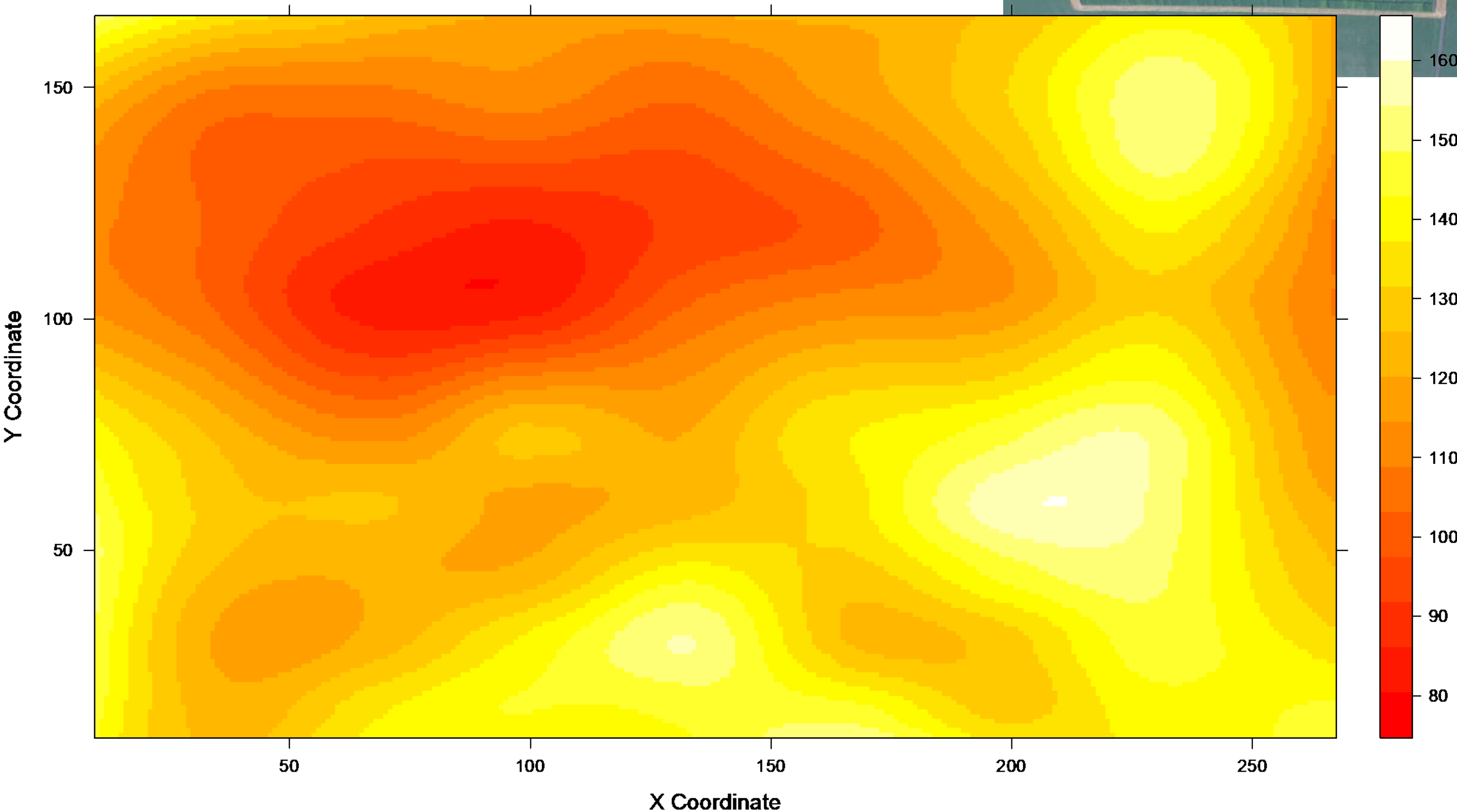



Observed 2013 Corn Yield
150
100
50
50
100
150
200
250
X Coordinate
Y Coordinate
180
160
140
120
100
80
60

2013 YIELD BASED ON P RATES



Observed 2014 Corn Yield



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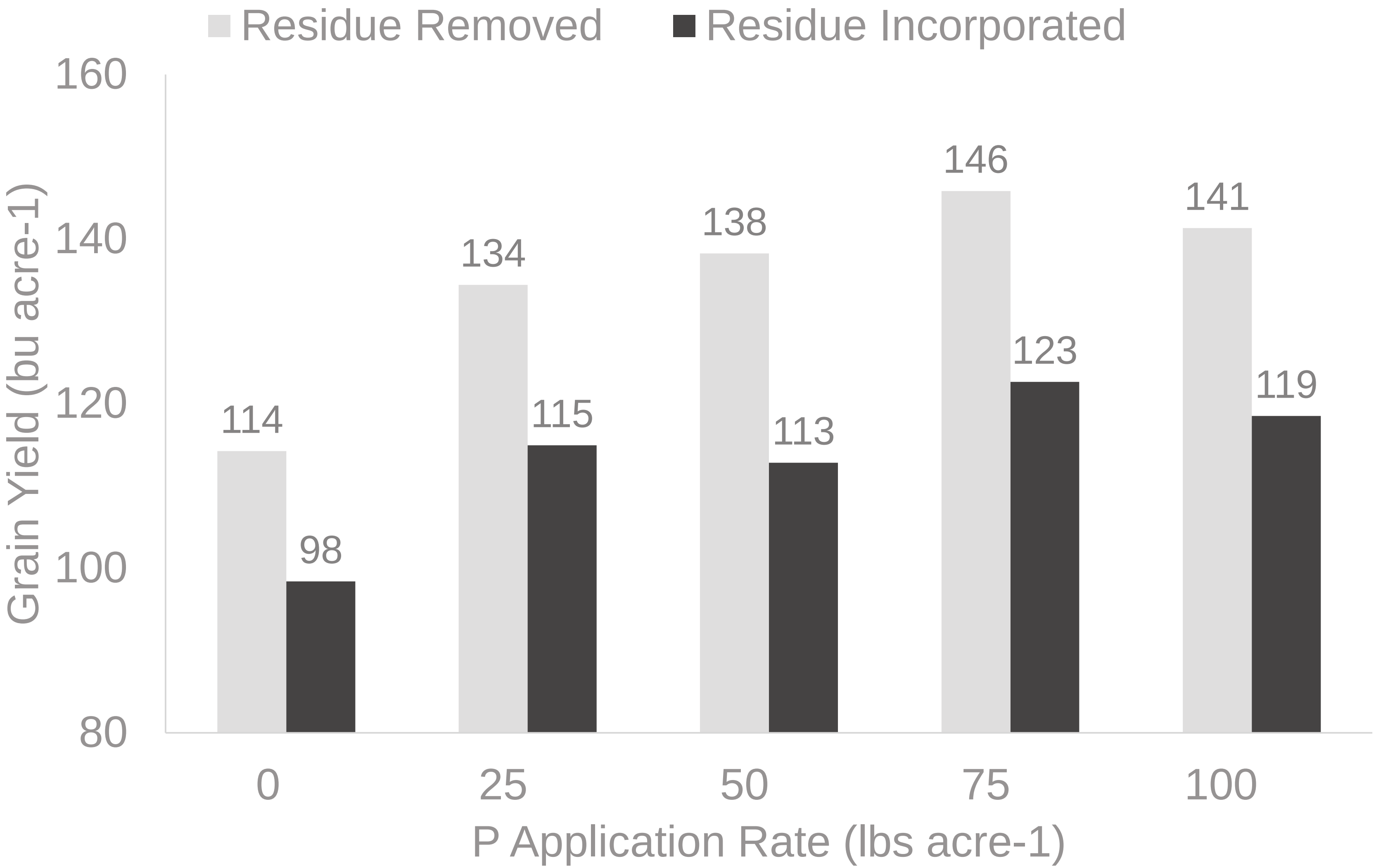
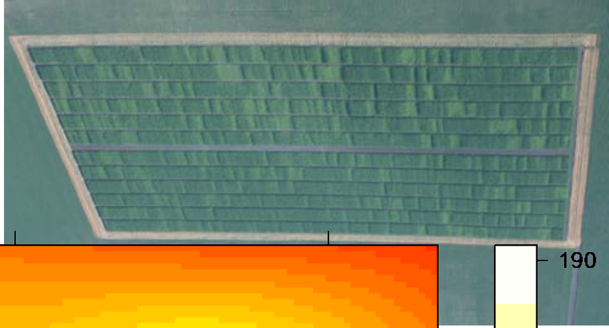
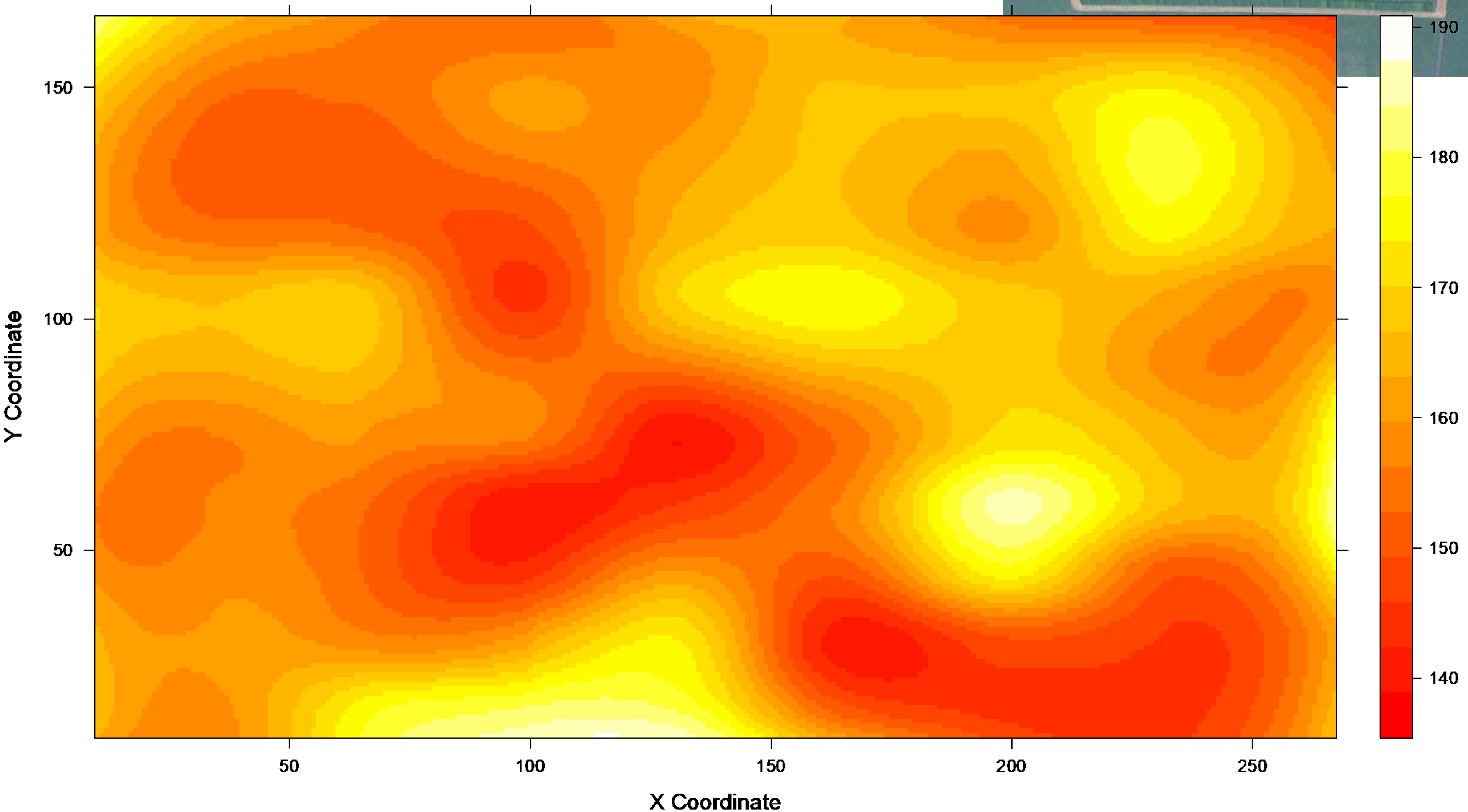
2014 YIELD BASED ON P RATES

