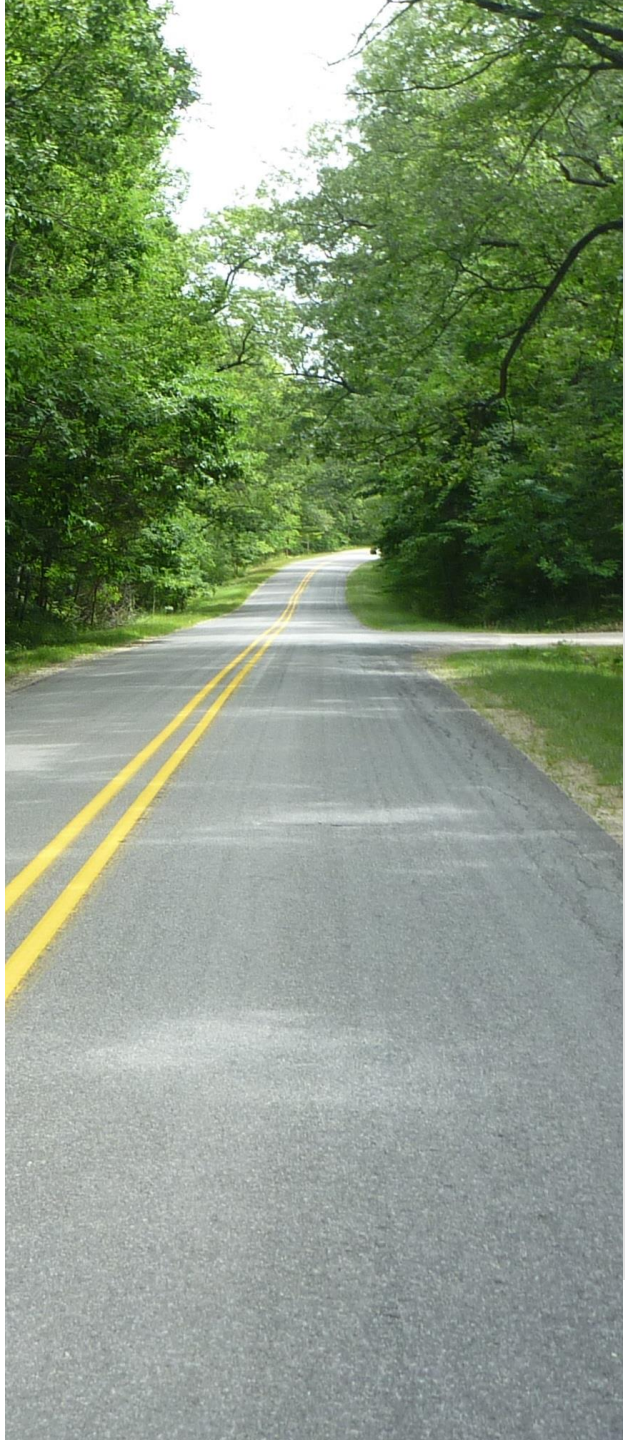
Capturing the Value of Carbon Intensity Reductions in Low Carbon Fuel Markets at Ethanol Plants and Corn Farms

Ron Alverson:

Corn Producer, Board of Directors Dakota Ethanol




WILL TRADE
SISTER
TRACTOR

Topics

- Current and Prospective Low Carbon Fuel Markets
- Current State of Fuel Carbon (GHG) Intensity Accounting/Modeling
- Opportunities for Corn Ethanol to Reduce Carbon Intensity

Low Carbon Fuel Markets

- U.S. EISA-RFS2 - 2007
- California LCFS – 2007
- British Columbia – 2008
- European Union – 2008
- United Kingdom
- Oregon – Just starting now
- Under consideration:
  - Washington State
  - 11 Northeast and Mid-Atlantic States

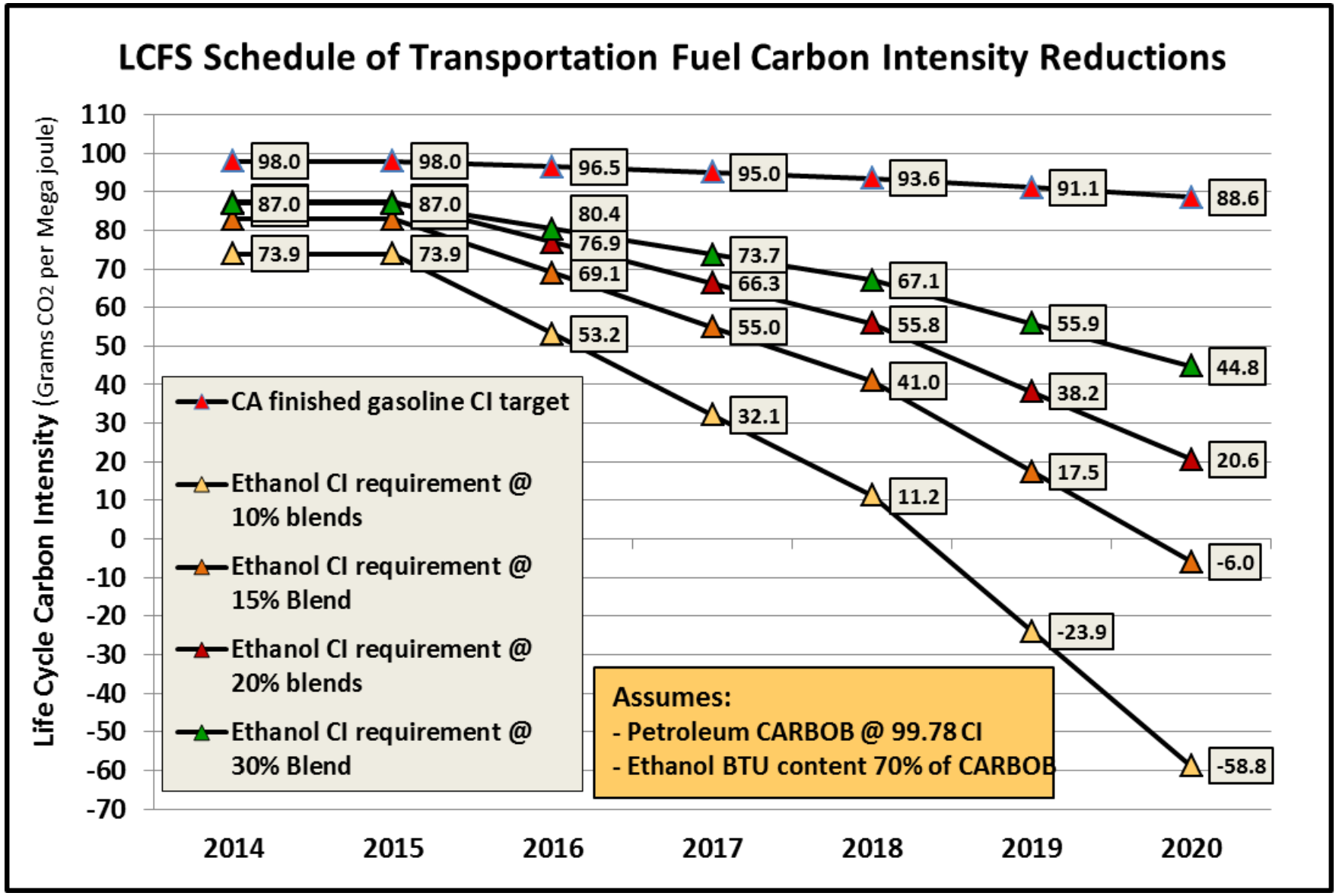
California Low Carbon Fuel Standard (LCFS)

Administered by the California Air Resource Board (CARB)

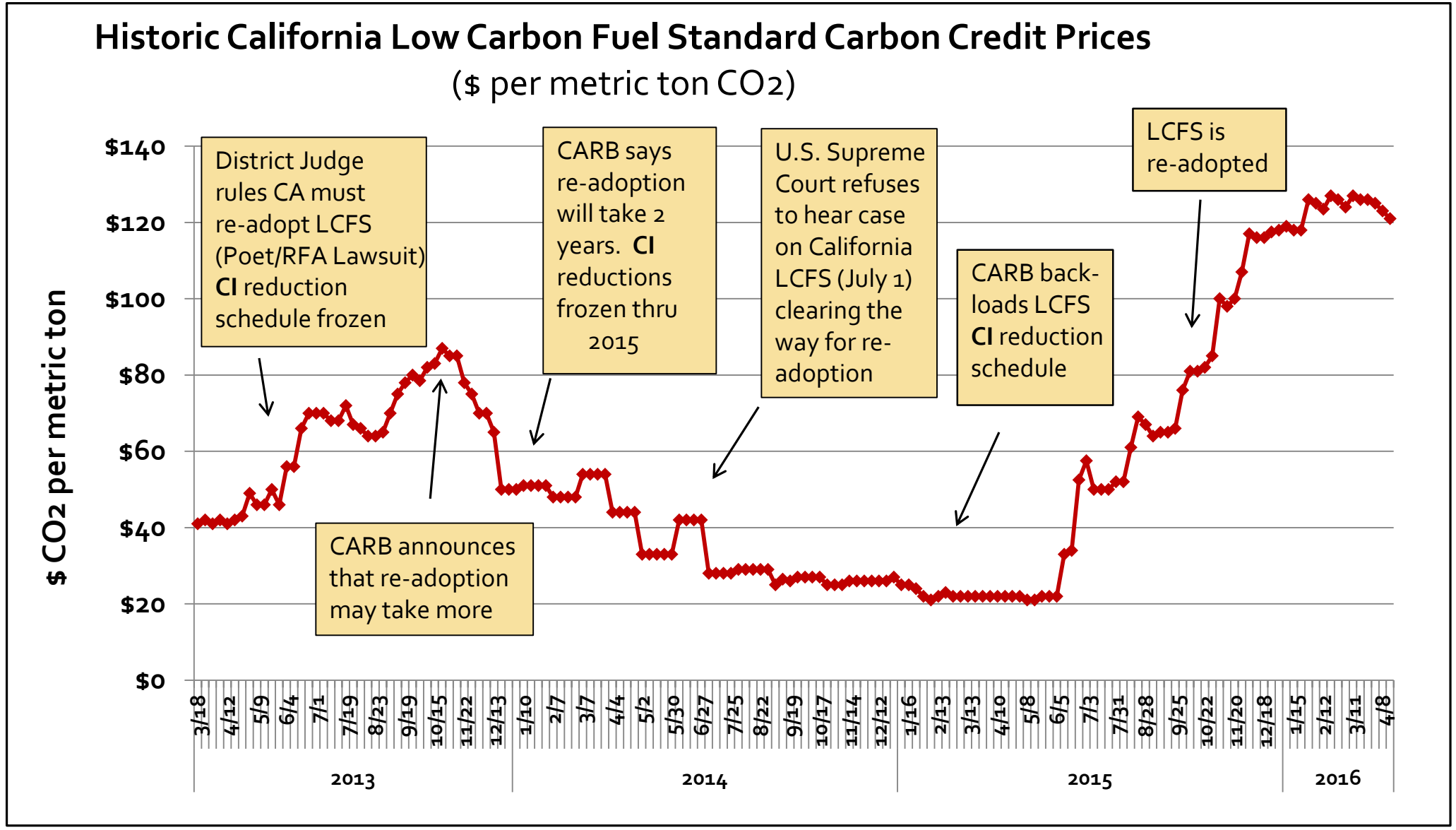
Transportation Fuel Carbon Intensity (CI) must be reduced by 10% by 2020.

