



Ethanol Sustainability: Using Life Cycle Analysis to Design Better Futures

**Venkatesh Balan, Seungdo Kim and
Bruce E. Dale**

Michigan State University

Iowa Bio meeting

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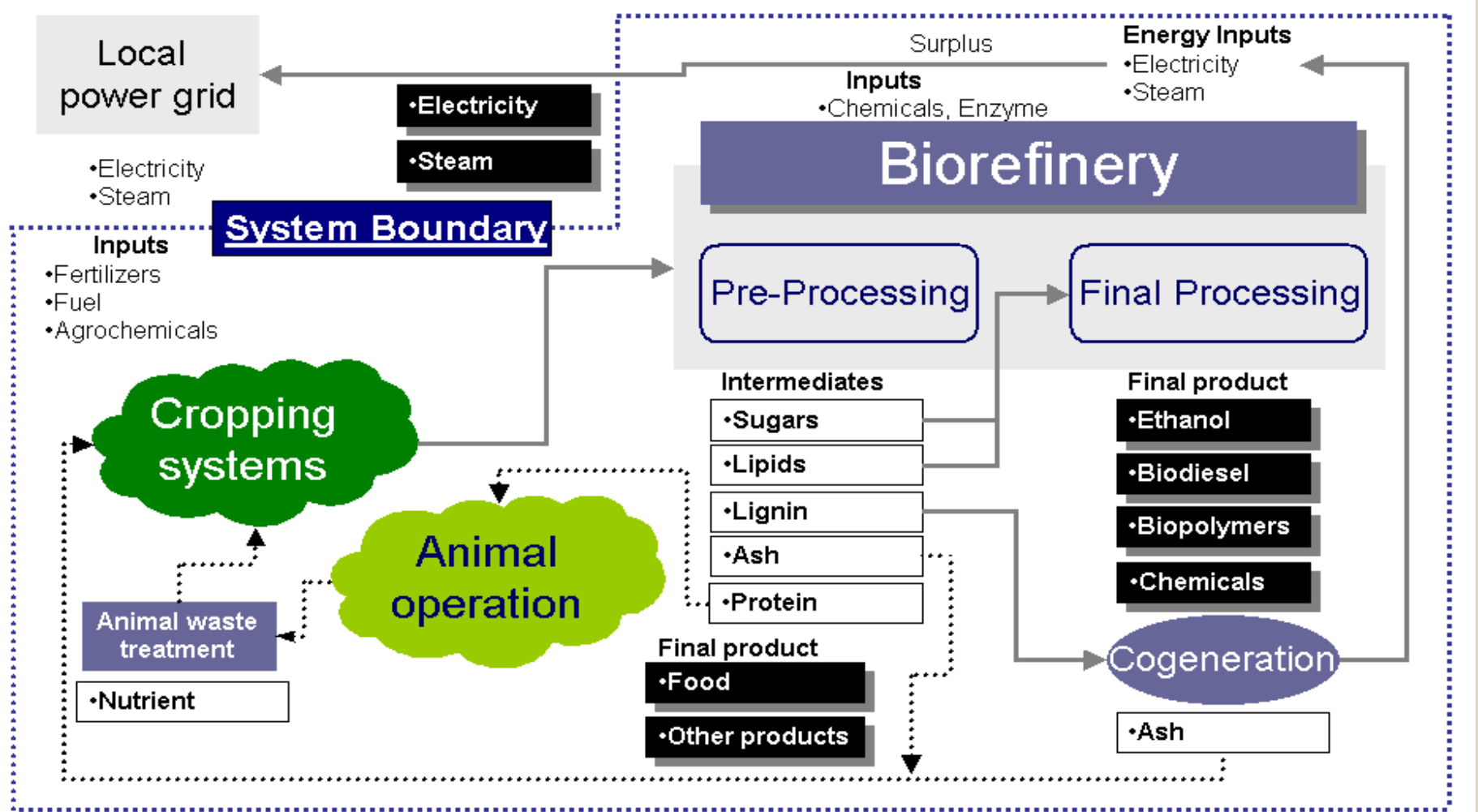


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ALL BIOMASS IS LOCAL



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Objective

- Assess/improve environmental performance of corn based ethanol production
 - Identify roles of N_2O and of carbon sequestered by soil in GHG profile
 - Nitrous oxide is ~300x more potent than CO_2 as greenhouse gas
 - Estimate local environmental effects of the ethanol fuel systems due to farming sites chosen
 - Determine the effects of different agricultural management practices, eg. cover crops, for reducing nitrogen losses from soil during corn cultivation
 - Assessment includes agricultural phase, biorefinery phase and ethanol use phase: “well to wheels”



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Farming sites

- 38 counties in eight states (Indiana, Illinois, Iowa, Michigan, Minnesota, Missouri, Nebraska and South Dakota)
 - To determine soil organic carbon and soil nitrogen dynamics in corn & corn-soybean cultivation
- Eight counties are chosen
 - To determine soil organic carbon and soil nitrogen dynamics in other cropping systems
 - To estimate environmental performance of the ethanol application system.
 - Each county has existing ethanol plant
- We report on four of these counties today (lots of data—but trends are similar for most cases)
- We have similar data on soy biodiesel—not enough time today to report it—will be in the paper