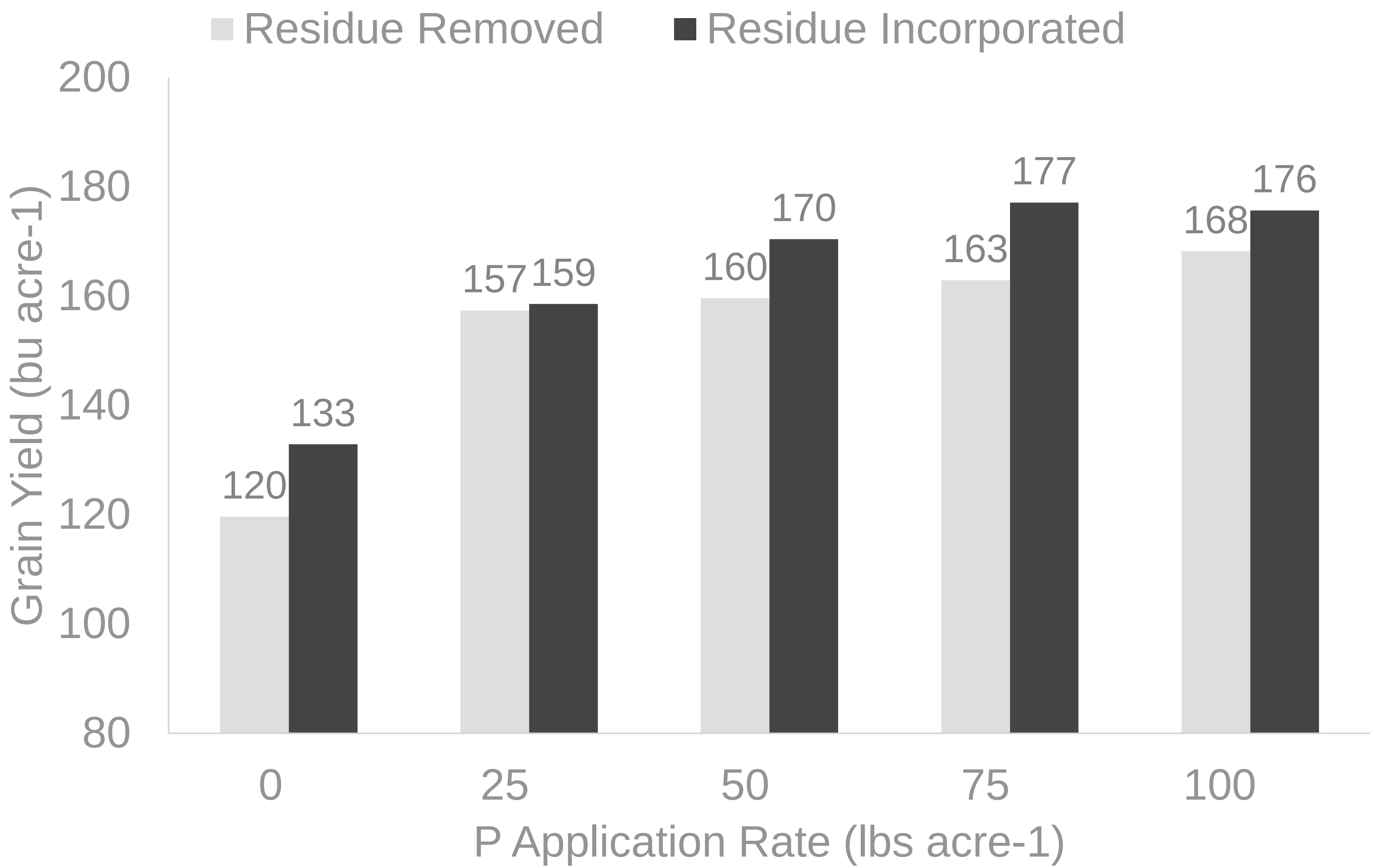




Observed 2015 Corn Yield



2015 YIELD BASED ON P RATES



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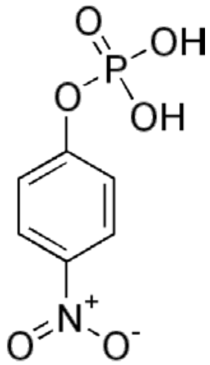
SOIL PROPERTIES

- Enzyme Activity
  - Enzyme assay:
    - 1 gram soil + 10 ml of substrate, incubated at 37^{o}C for 1 hr
    - Acid phosphatase: p-nitrophenyl phosphate
    - Aryl-sulfatase: p-nitrophenyl sulfate
    - B-glucosidase: p-nitrophenyl glucopyranosite

ENZYME ACTIVITY

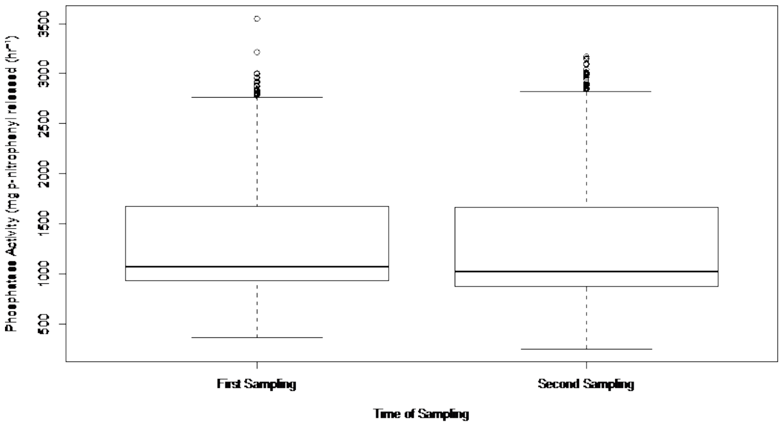
http://www.wikiwand.com/en/Alkaline_phosphatase