Established a Carbon Trading Market that rewards Fuel Producers for Carbon Intensity reductions.

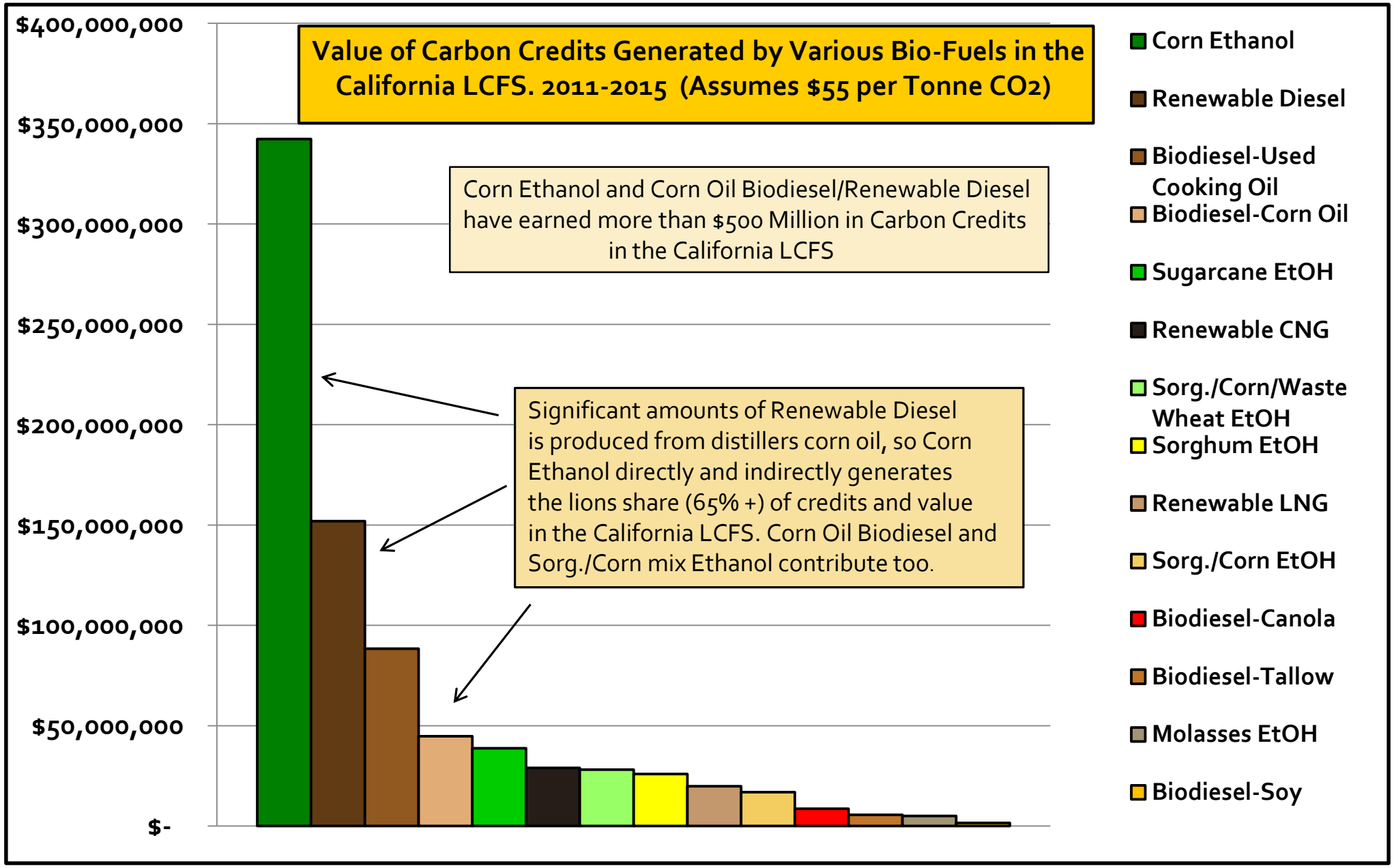
LCFS Carbon Credits have traded for $20 to $127 per metric ton CO_2 over the past 12 months.



Where is the CA LCFS going to get enough Low Carbon Fuel to Meet this Schedule? Higher Blends of Ethanol?



CARB has Capped CO2 Credits at $200 per Metric Ton


Value of Carbon Credits Generated by Various Bio-Fuels in the California LCFS. 2011-2015 (Assumes $55 per Tonne CO2)
$400,000,000
$350,000,000
$300,000,000
$250,000,000
$200,000,000
$150,000,000
$100,000,000
$50,000,000
$-
Corn Ethanol and Corn Oil Biodiesel/Renewable Diesel have earned more than $500 Million in Carbon Credits in the California LCFS
Significant amounts of Renewable Diesel is produced from distillers corn oil, so Corn Ethanol directly and indirectly generates the lions share (65% +) of credits and value in the California LCFS. Corn Oil Biodiesel and Sorg./Corn mix Ethanol contribute too.
Corn Ethanol
Renewable Diesel
Biodiesel-Used Cooking Oil
Biodiesel-Corn Oil
Sugarcane EtOH
Renewable CNG
Sorg./Corn/Waste Wheat EtOH
Sorghum EtOH
Renewable LNG
Sorg./Corn EtOH
Biodiesel-Canola
Biodiesel-Tallow
Molasses EtOH
Biodiesel-Soy