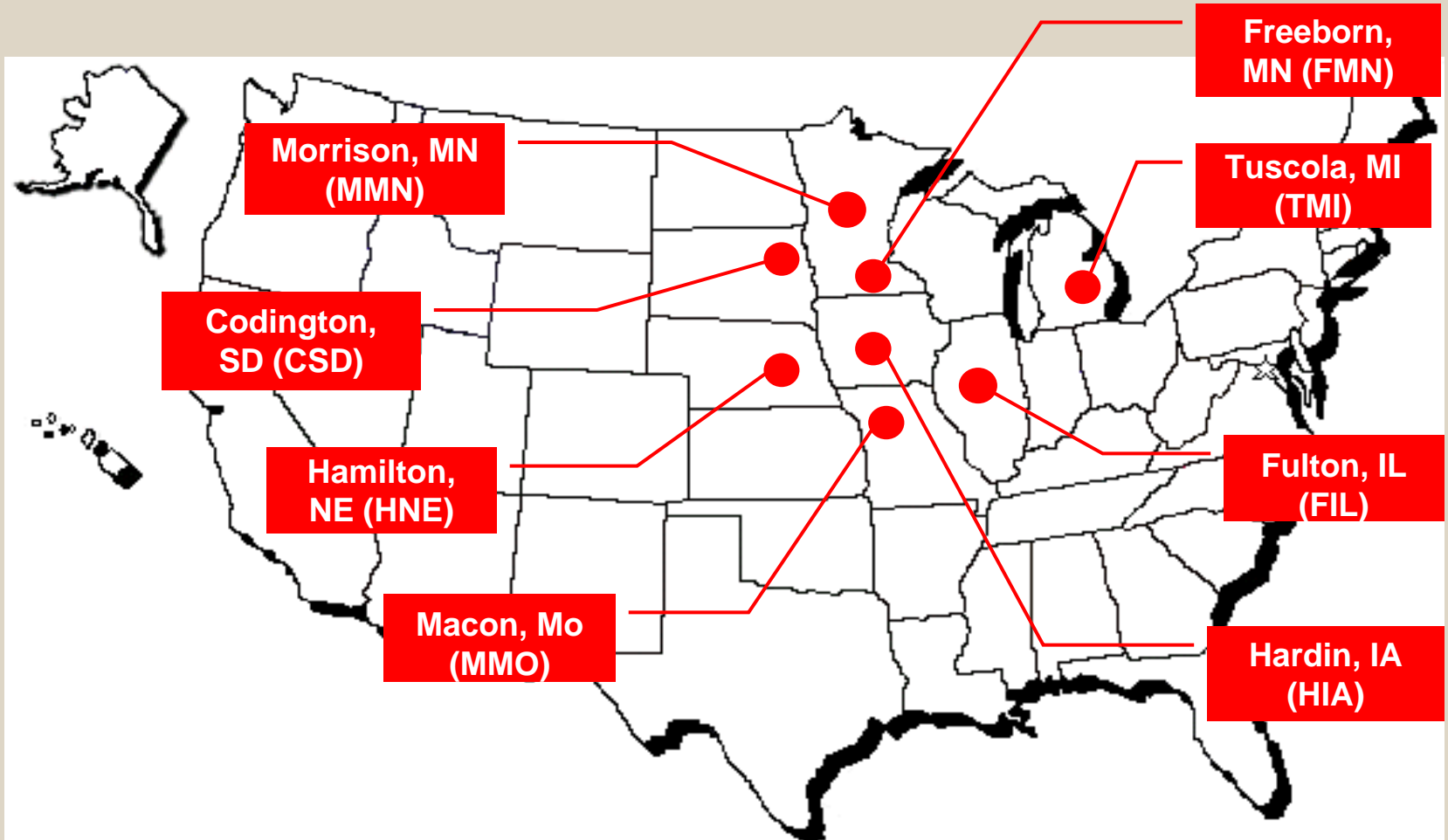


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Ethanol Plants



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Soil Organic Carbon and Nitrogen Dynamics