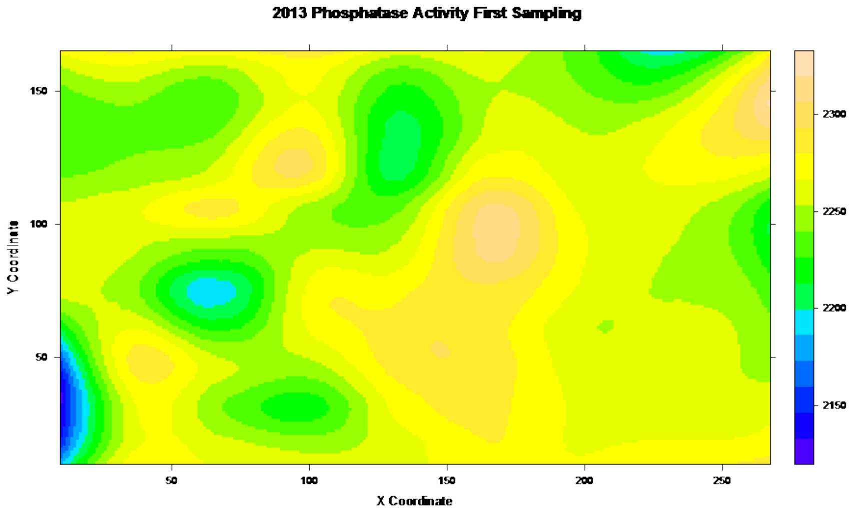


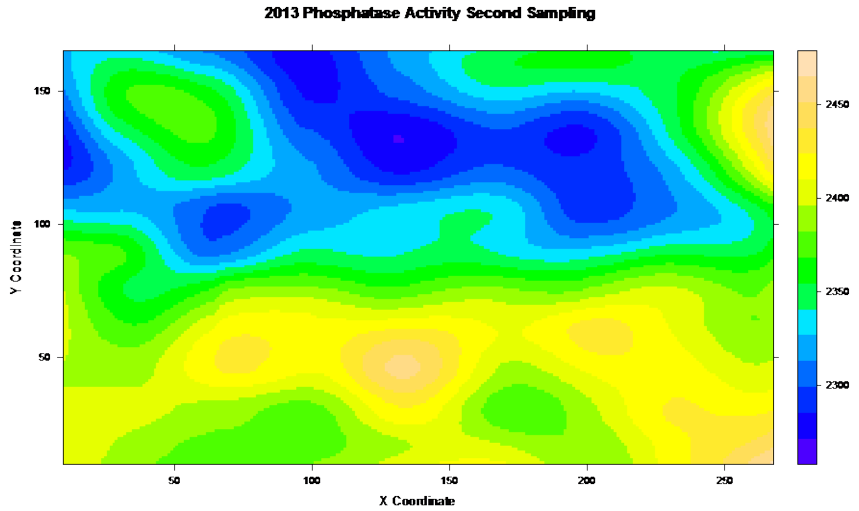
- Phosphatase
  - Tested by combining soil with p-nitrophenylphosphate (1:10 soil:reactant)
  - After reaction p-nitrophenol is produced
  - p-nitrophenol is determined by color – yellow pH>7.5

PHOSPHATASE ACTIVITY - 2013

- Residue incorporation decreased enzyme activity compared with residue removal when high N rates (160# and 200# N) were used