Low Carbon Fuels Used in California for LCFS Compliance

- 2011 - 2015 Statistics

- Ethanol (All types) - 57%
- Bio/Renewable Diesel - 37%
- Natural Gas - 6%

Economic Incentives for CI Reductions

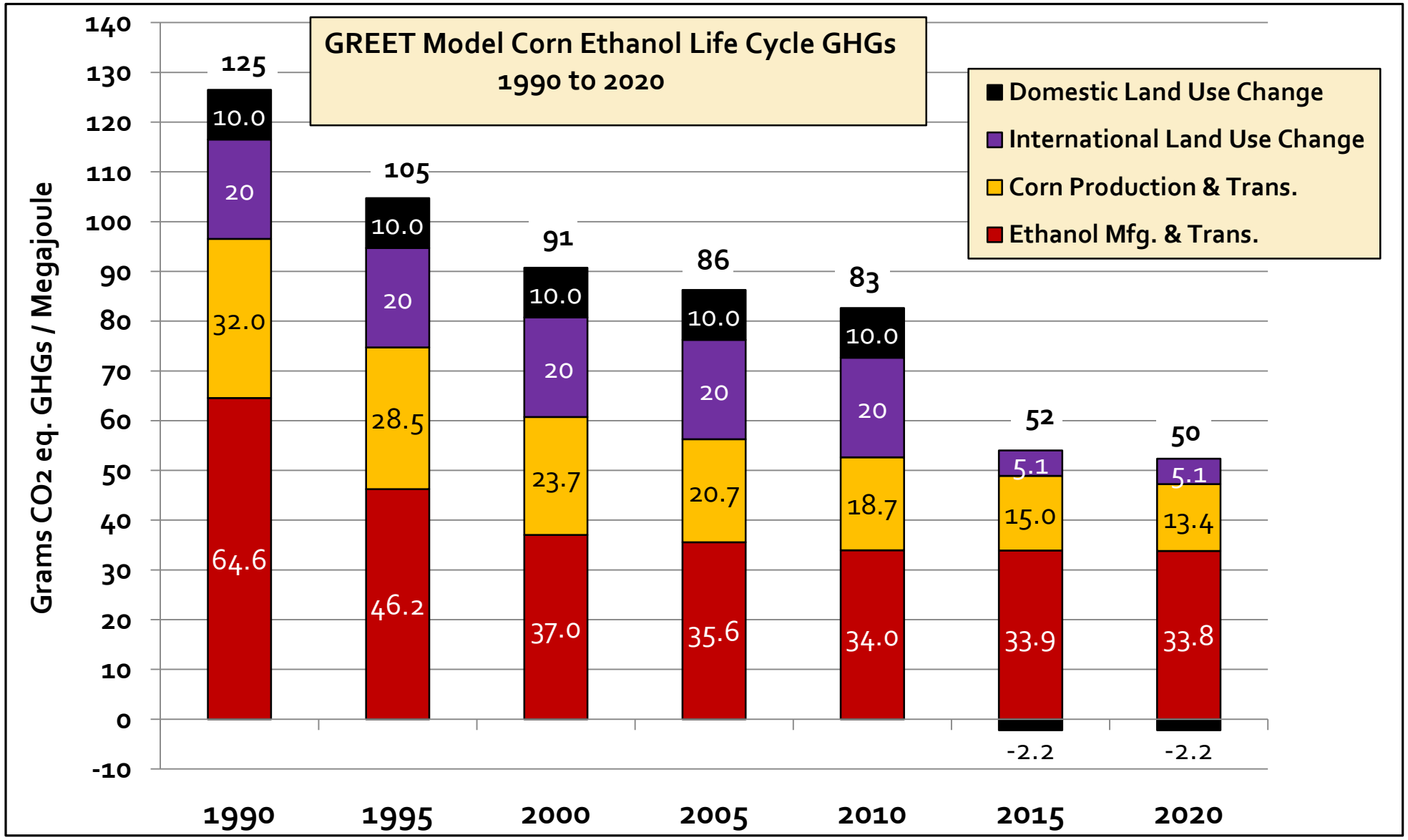
The Math

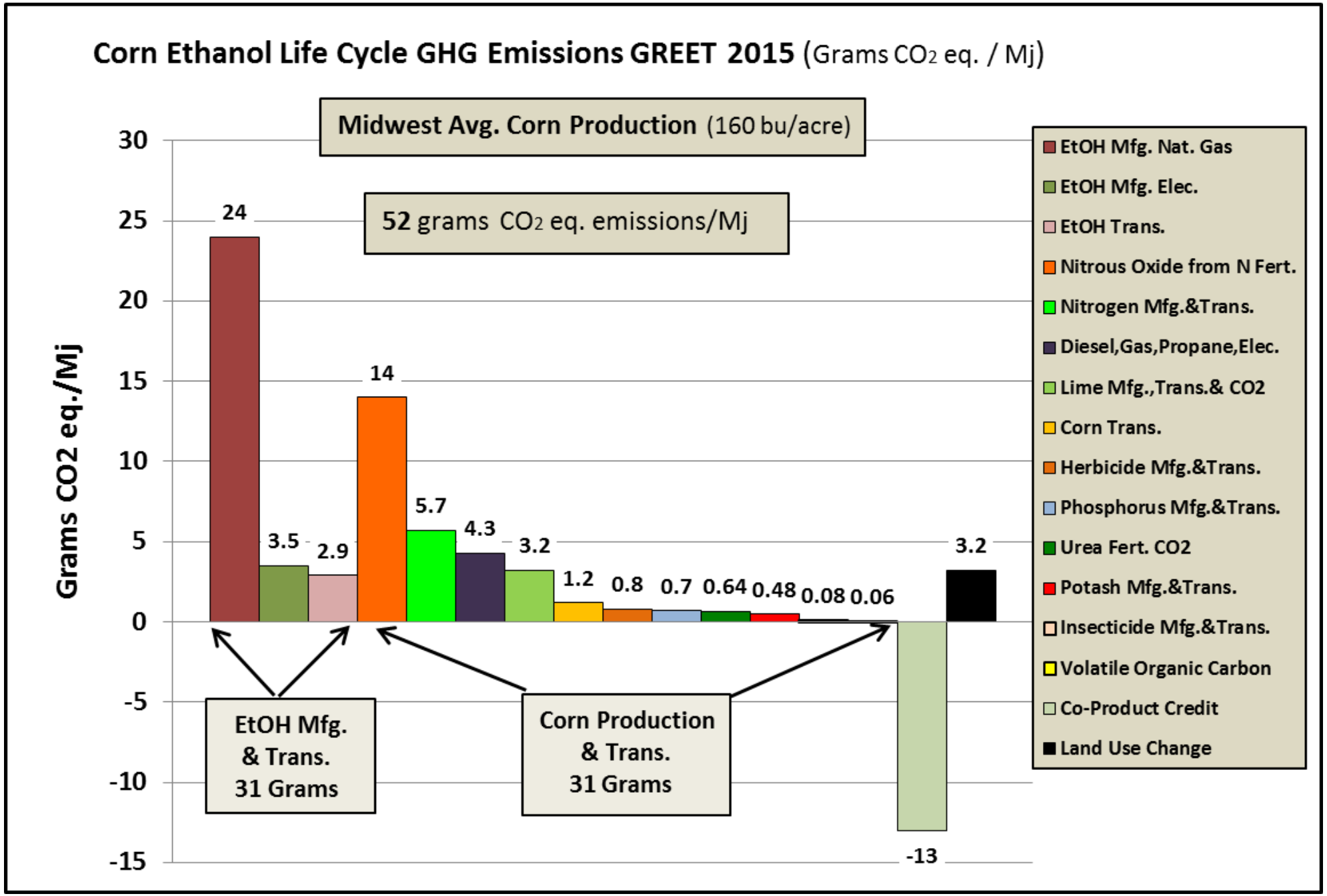
- Carbon Intensity in the LCFS is the Grams of CO_2 Equivalent Green House Gas Emissions from the Production of One Mega Joule of Fuel Energy.
- There are 80.53 Megajoules of Energy in each gallon of Ethanol (76,330 btu/gallon divided by 947.82 btus/Megajoule)
- Assuming $122/MT CO_2 eq. (1,000,000 grams), the value of 1 gram is $.0098 per gram. ($122*80.53/1,000,000)
- 80 CI Ethanol in 2016 (99.78 CI standard) generates credits worth 20 cents per gallon @$122/MT. (20*80.53*122/1,000,000) for ethanol sold in CA.

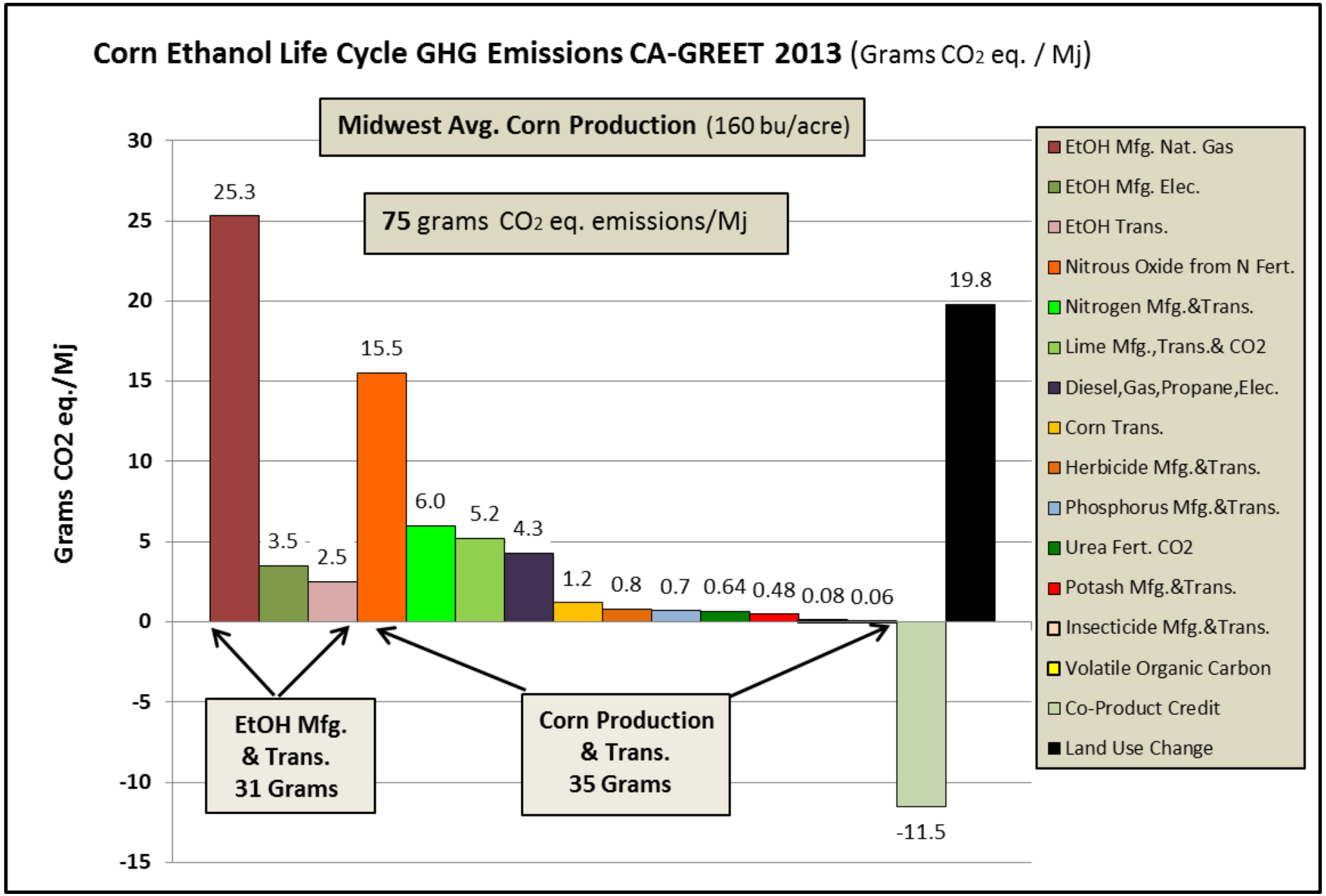
Economic Incentives for CI Reductions

- Using the GREET model……
- Each 1,000 btu/gallon reduction in NG energy use during ethanol manufacturing reduces CI by .9 grams
- Each .1 kWh/gallon reduction in electrical energy use during ethanol manufacturing reduces CI by 1.1 grams
- Improvements in conversion (gallons/bu) do not have a significant impact on CI. Gains in gallons per bushel are offset by losses of co-product production credit.
- Assuming $4 per mmbtu Nat Gas and $122/MT LCFS credits, the value of the LCFS credits is more than double the value of the reduction in energy use.