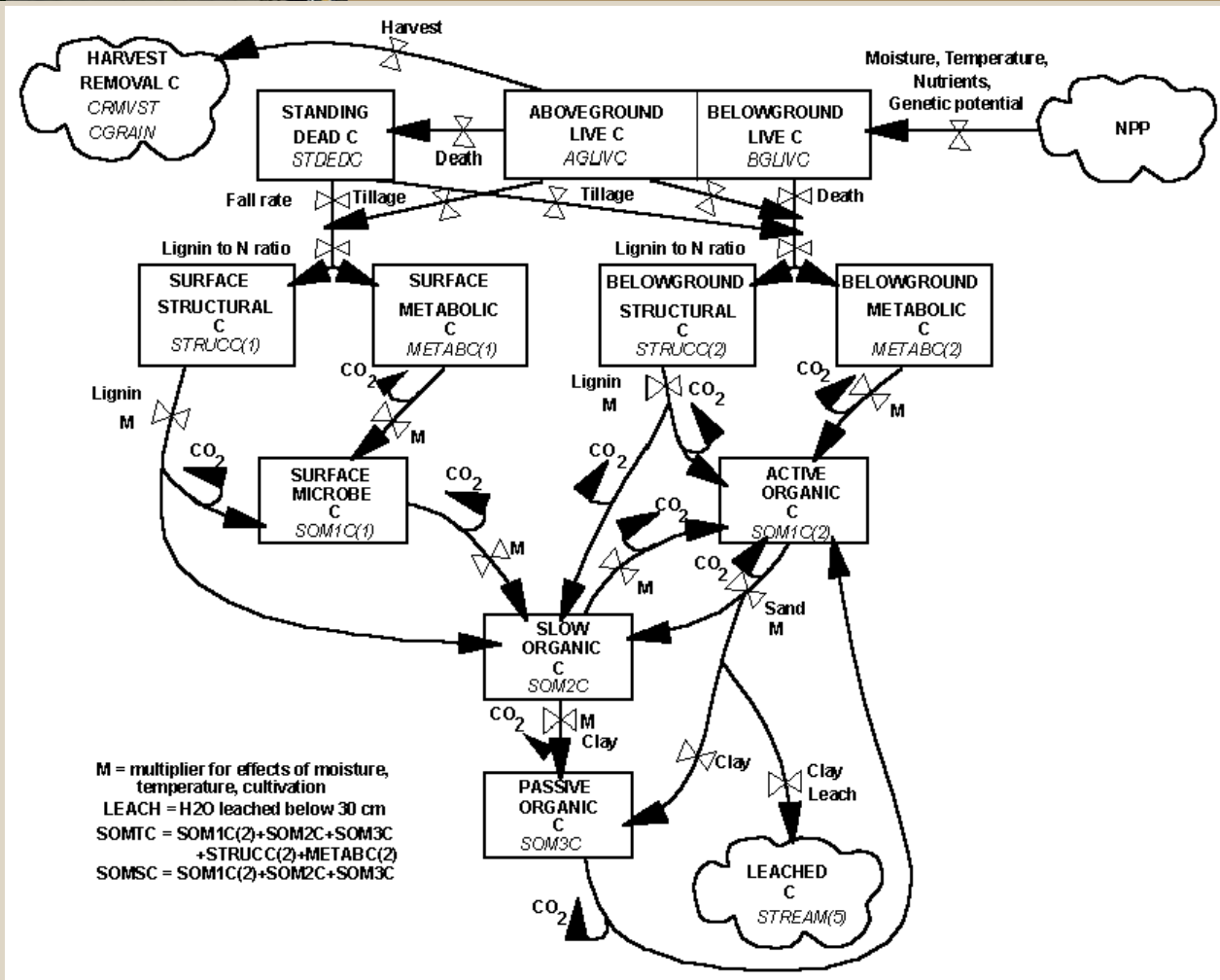
- Simulated by the DAYCENT model
 - Predicting
 - Soil organic carbon level
 - N_2O and NO_x emissions from soil, NO_3^- leaching
 - Information required
 - County-based soil textures
 - clay, slit, sand
 - County-based data
 - Daily maximum and minimum temperature
 - Daily precipitation
 - Cropping management
 - Tillage, application rate of nitrogen fertilizer, irrigation, etc



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Soil Organic Carbon Sub model