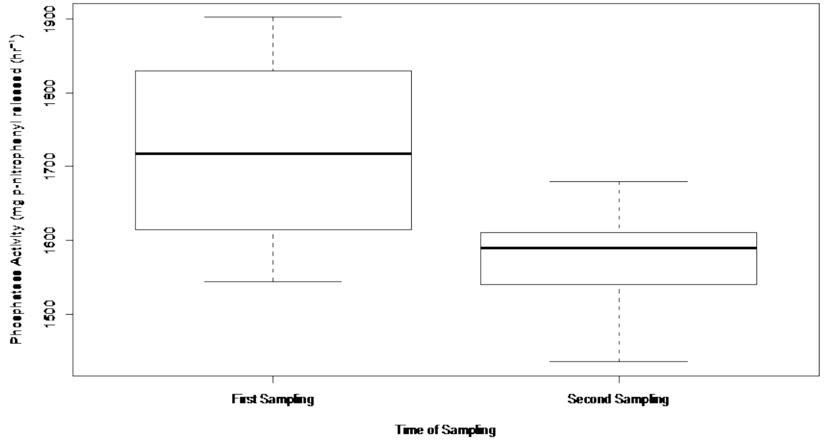


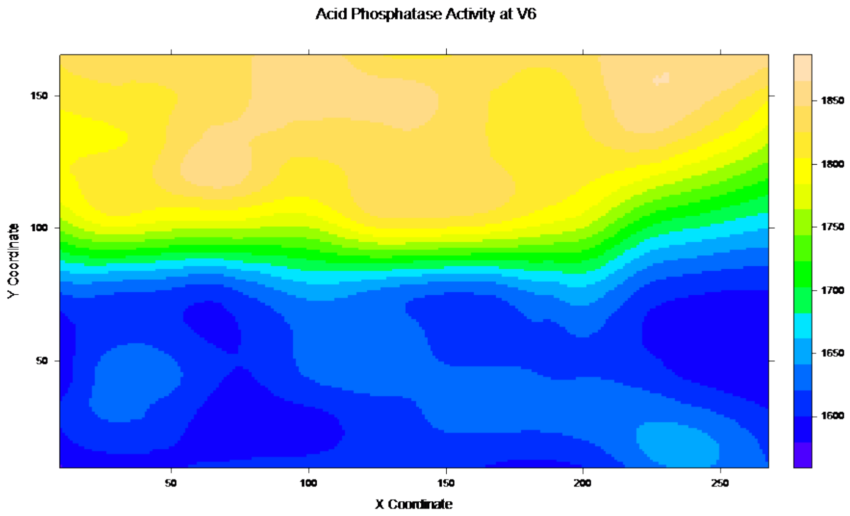


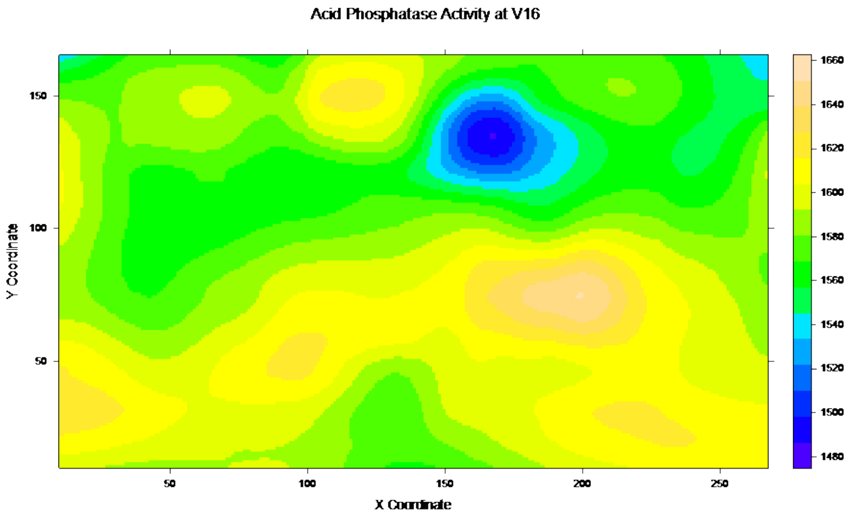


PHOSPHATASE ACTIVITY - 2014

- No treatment effects







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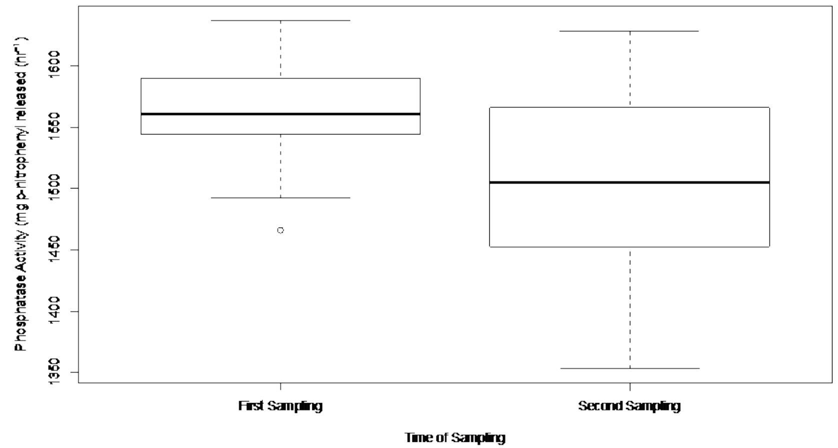
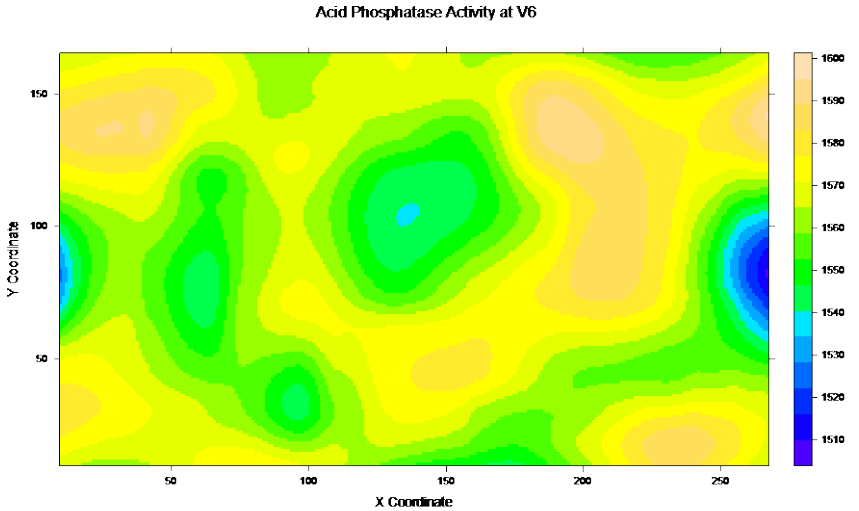
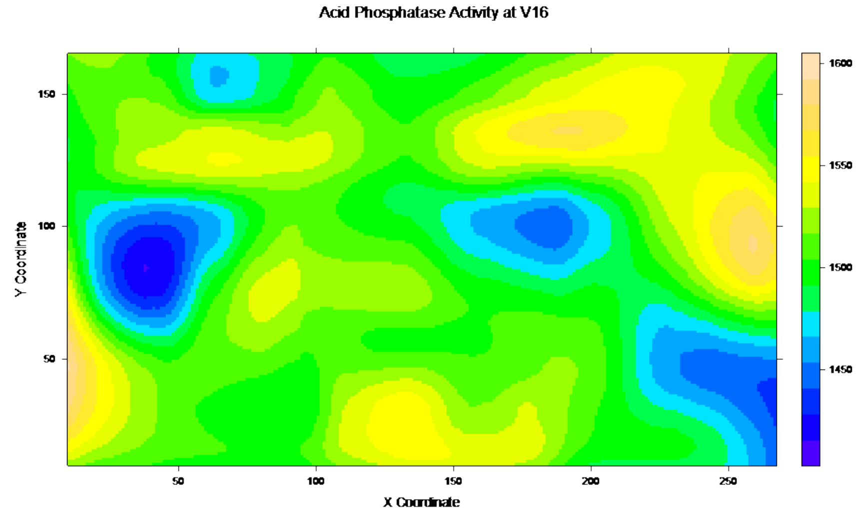
PHOSPHATASE ACTIVITY - 2015

- N and P addition tended to decrease enzyme activity early in the season, while residue removal decreased enzyme activity later in the season







PHOSPHATASE SUMMARY

- Residue incorporation decreases phosphatase activity on soy/corn
- Residue removal decreases phosphatase activity on corn/corn
- Both results are dependent on the level of P and N addition

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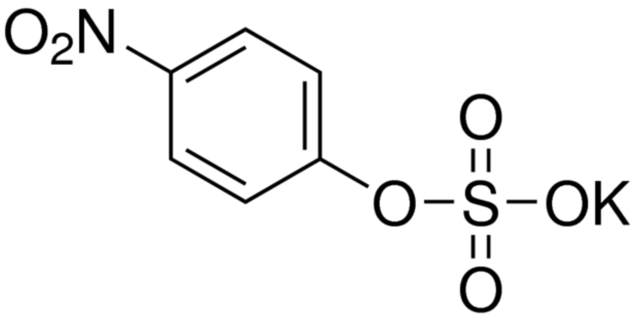
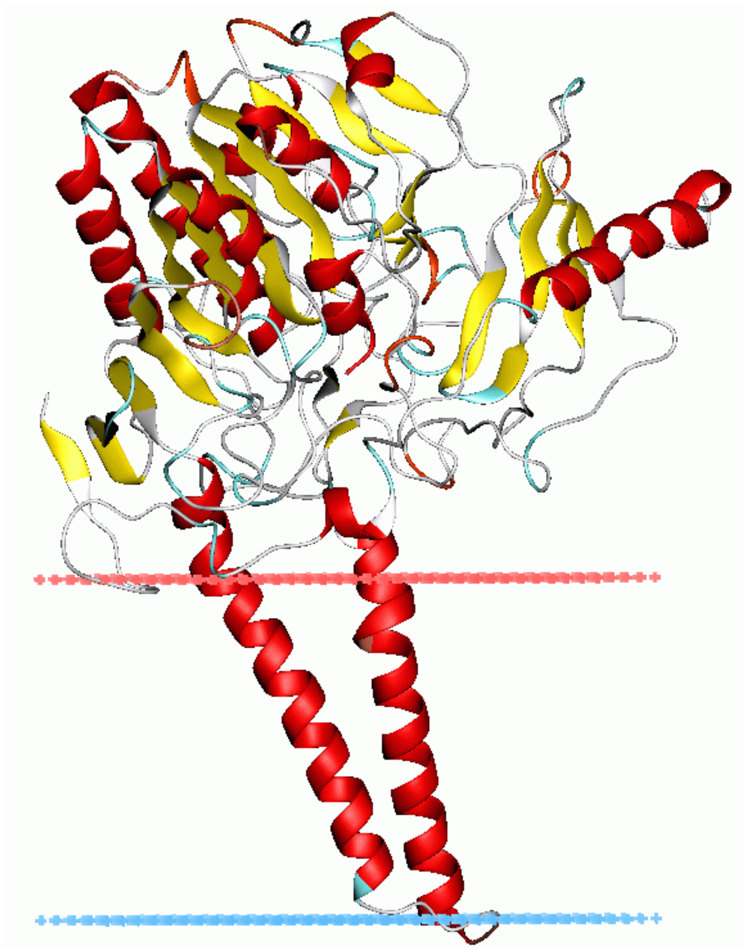
ENZYME ACTIVITY



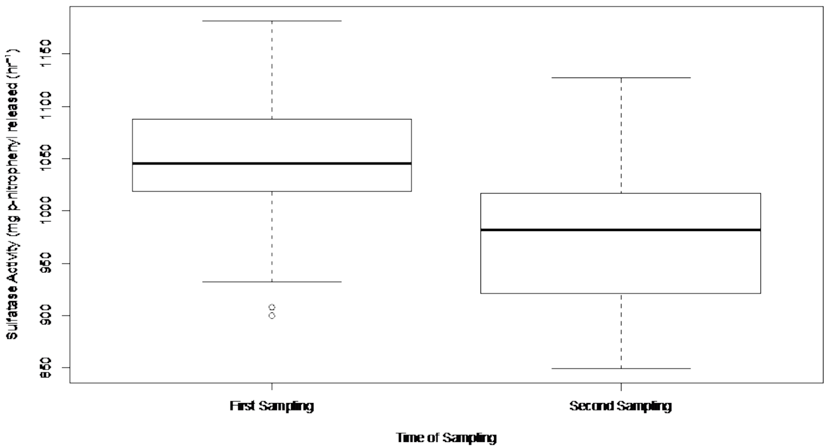


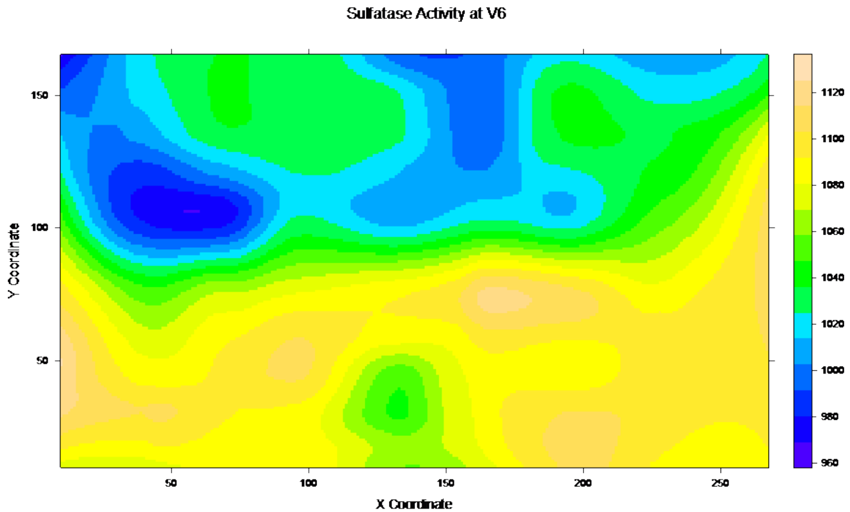
https://en.wikipedia.org/wiki/Sulfatase#/media/File:1p49_opm.png