Corn Ethanol Carbon Intensity Accounting/Modeling – Argonne GREET Model




Corn Ethanol Life Cycle GHG Emissions GREET 2015 (Grams CO2 eq. / Mj)
Midwest Avg. Corn Production (160 bu/acre)
52 grams CO2 eq. emissions/Mj
Grams CO2 eq./Mj
30
25
20
15
10
5
0
-5
-10
-15
24
3.5
2.9
14
5.7
4.3
3.2
1.2
0.8
0.7
0.64
0.48
0.08
0.06
3.2
-13
EtOH Mfg. & Trans. 31 Grams
Corn Production & Trans. 31 Grams
EtOH Mfg. Nat. Gas
EtOH Mfg. Elec.
EtOH Trans.
Nitrous Oxide from N Fert.
Nitrogen Mfg.&Trans.
Diesel,Gas,Propane,Elec.
Lime Mfg.,Trans.& CO2
Corn Trans.
Herbicide Mfg.&Trans.
Phosphorus Mfg.&Trans.
Urea Fert. CO2
Potash Mfg.&Trans.
Insecticide Mfg.&Trans.
Volatile Organic Carbon
Co-Product Credit
Land Use Change


Corn Ethanol Life Cycle GHG Emissions CA-GREET 2013 (Grams CO2 eq. / Mj)
Midwest Avg. Corn Production (160 bu/acre)
75 grams CO2 eq. emissions/Mj
Grams CO2 eq./Mj
30
25
20
15
10
5
0
-5
-10
-15
25.3
3.5
2.5
15.5
6.0
5.2
4.3
1.2
0.8
0.7
0.64
0.48
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19.8
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Volatile Organic Carbon
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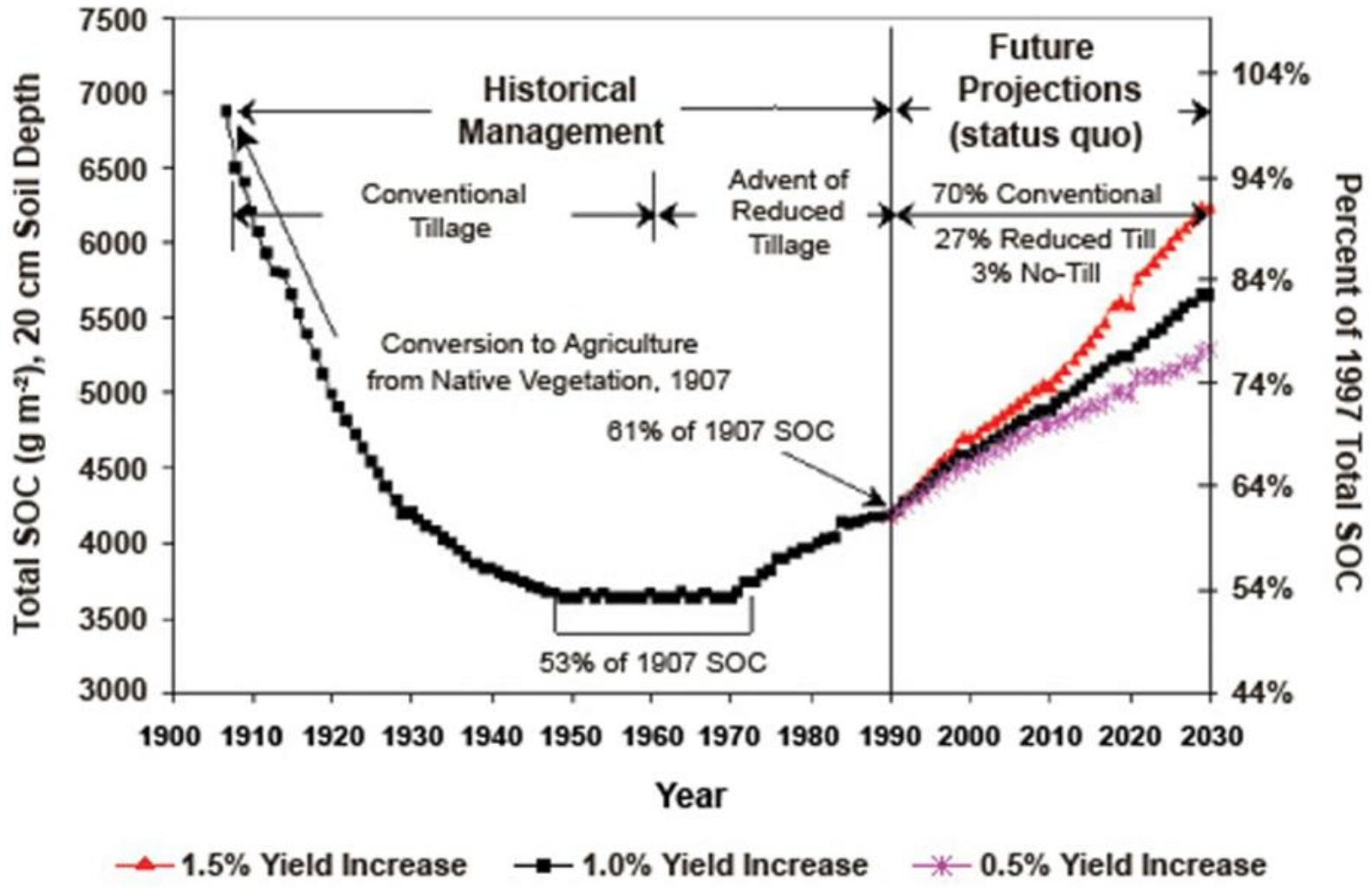
Opportunities to Reduce Corn Ethanol CI with Recent Science

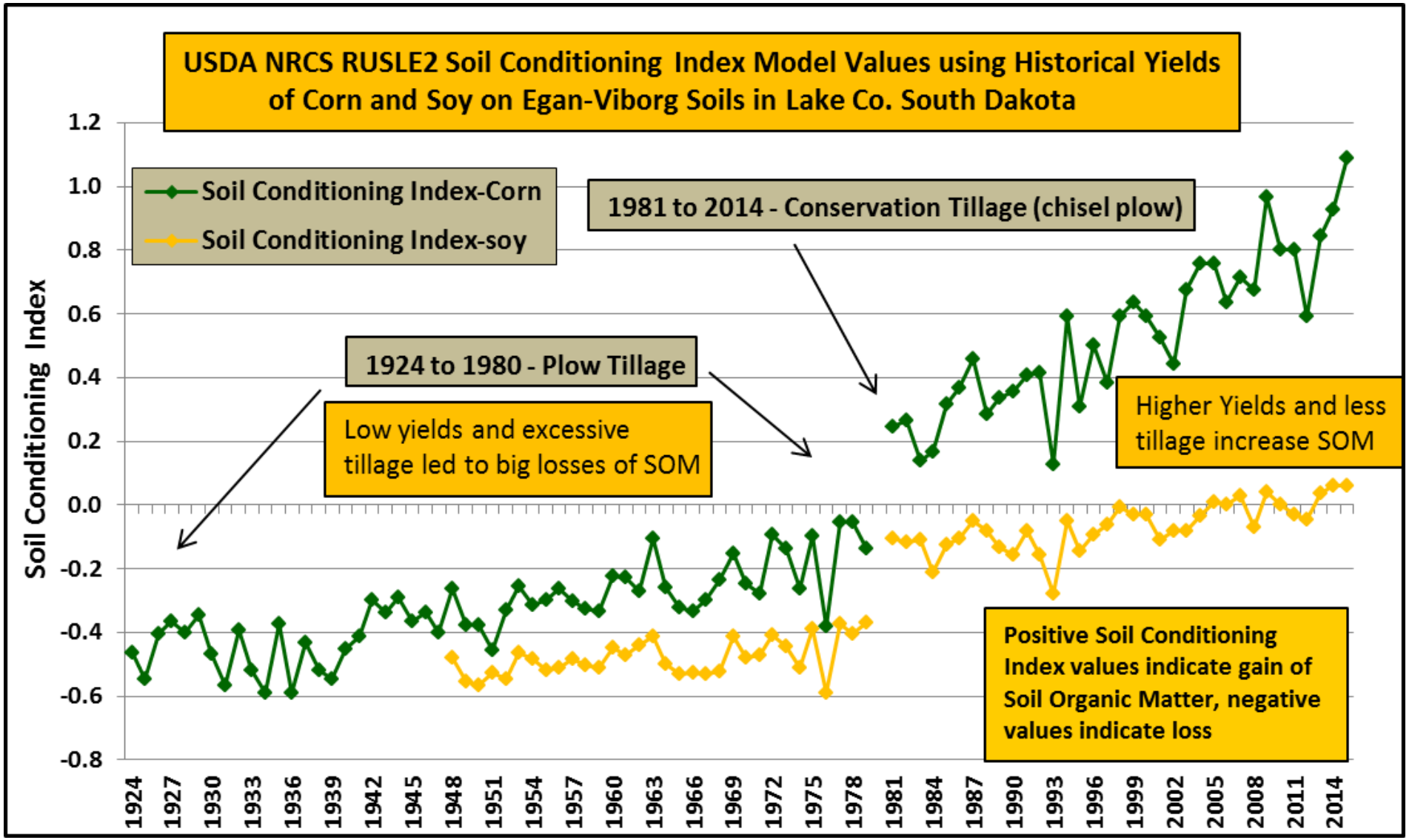
- **Soil Carbon Accounting and Nitrous Oxide Accounting**
  - **Soil Carbon accounting is not currently done by Argonne…….except in Land Use Change Calculations……..Modelers assume all biofuel crops (soy biodiesel, canola biodiesel, corn ethanol, sugar cane ethanol) have the same effect on soil carbon stocks!**
  - **Nitrous Oxide modeling currently done uses old science…..Nitrogen Use Efficiency during Corn Production has greatly improved in the past two to three decades.**