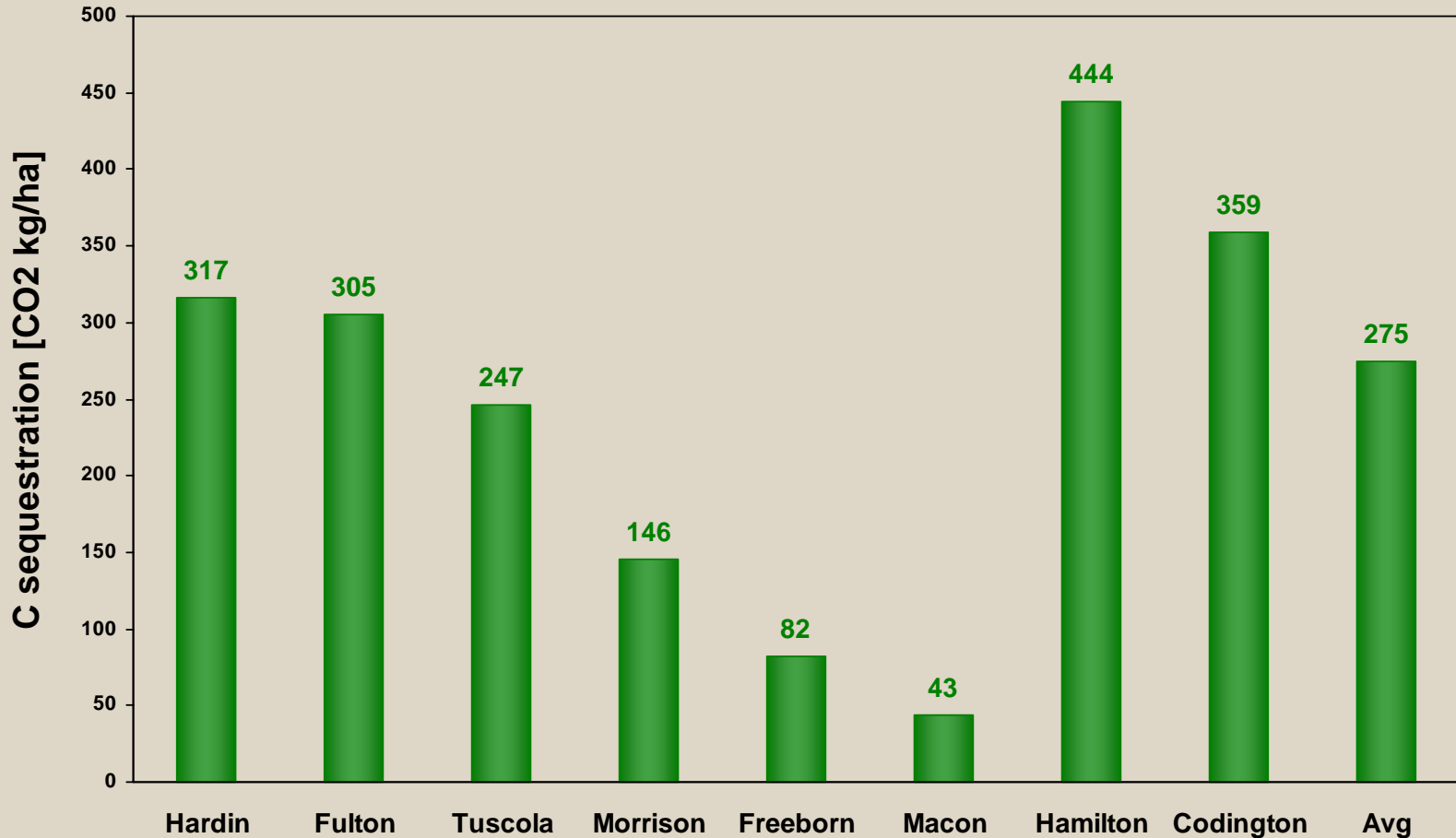
Source: Natural Resource Ecology Laboratory, Century soil organic matter model: user's guide and reference, Colorado State University

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Overall Carbon Sequestration* in Corn & Soybean Agriculture



* Current tillage & rotation practices- “averages” are **simply inadequate** to represent system



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Improving the Sustainability of Biofuels: Corn Stover Removal & Cover Crops

- We want to harvest corn residue (stover) to make cellulosic ethanol & improve farmer profits
- However, corn stover removal will tend to reduce soil organic matter (soil fertility) & increase soil erosion
- **This is not the right direction to be heading...**
- *Can we find a way to remove stover sustainably?*
- **Use winter cover crop**
 - Plant cover crop (cool season grass: wheat, rye, oats) after corn harvest
 - Cover crop grows rapidly in spring, takes up excess soil nitrogen & phosphorus
 - Kill or plow under cover crop before planting next corn crop
 - Or harvest cover crop as biofuel feedstock- we are now studying this option



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Winter Cover Crops in Corn Rotation



Winter cover crop
May 5, 2005 Holt, MI



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Bare Corn Field- Holt, Michigan

May 5, 2005



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Cropping Systems

- No corn stover removal
 - Continuous corn culture [denoted by **CC**]
 - Corn-soybean culture [denoted by **CS**]: Soybeans are also utilized in biofuel system (biodiesel).
- Corn stover removal
 - Continuous corn culture (Harvesting 50 % of corn stover) [denoted by **CC50**]
 - Continuous corn culture with winter cover crop (not harvested) (Harvesting 70 % of corn stover) [denoted by **CwC70**]
- “No tillage” practices applied (we have explored conventional tillage also—not reported today)

