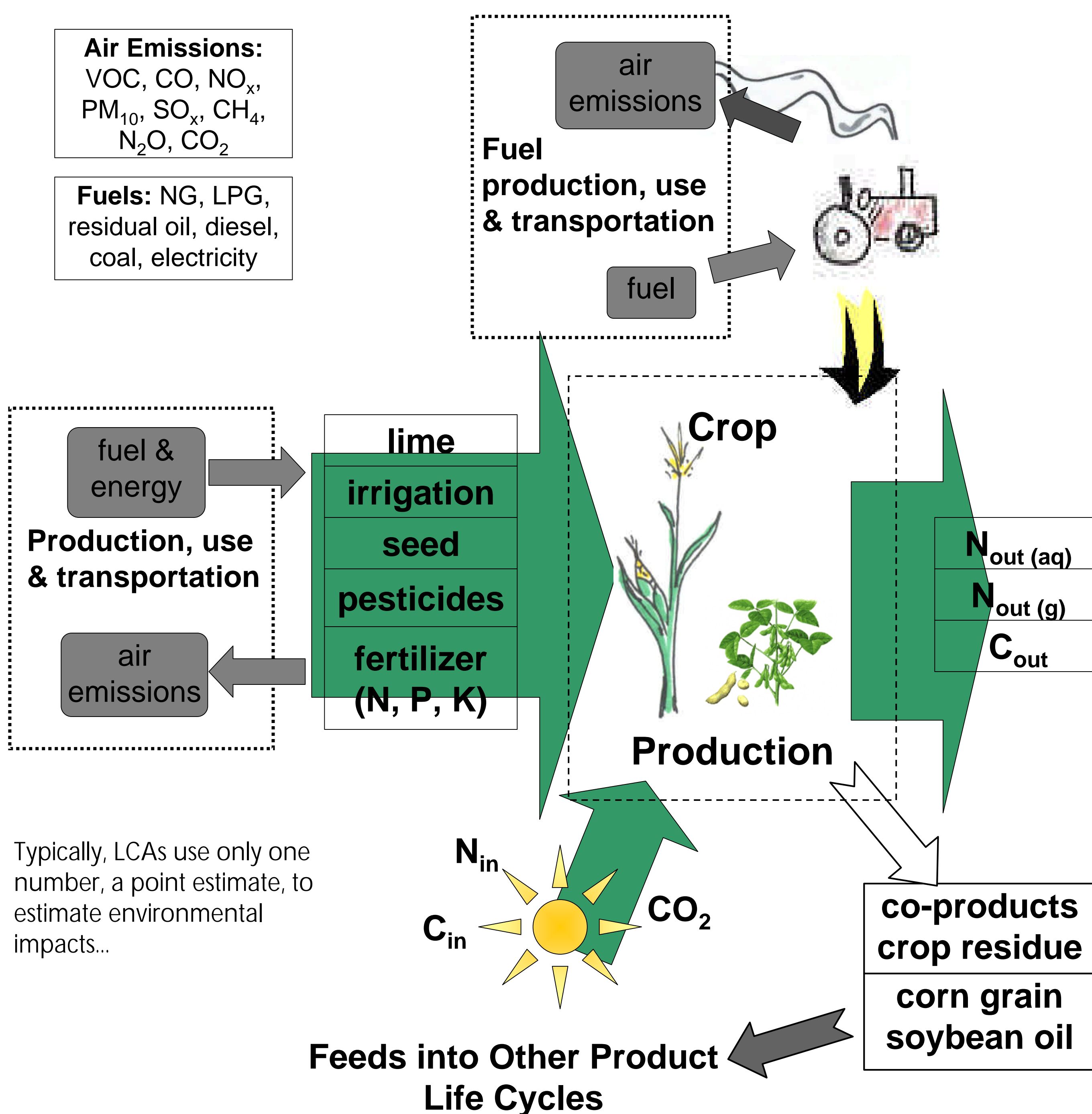


Environmental Tradeoffs of Biobased Production: The Carbon and Nitrogen Cycles

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Life Cycle Inventory Boundaries



The Carbon Cycle

The body of work surrounding bio-based production exclusively focuses on energy (fossil fuel) usage and greenhouse gas emissions during the agriculture and production stages (See Vink et al. 2003 and Gerngross & Slater 2000). Bioproducts cannot discharge more carbon than they obtain from the environment. Due to this, biocommodities are sometimes said to have "net zero" carbon emissions, but only if the fossil fuel use during farming, fertilizer processing, and oil crushing steps is neglected. The use of petroleum products for agricultural needs is significant and likely to remain so in the short to medium term. Some biocommodities have been shown, through preliminary energy audits, to emit more GHGs than their petroleum counterparts. For example, polyhydroxyalkanoate (PHA) biopolymer production (accounting for the entire life cycle of carbon) releases twice as many grams of CO₂ equivalent as low density polyethylene (LDPE) when oil energy is used in agriculture, processing, and production (Kurdikar et al. 2000).