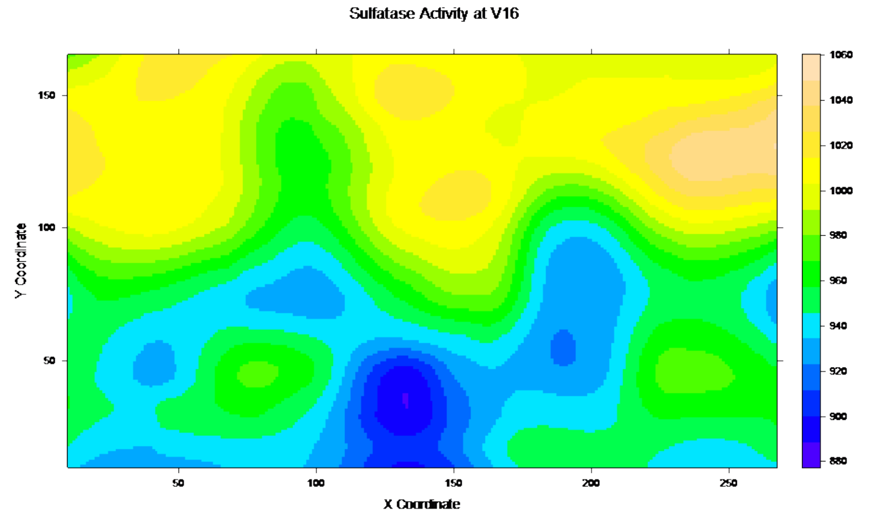
- Sulfatase
  - S turn over in the soil
  - Tested by combining soil with p-nitrophenylsulfate (1:10 soil:reactant)
  - After reaction p-nitrophenol is produced
  - p-nitrophenol is determined by color

SULFATASE ACTIVITY - 2014

- Enzyme activity was higher early in the season and decreased later in the season in plots where residue was removed



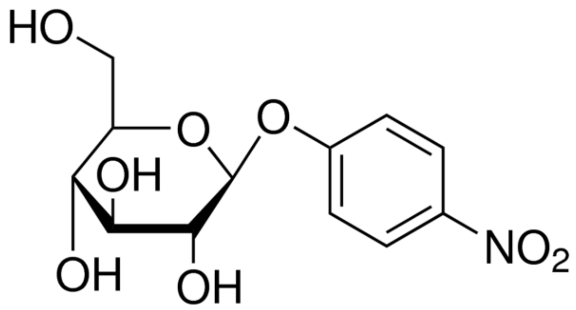


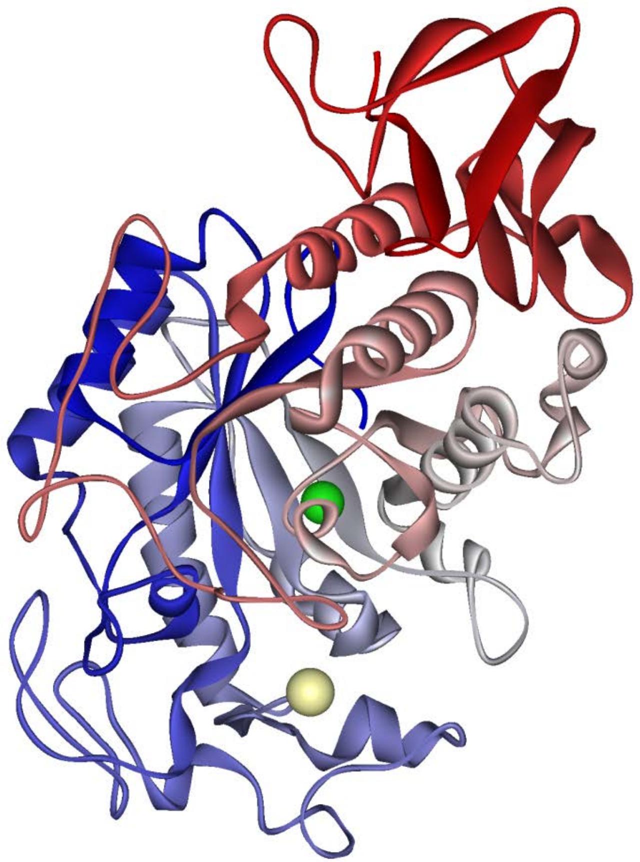


SULFATASE SUMMARY

- Residue removal decreases sulfatase activity on corn/corn
- Nitrogen tends to decrease sulfatase activity on corn/corn early in the season

ENZYME ACTIVITY



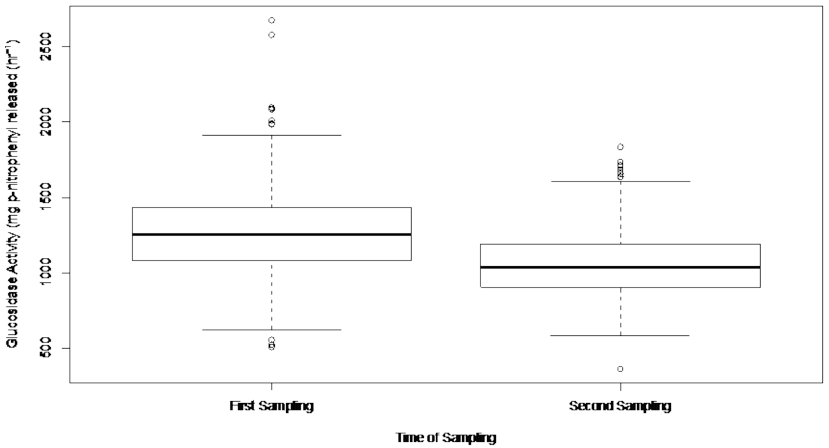


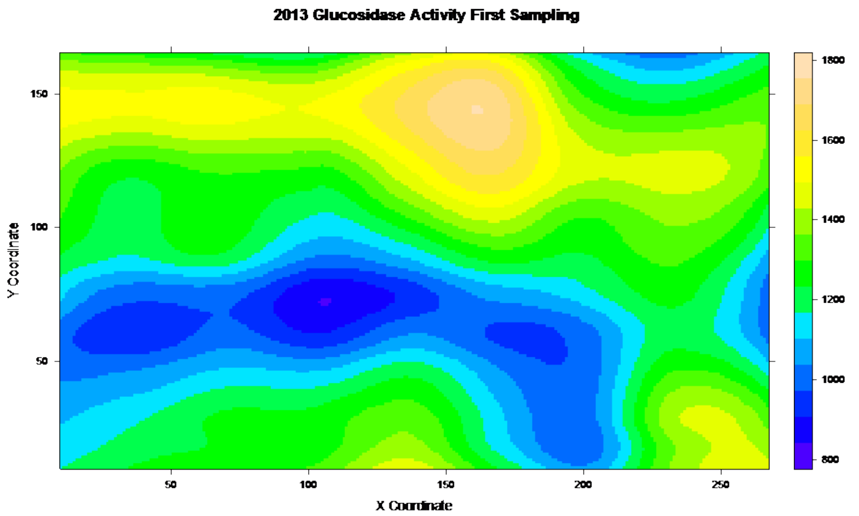
- Glucosidase
  - sugar turn over in the soil
  - Tested by combining soil with p-nitrophenyl glucopyronoside (1:10 soil:reactant)
  - After reaction p-nitrophenol is produced
  - p-nitrophenol is determined by color

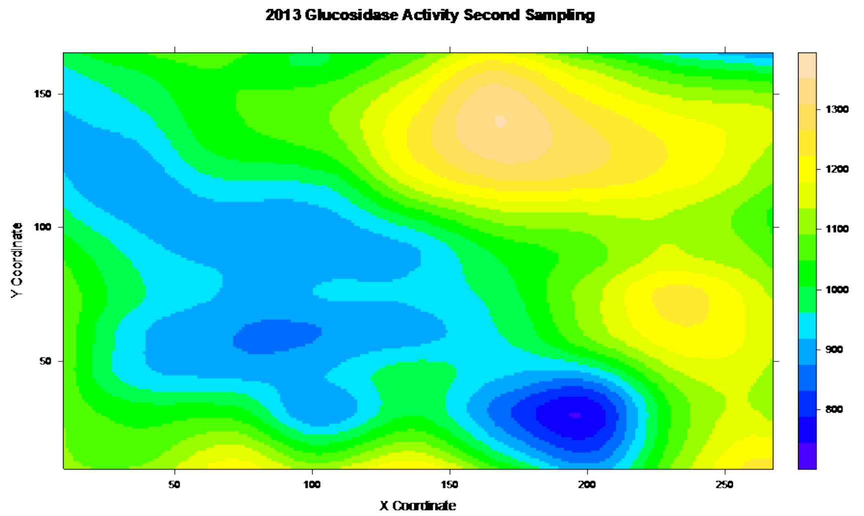
https://en.wikipedia.org/wiki/Glycoside_hydrolase