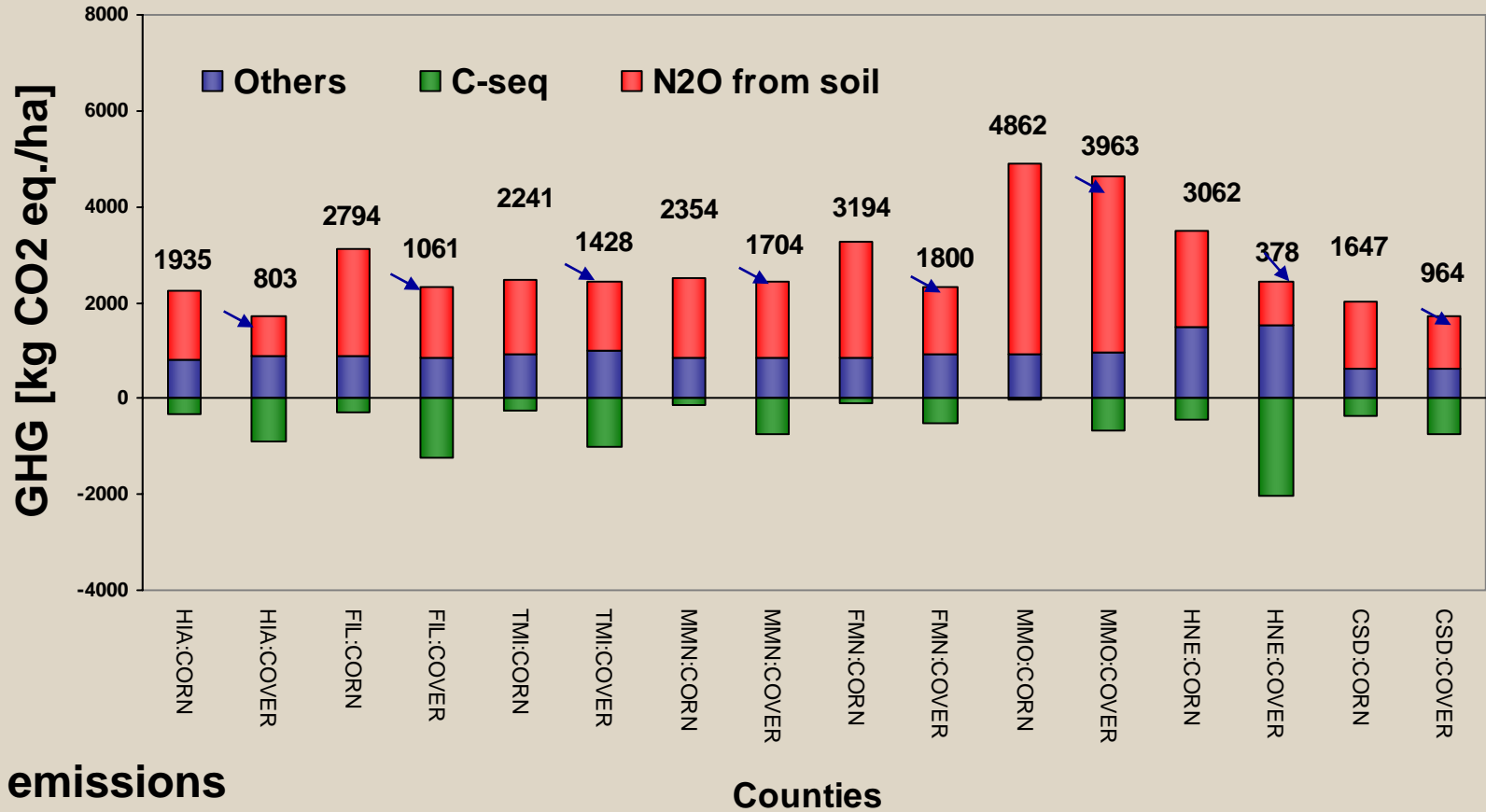


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Effects of Cover Crop in Corn System