Historic Soil Carbon Stock Loss, and Now Gains

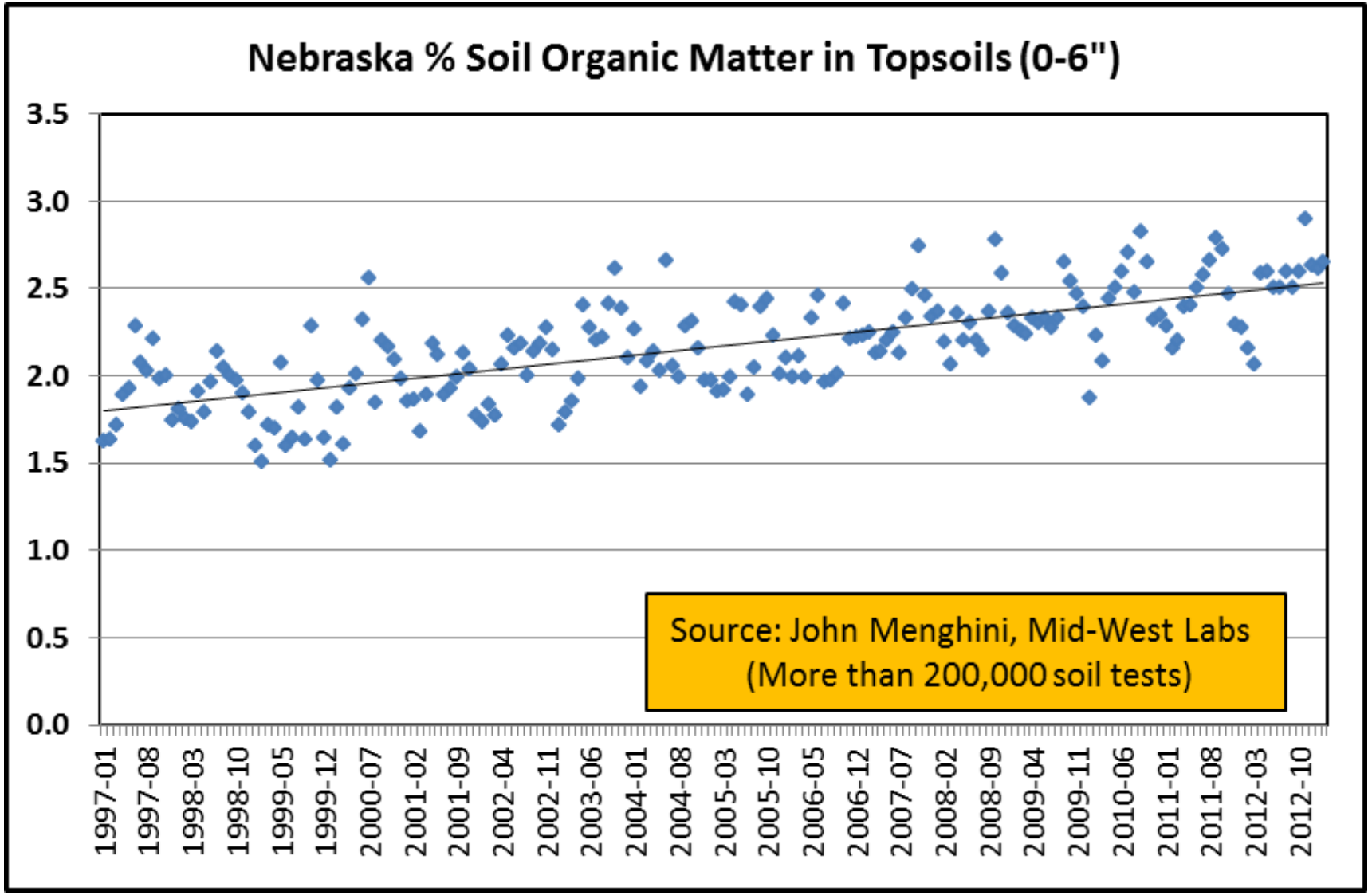


Source: Dr. Rattan Lal, Ohio State University Soil Science Dept.

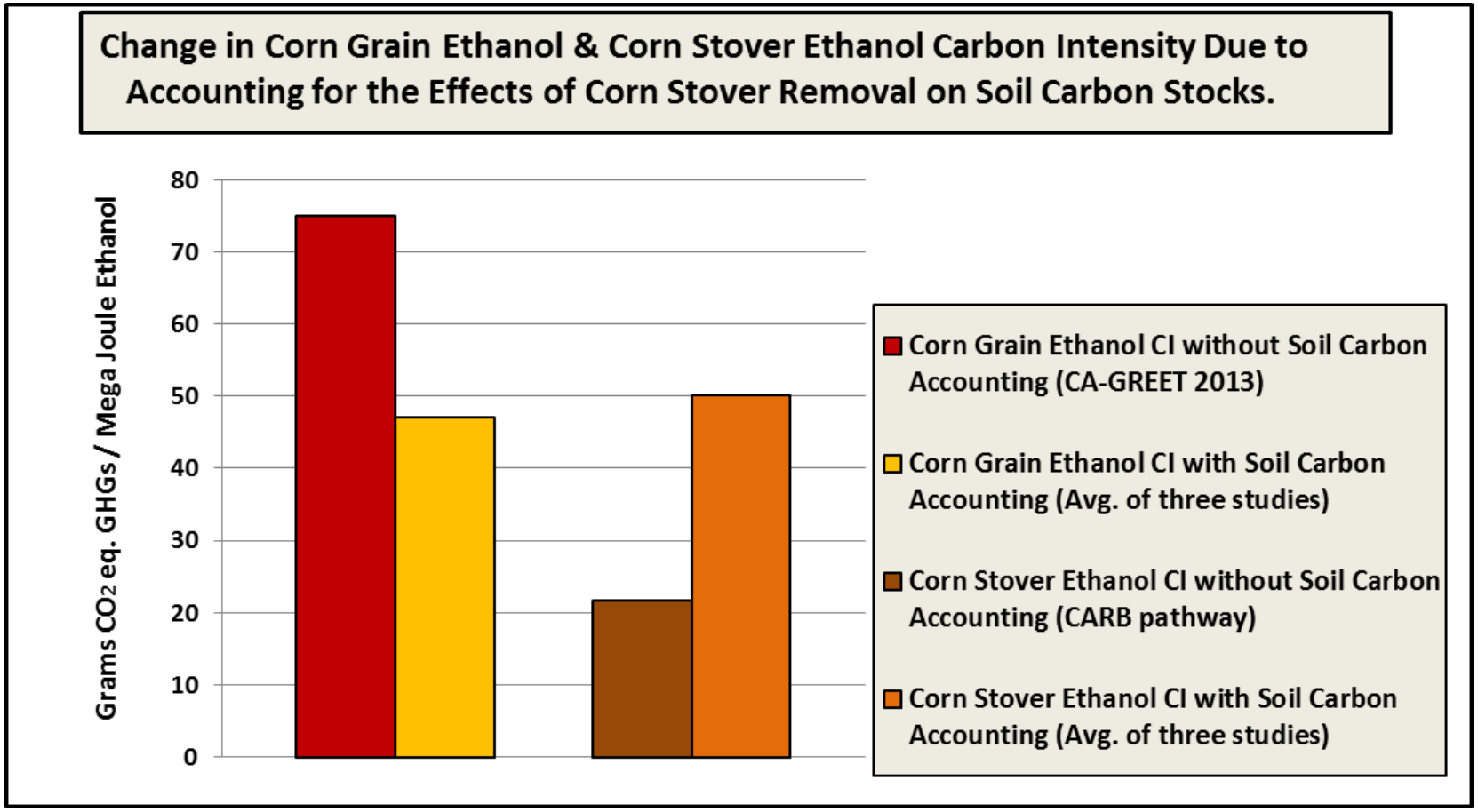
What do Soil Carbon Models Predict?