GLUCOSIDASE ACTIVITY - 2013

- Enzyme activity was higher at both sampling where residue was incorporated







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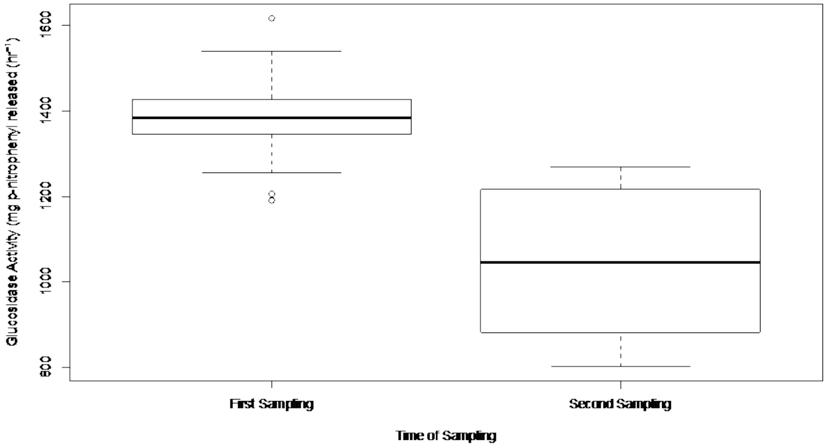
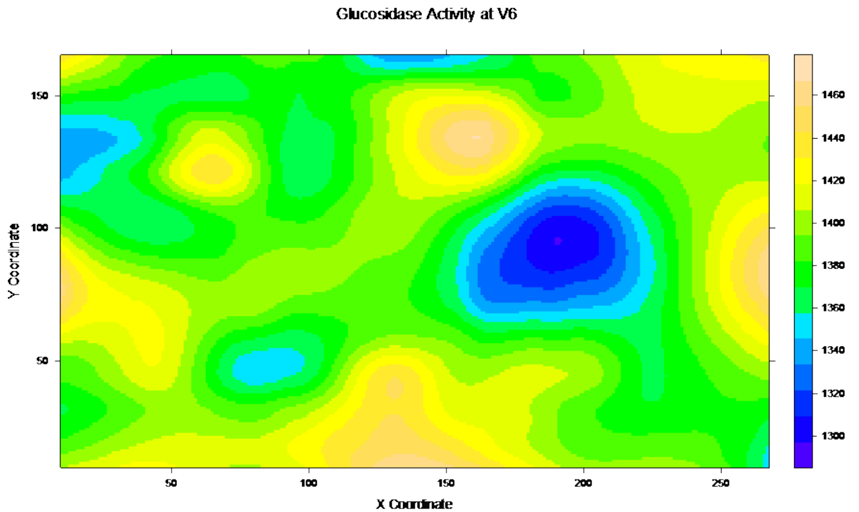
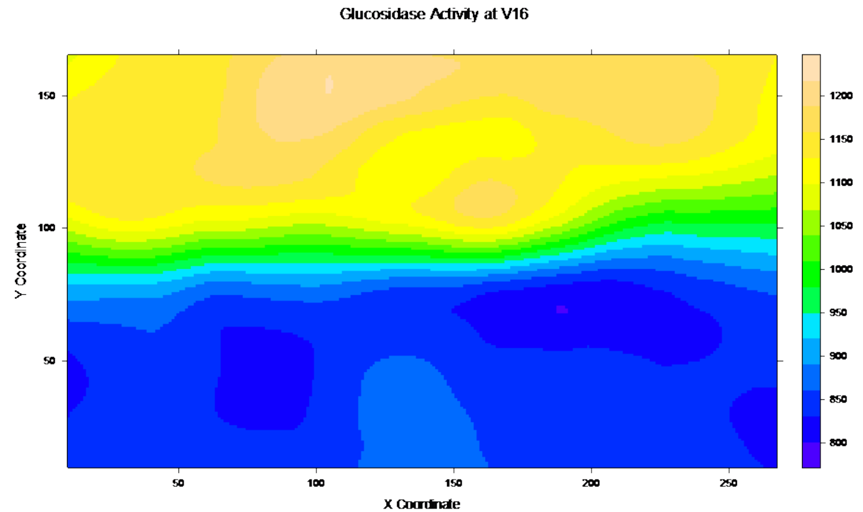
GLUCOSIDASE ACTIVITY - 2014

- Enzyme activity increased after N and P addition compared with the control.
- Residue removal decreased enzyme activity later in the season







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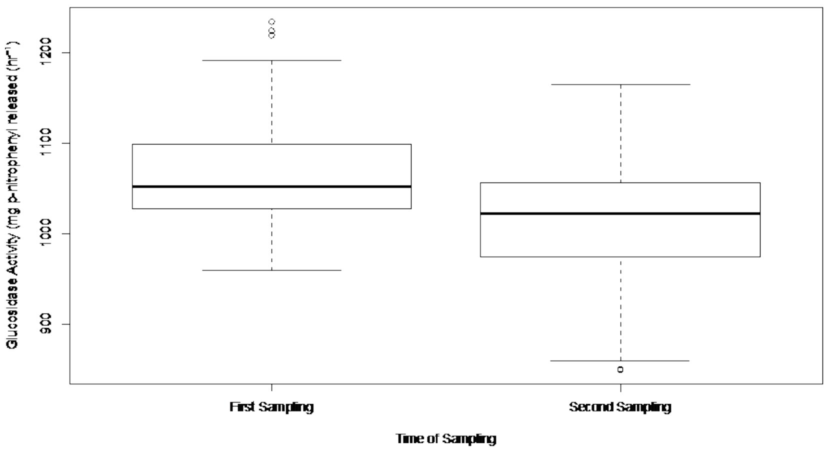
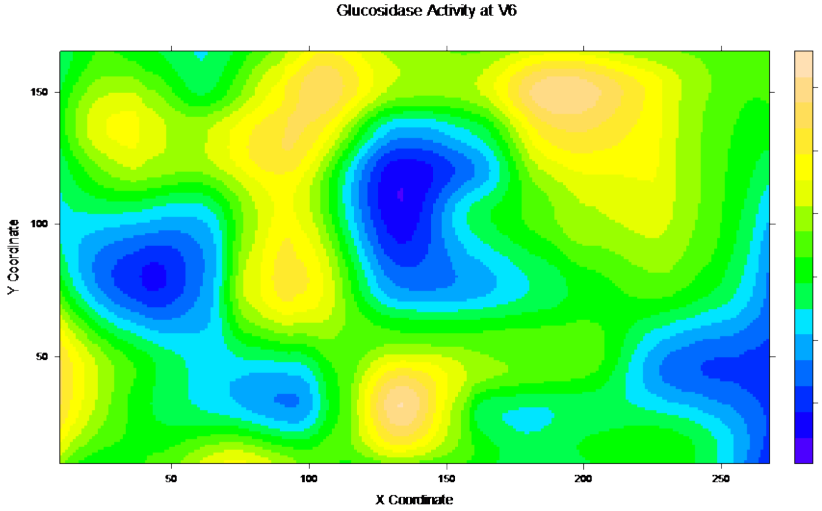
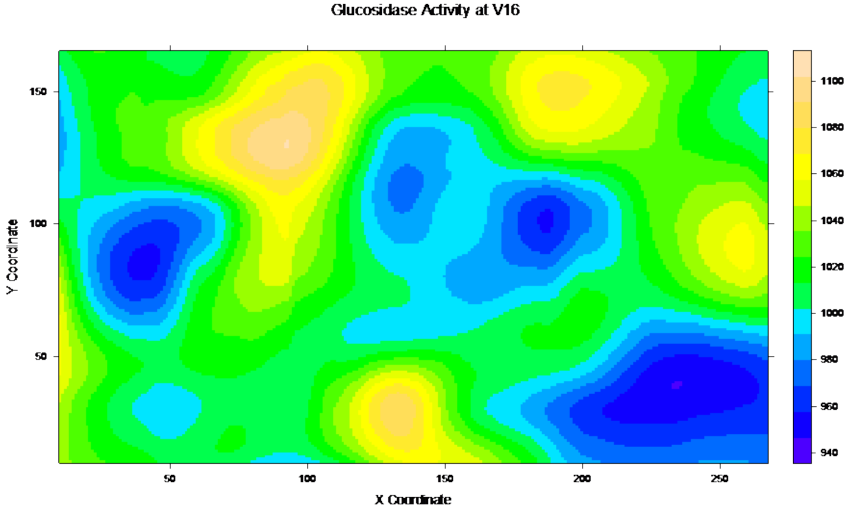
GLUCOSIDASE ACTIVITY - 2015

- Enzyme activity decreased after N addition in the 1st sampling, but it increased in the 2nd sampling.
- Residue removal tended to decreased enzyme activity







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GLUCOSIDASE SUMMARY

- Residue removal decreases glucosidase activity on corn/corn
- Nitrogen tends to decrease glucosidase activity on corn/corn early in the season, but might increase later in the season on corn/corn