GHG emissions

CORN: 1.6 ~ 4.8 ton CO₂ per ha

COVER: .38 ~ 3.9 ton CO₂ per ha

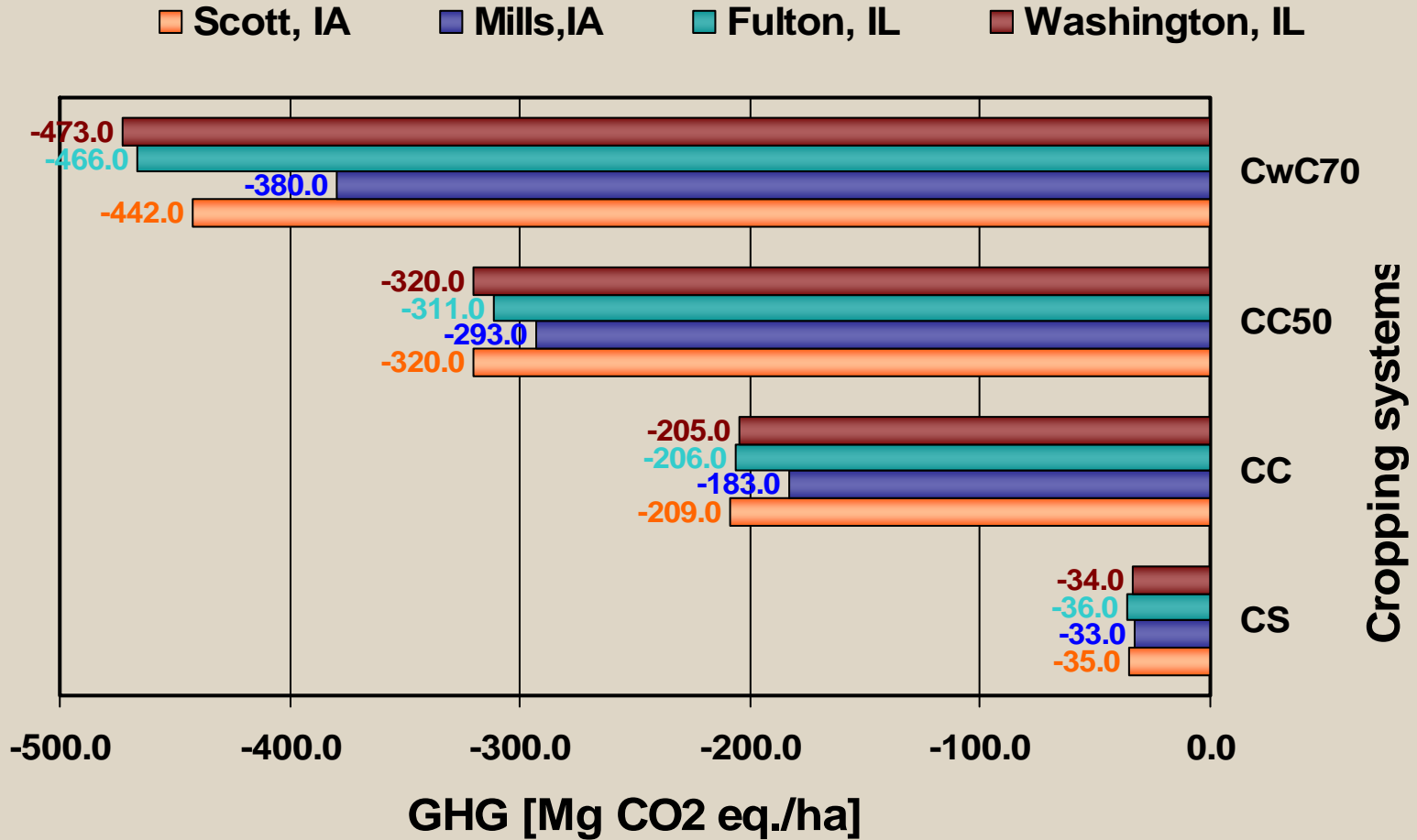


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Greenhouse Gas Emissions

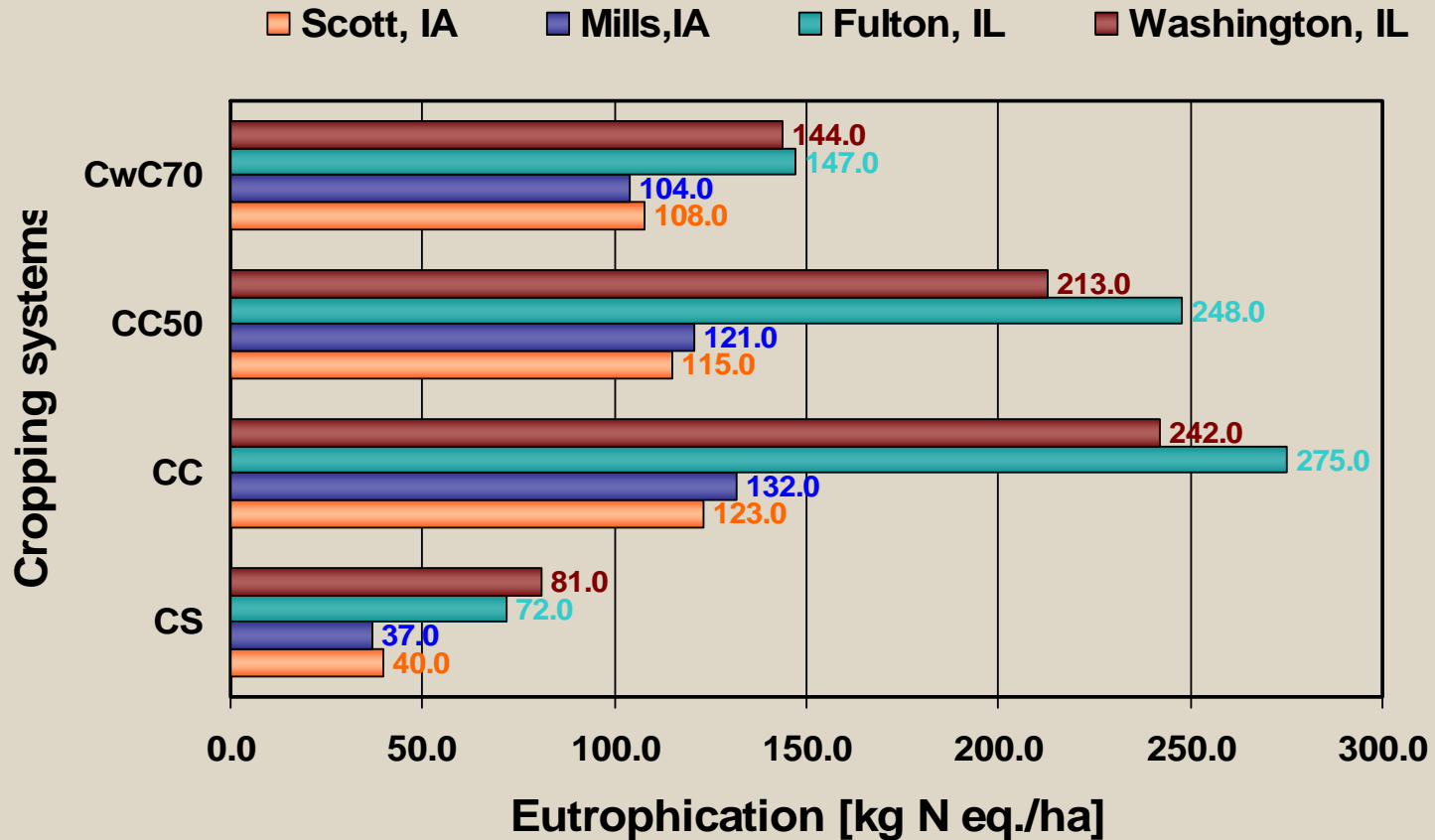