Trends in Organic Matter Content of Soil - Major Soil Testing Labs

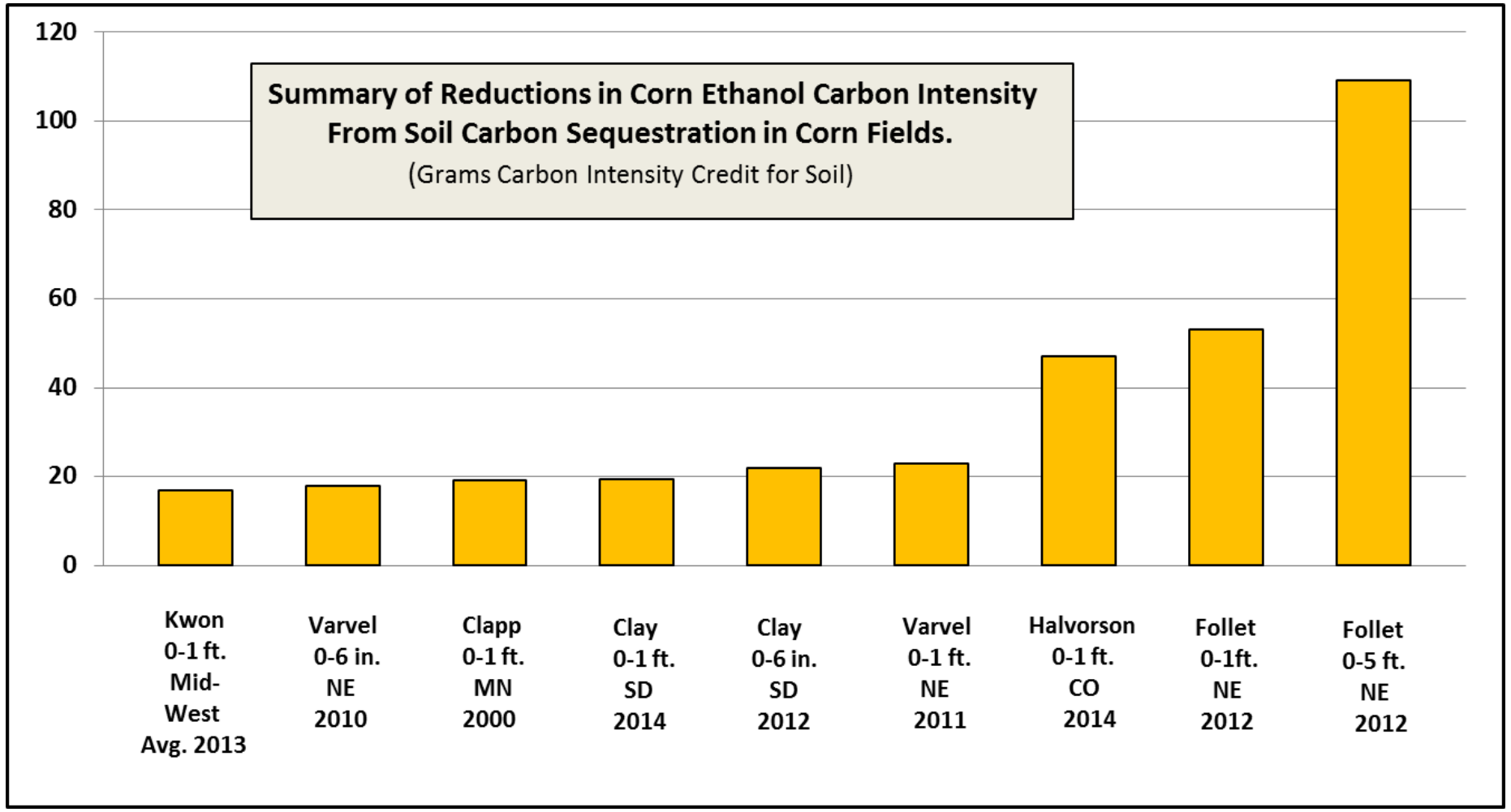


Summary of 3 Peer Reviewed Studies on the Effect of Retaining or Removing Stover on Soil Carbon Stocks, and the Effect that Change in Soil Carbon Stocks has on Life Cycle GHG Emissions of Corn Grain Ethanol and Corn Stover Cellulosic Ethanol produced from those fields



Corn Ethanol get all the gasses, Corn Stover Ethanol gets all the Glory!….without Proper Modeling

Nine Peer Reviewed Corn Soil Carbon studies average CI credit is more than 30 grams!



Bottom Line: Corn Ethanol is at a disadvantage in Low Carbon Markets because Argonne, CARB, and the U.S. EPA do not consider/account for Corn's effect on Soil Carbon Stocks !

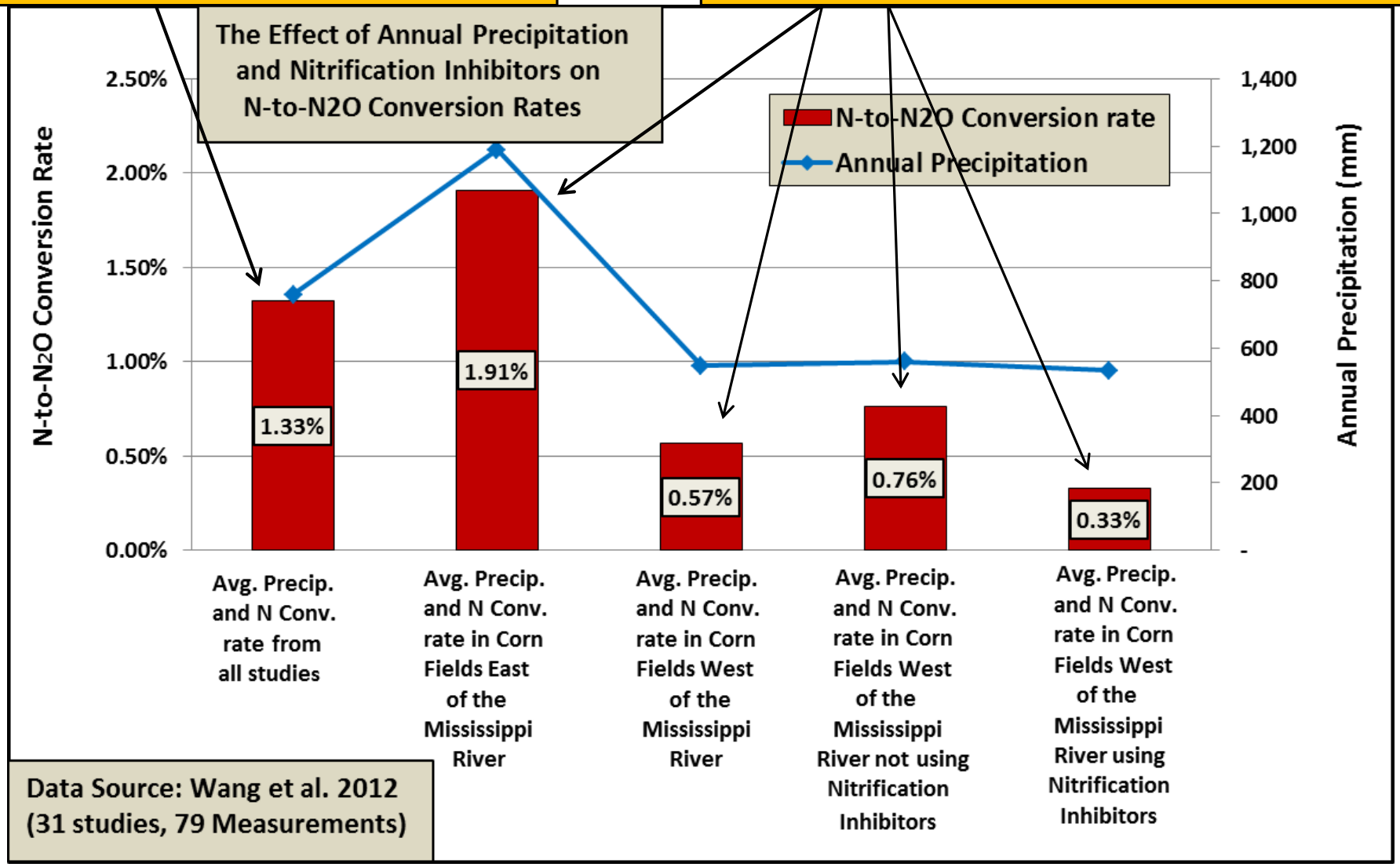
Nitrous Oxide Modeling / Accounting

- **CARB and Argonne's GREET Model Assumes:**
  - **1.325 % of Nitrogen Applied to Corn converts to Nitrous Oxide Gas, a powerful GHG (265X CO_2).**
  - **1.325% of the Nitrogen Content of Corn Stover also converts to Nitrous Oxide.**
  - **30% of Applied Nitrogen is Leached from Corn Fields and 1% of that Leached N converts to Nitrous Oxide.**
  - **All these assumptions are based on 1980 – 1990 data**

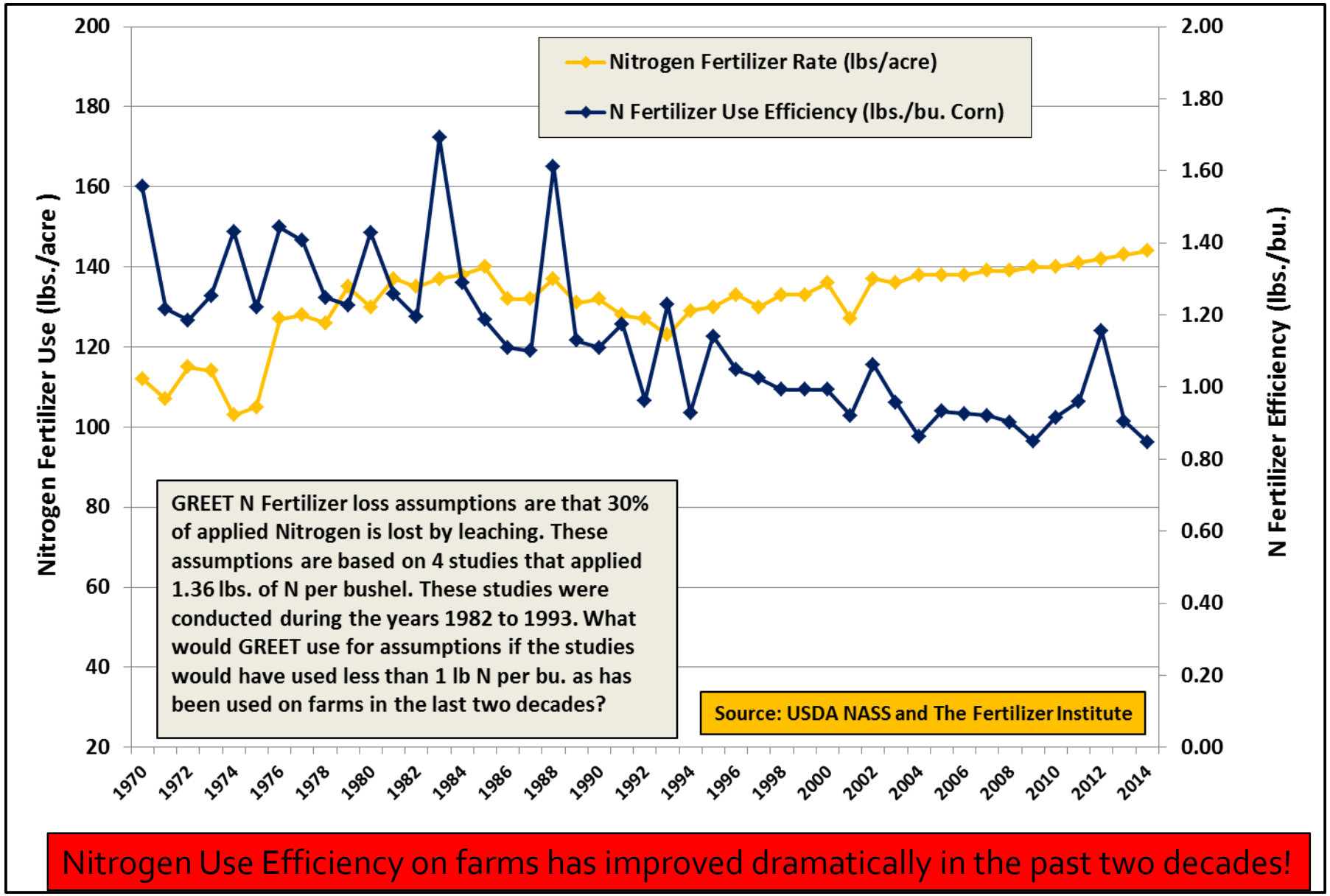
How did Argonne Determine the N to N2O Conversion Rate?