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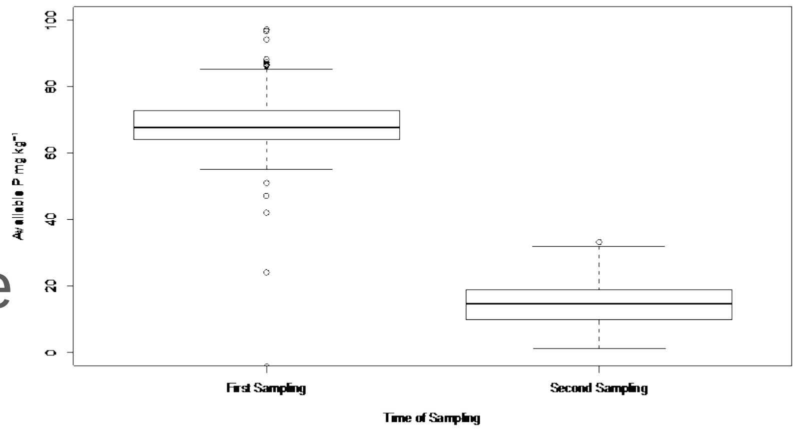
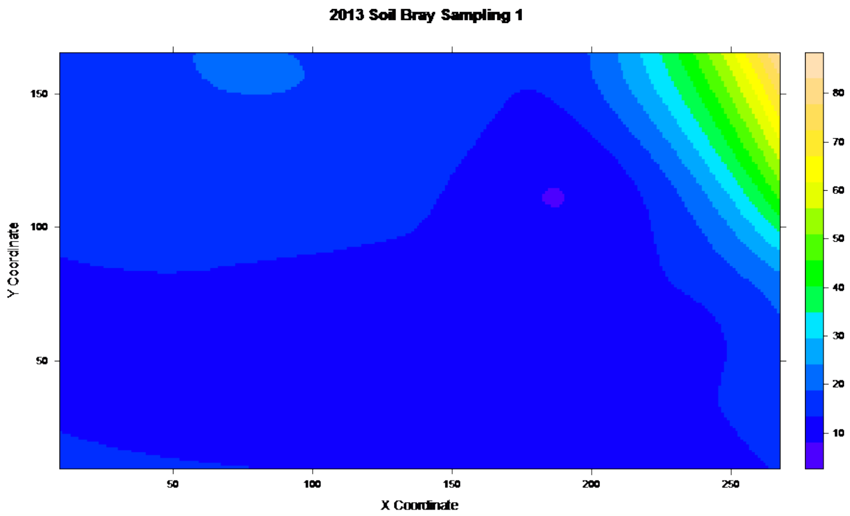
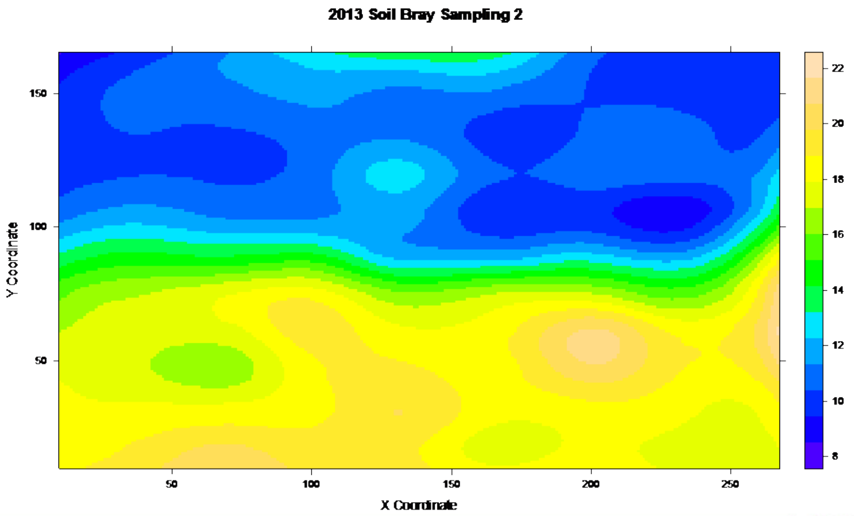
AVAILABLE P - 2013

- STP tended to increase more where residue was incorporated in the first sampling, but decreased in the second sampling compared with residue removal







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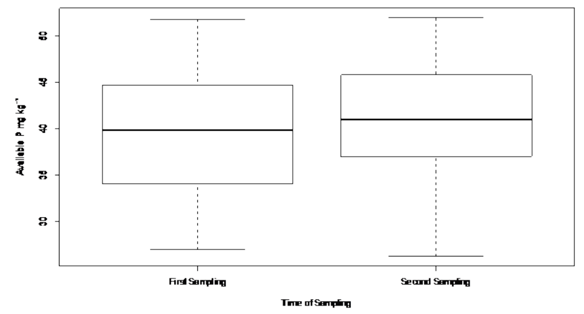
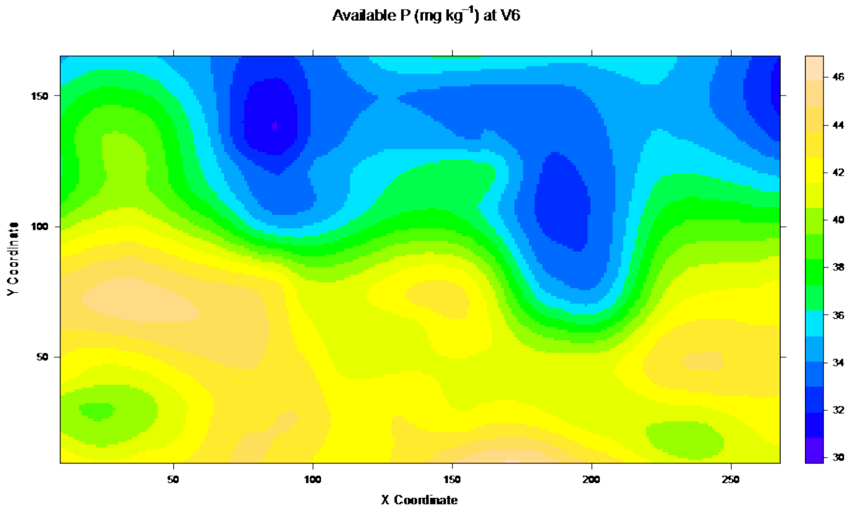
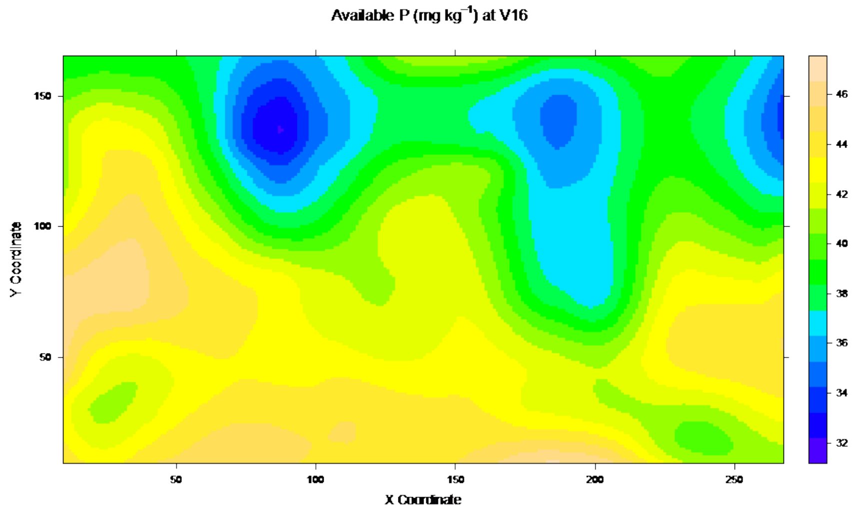
AVAILABLE P - 2014