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Eutrophication

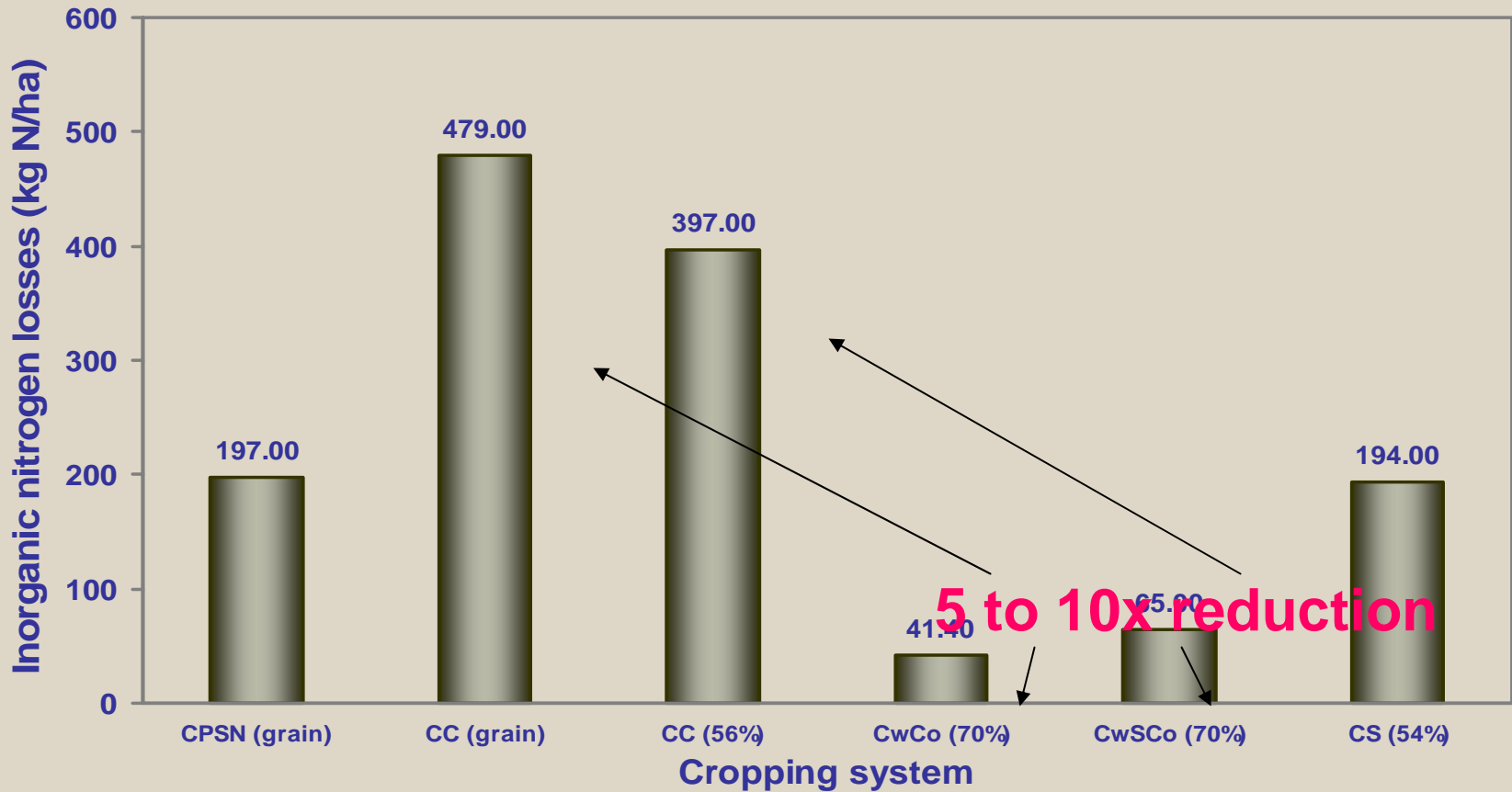


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Cover Crops Reduce Nitrogen Losses Tenfold*