Argonne's Literature Review Results

Additional Analysis of Argonne's Literature Review

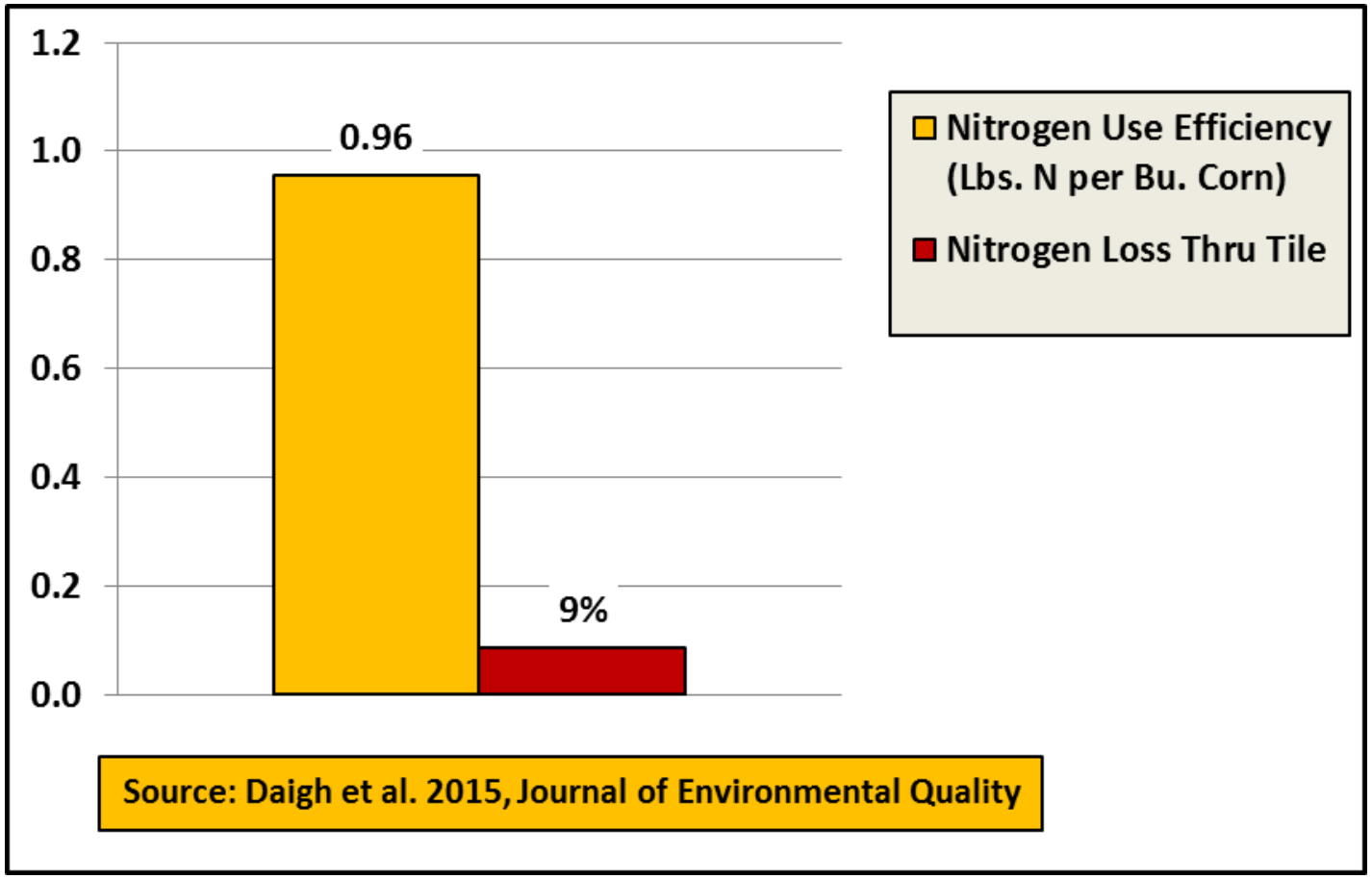


Historic Nitrogen Use and Efficiency on Corn



A Recent Four Year Study in Central Iowa on NUE and N Loss

(worse case scenario…high N rates, high rainfall, 100% pattern tiled)



Nitrogen losses thru tile have been reduced dramatically in the past 3 decades!

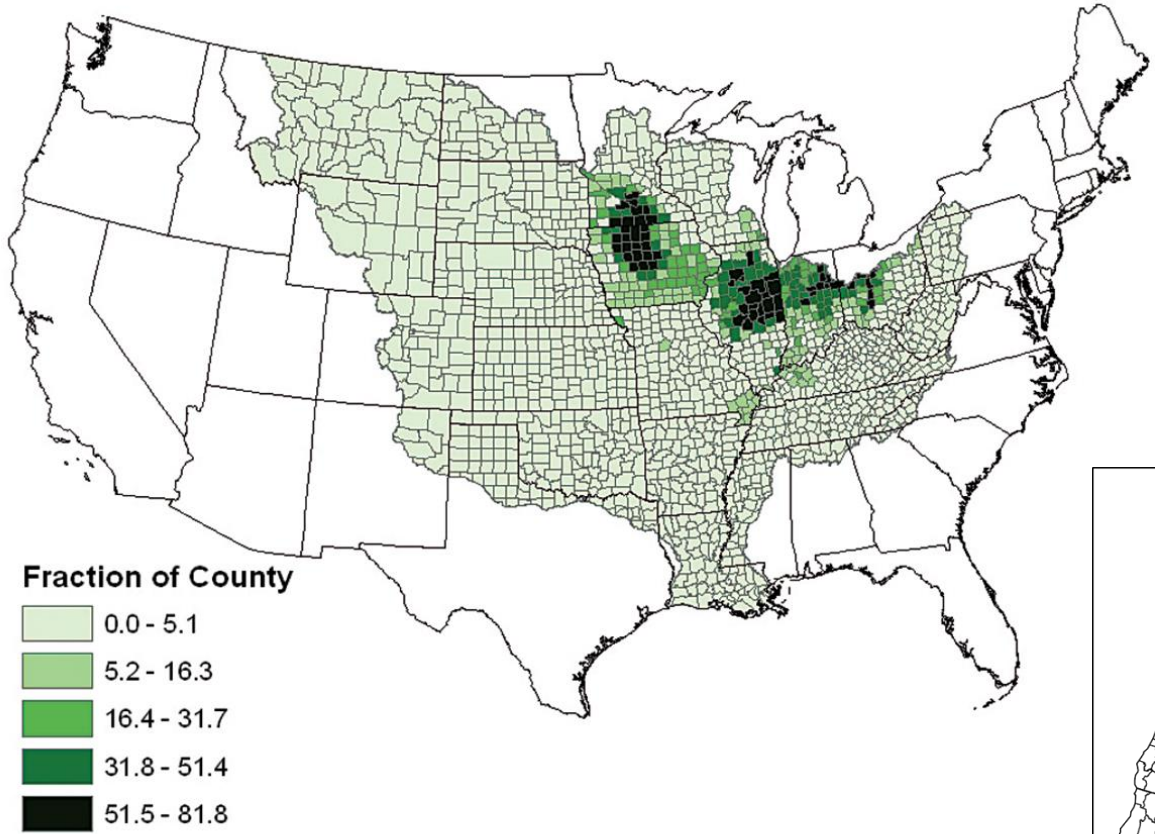
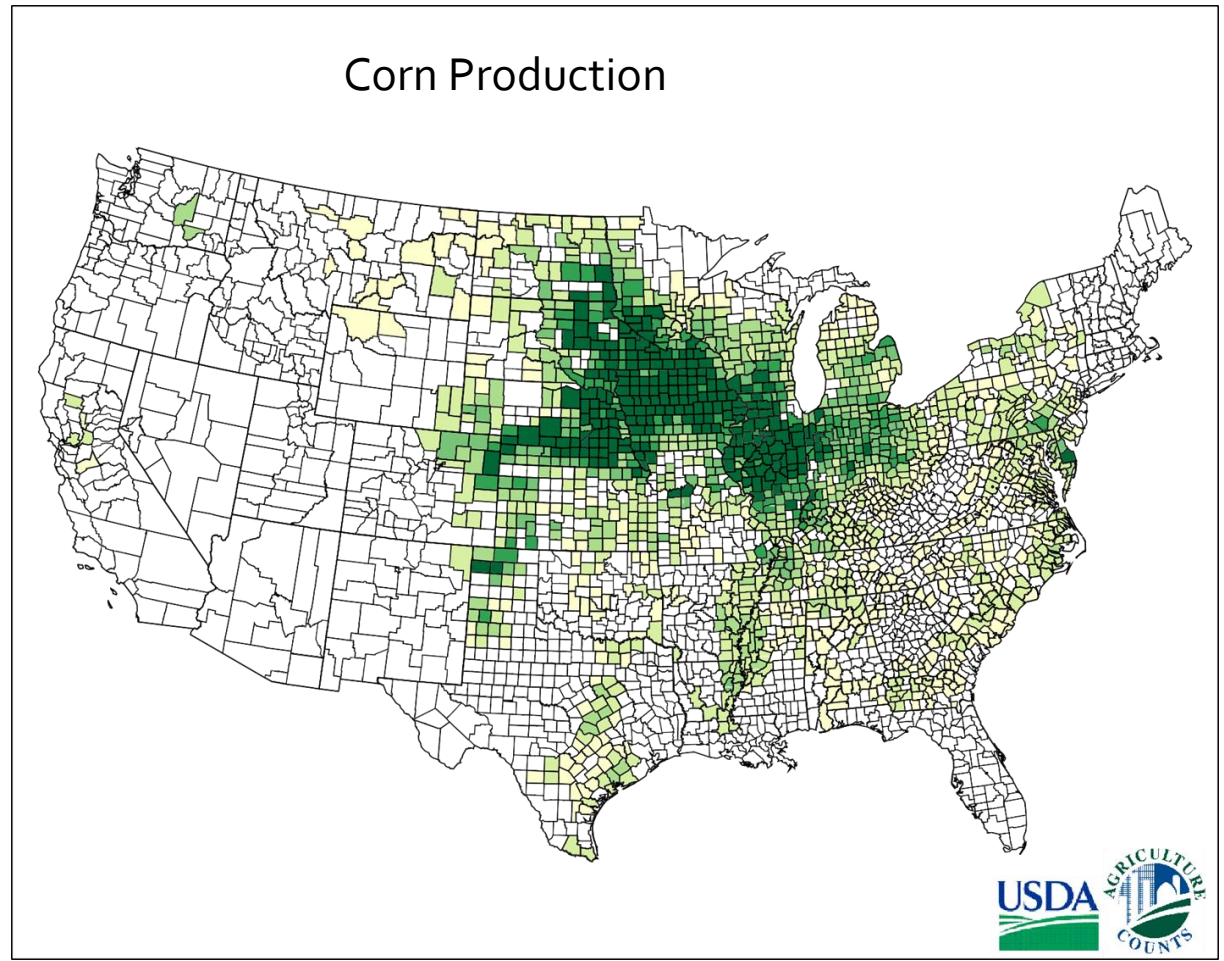
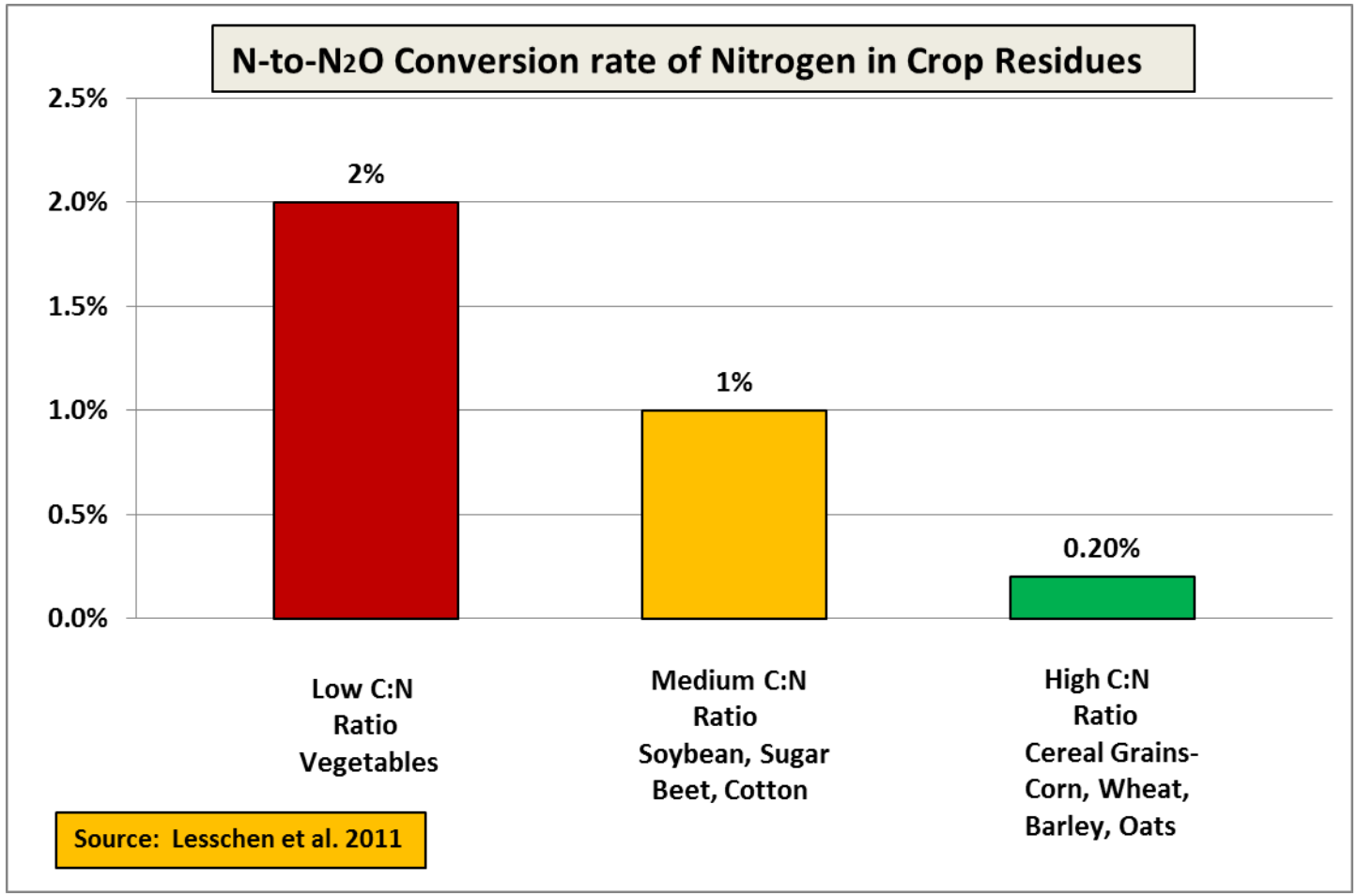