- Increases in STP were higher were residue was removed







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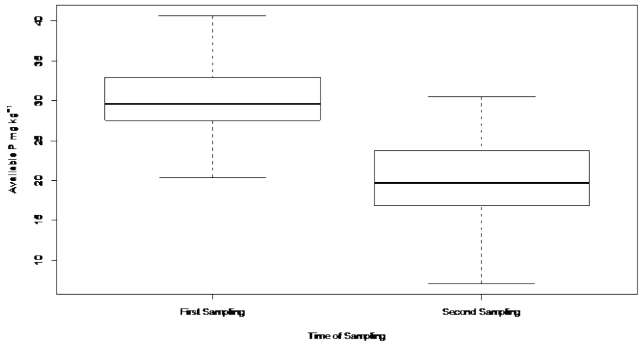
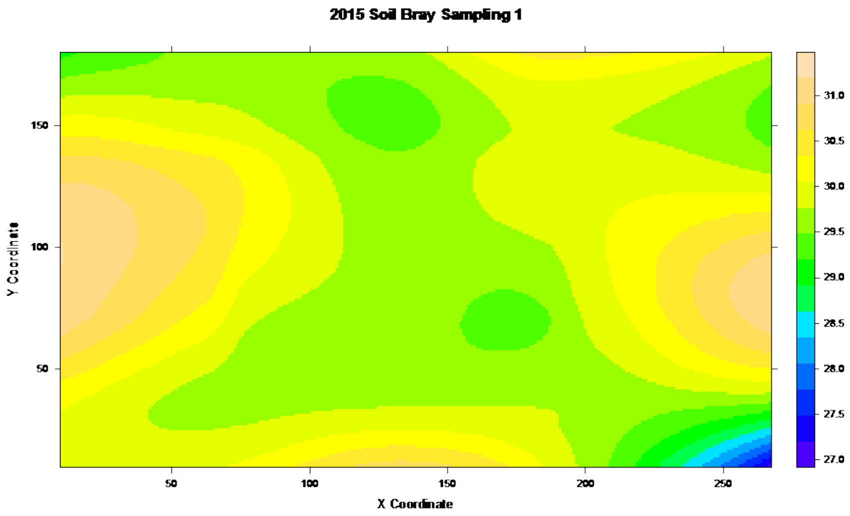
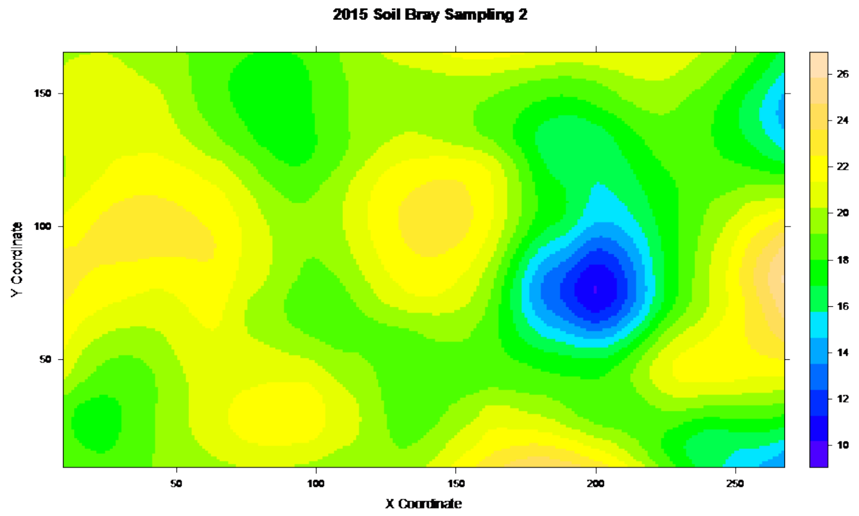
AVAILABLE P - 2015

- At both samplings STP tended to be higher where residue was incorporated



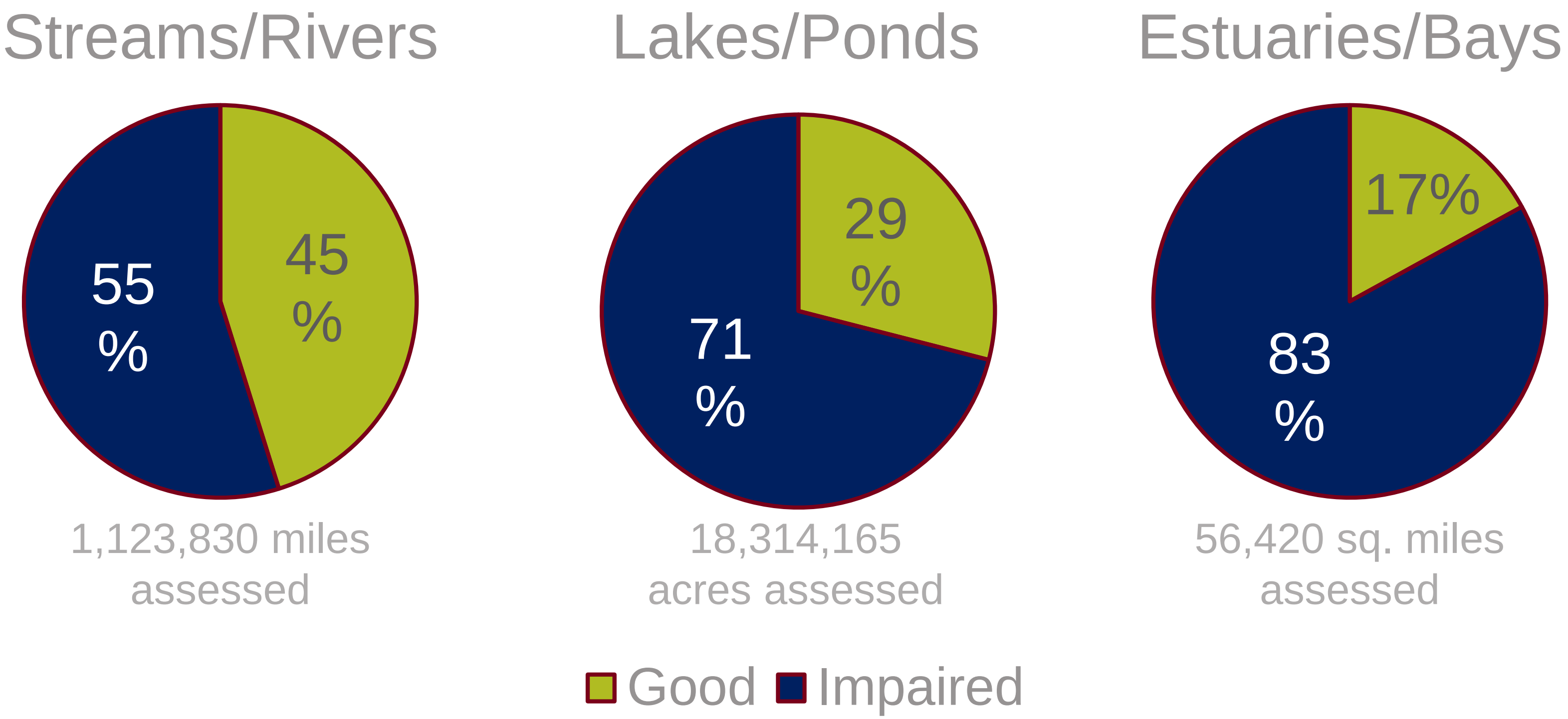




AVAILABLE P SUMMARY

- In the first year of the study residue incorporation kept STP levels lower than residue removal.
- STP levels were higher where residue was incorporated in the later years

WATER QUALITY IMPAIRMENT IS WIDESPREAD IN THE U.S.



About 50% in each case due to Agriculture

Information from: EPA. 2017. https://ofmpub.epa.gov/waters10/attains_nation_cy.control#STREAM/CREEK/RIVER

Slide shared by Dr. Melissa Wilson

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- Lake Erie, Sept. 6, 2015

https://www.flickr.com/photos/noaa_glerl/23571525522/in/album-72157639592150973/

IMPAIRED WATERS IN MN

MINNESOTA POLLUTION CONTROL AGENCY

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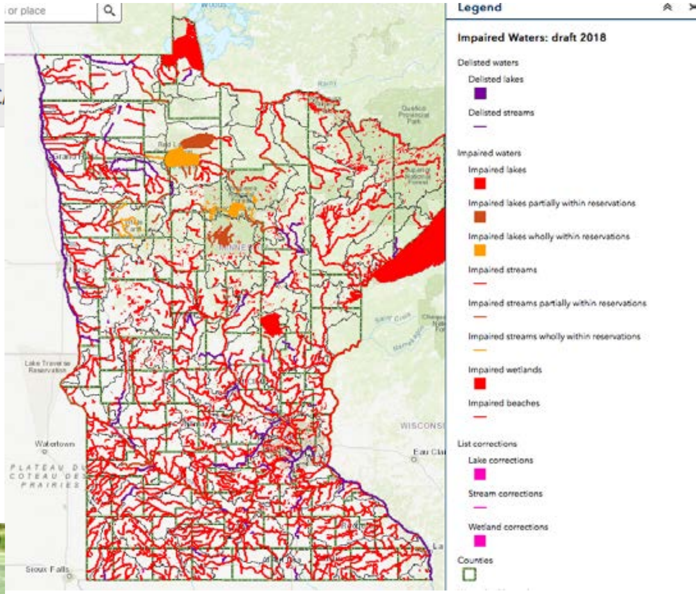
Water / How's the water? / Water monitoring and assessment

Minnesota's Impaired Waters List

Every two years, MPCA creates a list of impaired waters that do not meet water quality standards. Monitoring suggests that about 40% of Minnesota's lakes and streams are impaired for conventional pollutants. Learn more: **Defining impaired waters.**

Stay informed. Have questions or need assistance? Contact Miranda Nichols, 651-757-2614 or 800-657-3864 toll free.

Draft 2018 Impaired Waters List



https://www.pca.state.mn.us/water/minnesotas-impaired-waters-list

QUESTIONS?

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Questions?

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