The Nitrogen Cycle

The trade-off effects of other nutrient cycles, such as nitrogen, are largely ignored. These increases of anthropogenic reactive nitrogen are caused primarily by the agricultural sector

- >75% of anthropogenic nitrogen present in the environment is due to food production
- >71% of fertilizer is lost to the air or water through inefficient application methods

The excessive fossil energy requirements for Nitrogen fertilizer production result in higher nitrogen and CO₂ emissions for the agriculture stage. Nitrogen production and application for corn growing purposes causes 40% of total CO₂ emissions from agriculture and corn transportation while 41% of energy consumed in agriculture is devoted to nitrogen fertilizer production.

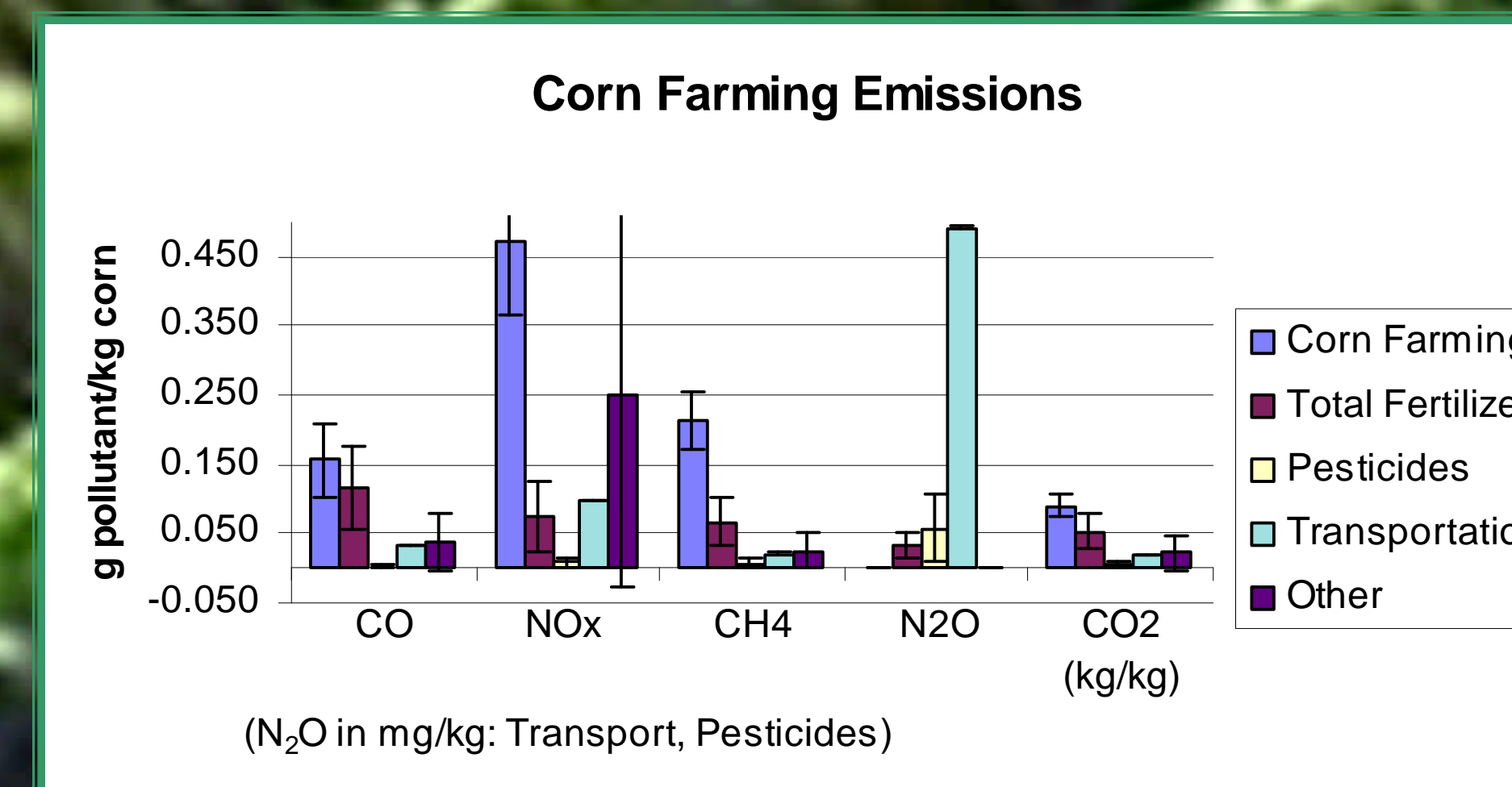
Environmental Impacts:

Carbon: global warming, changing sea levels, and extinction of some species due to altered weather conditions

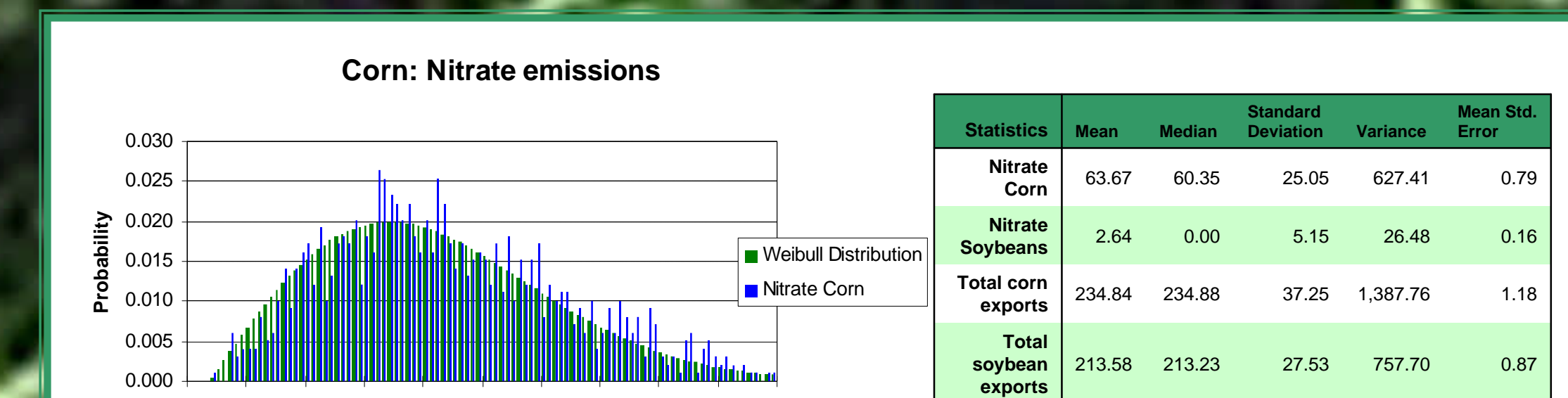
Nitrogen: acidification, eutrophication, hypoxia, global climate change, particulate matter, and ozone

Upstream Air Emissions

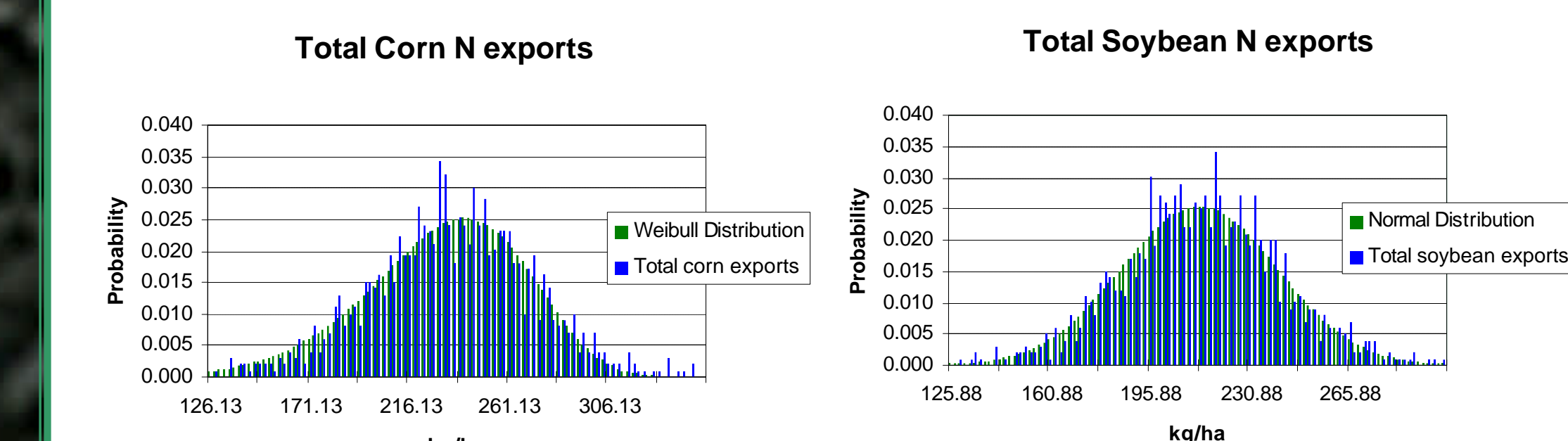
Air emissions were calculated using a modified version of the GREET 1.6 model (Wang 1999). (Other includes the production, transportation and use of lime, seeds and irrigation) Uncertainty bars developed through Monte Carlo simulations.