*40 year time scale, Washington County, Illinois

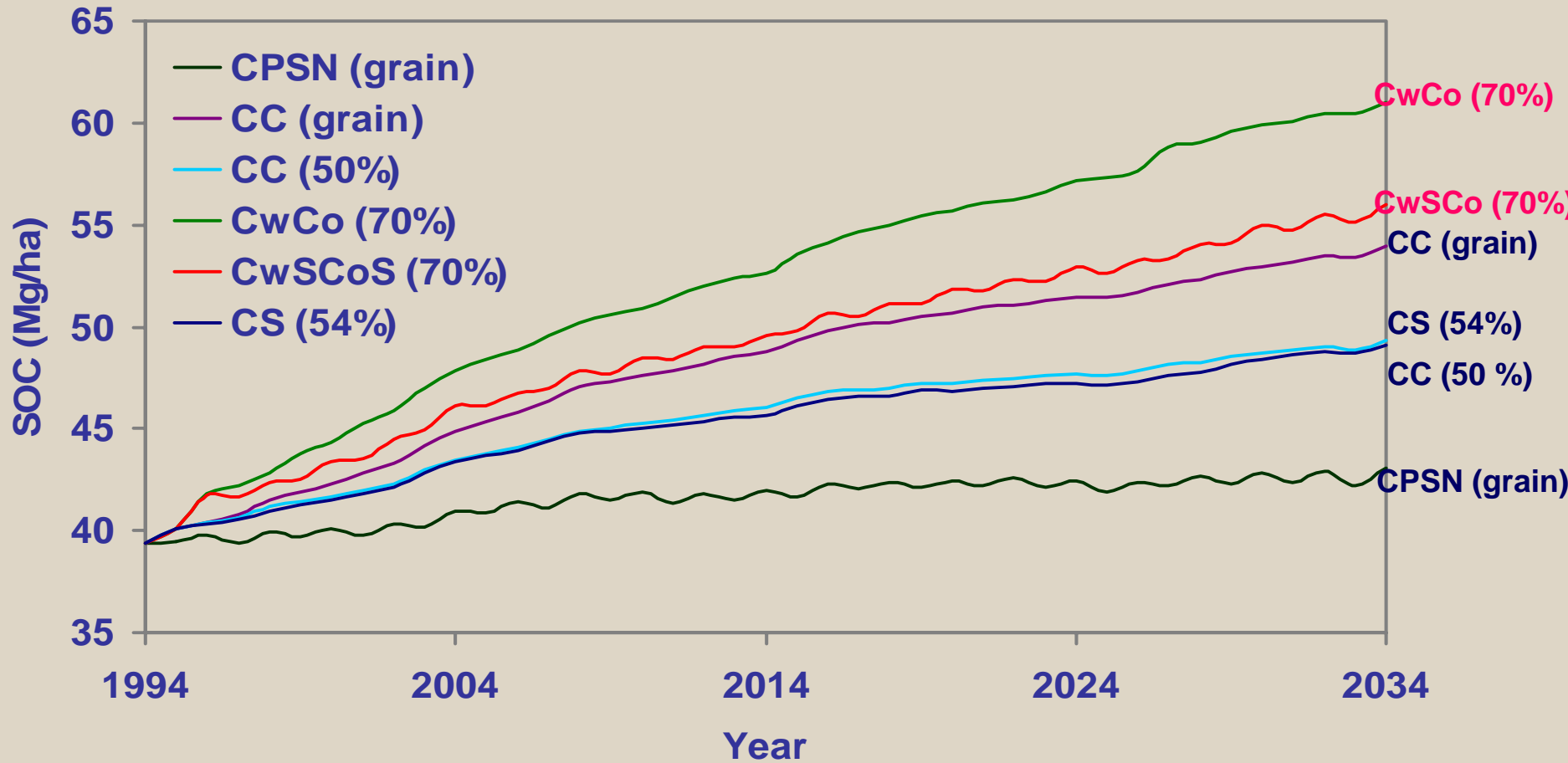


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Cover Crop **Increases** Soil Fertility While Still Removing Lots of Stover



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(A Few) Conclusions

- The agricultural subsystem dominates or strongly influences the overall environmental performance of biofuels—these effects are **highly variable & local**
- Thus agricultural practice & innovation **matter** for the environmental performance of biofuels
- Biofuels are not always environmentally superior to their petroleum-derived counterparts (for all environmental metrics)
- Biofuels tend to do worse for regional environmental impacts (acidification & eutrophication)
- Biofuel environmental performance can be **improved** by “win-win” approaches—eg. cover crops
- Biofuel environmental performance is maximized by the highest per acre production of biofuels & by careful attention to nitrogen utilization



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All Biomass Is Local

- Local conditions (farm specific conditions):
 - strongly influence ethanol fuel environmental impacts
 - these impacts vary widely with location
- *Therefore:*
 - *using averages to represent agricultural system environmental impacts is probably not justified.*
 - *location specific knowledge of these impacts is required— “all biomass is local”*
- We can improve the environmental performance of these systems by wise management, eg, cover crops.



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Questions ??



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