Fig. 5. Fraction of county area that is tile drained in the Mississippi River basin.



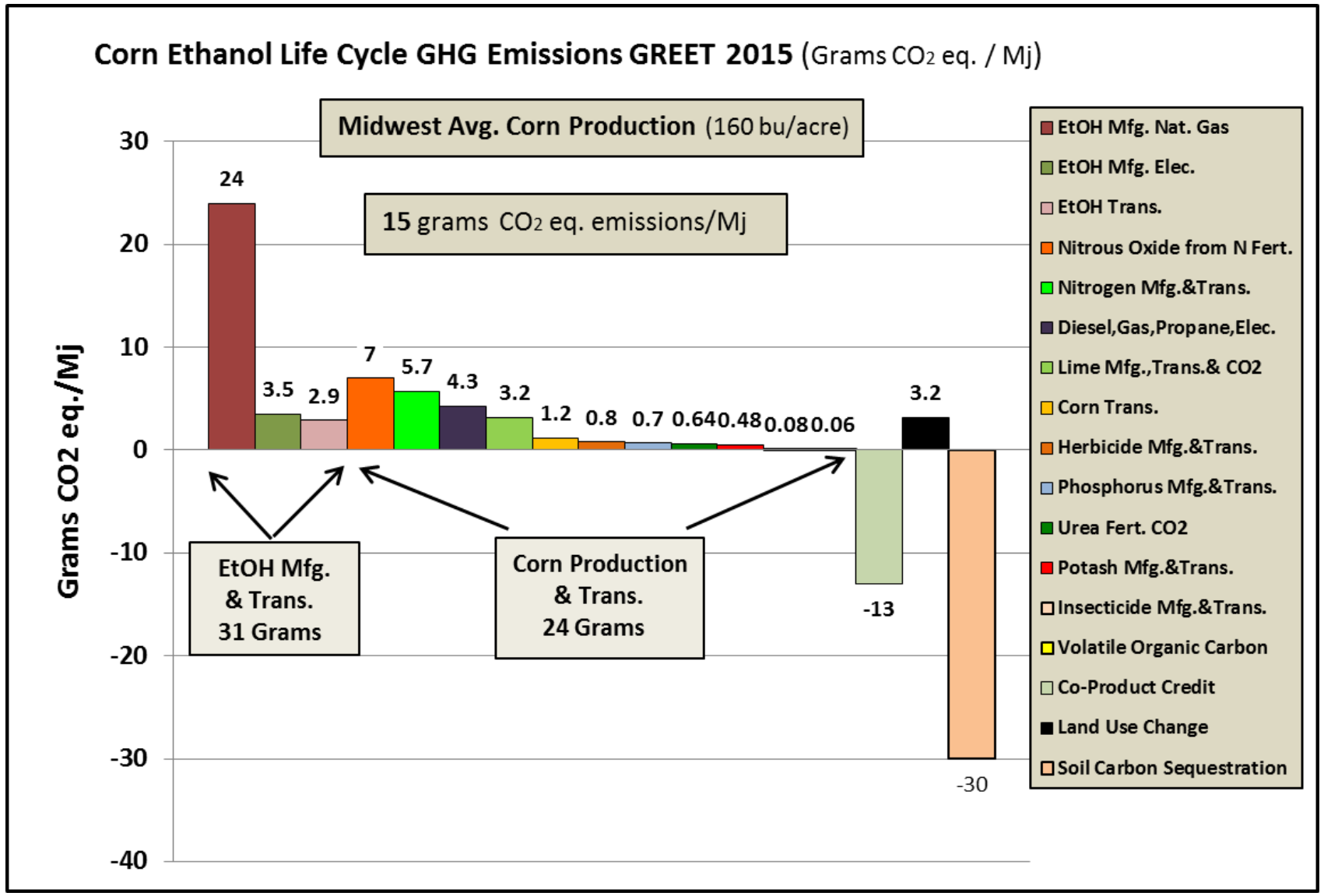
Nitrogen in Corn Stover has a low N-to-N2O conversion rate



Summary of Nitrous Oxide Emissions Reductions

- Nitrogen fertilizer leaching losses used to be 30%……recent science indicates a 5% average corn belt wide loss
- N-to-N2O conversion rates average 1.325%……a regional precipitation weighted corn belt average indicates .9%
- N-to-N2O conversion rate of N in corn stover is far less than 1.325%…..science says .2%
- Nitrous Oxide Emissions should be **7** grams CI, rather than the **14** g that is currently modeled in GREET

Corn Ethanol's Carbon Intensity would be only 15 grams if the Modeling/Accounting was done using the latest science!



SUMMARY

- Expanding Low Carbon Fuel Markets offer Opportunities for Ethanol Producers and Corn Producers
- Incentives to reduce Carbon Intensity can be Large – up to $.50 per gallon!
- Ethanol Plants and Corn Producers have dramatically Reduced Energy Use and GHG Emissions
- GHG Modelers must update their accounting with the latest science that reflects the efficiency of modern Corn Production