On Farm N Emissions

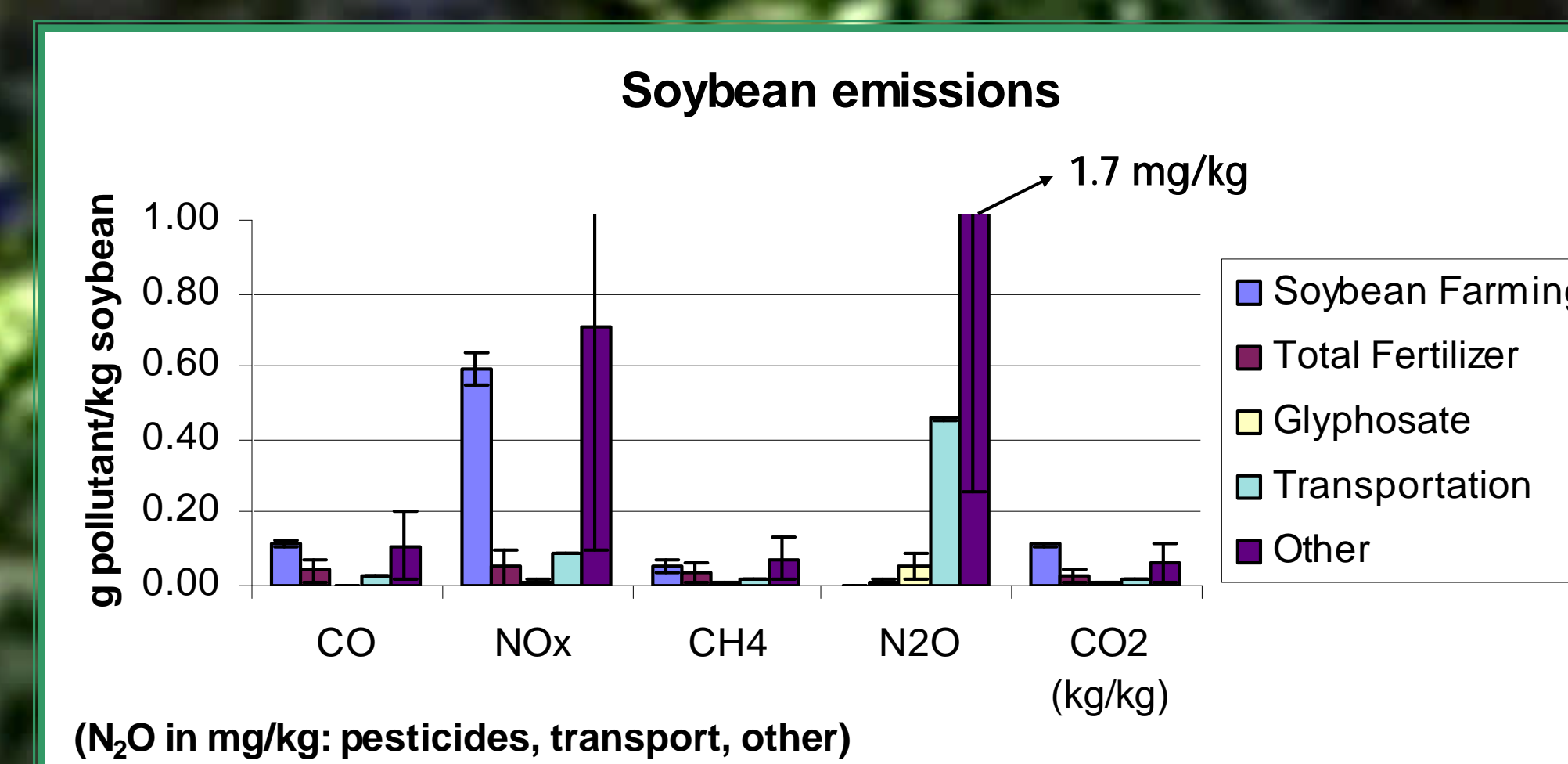
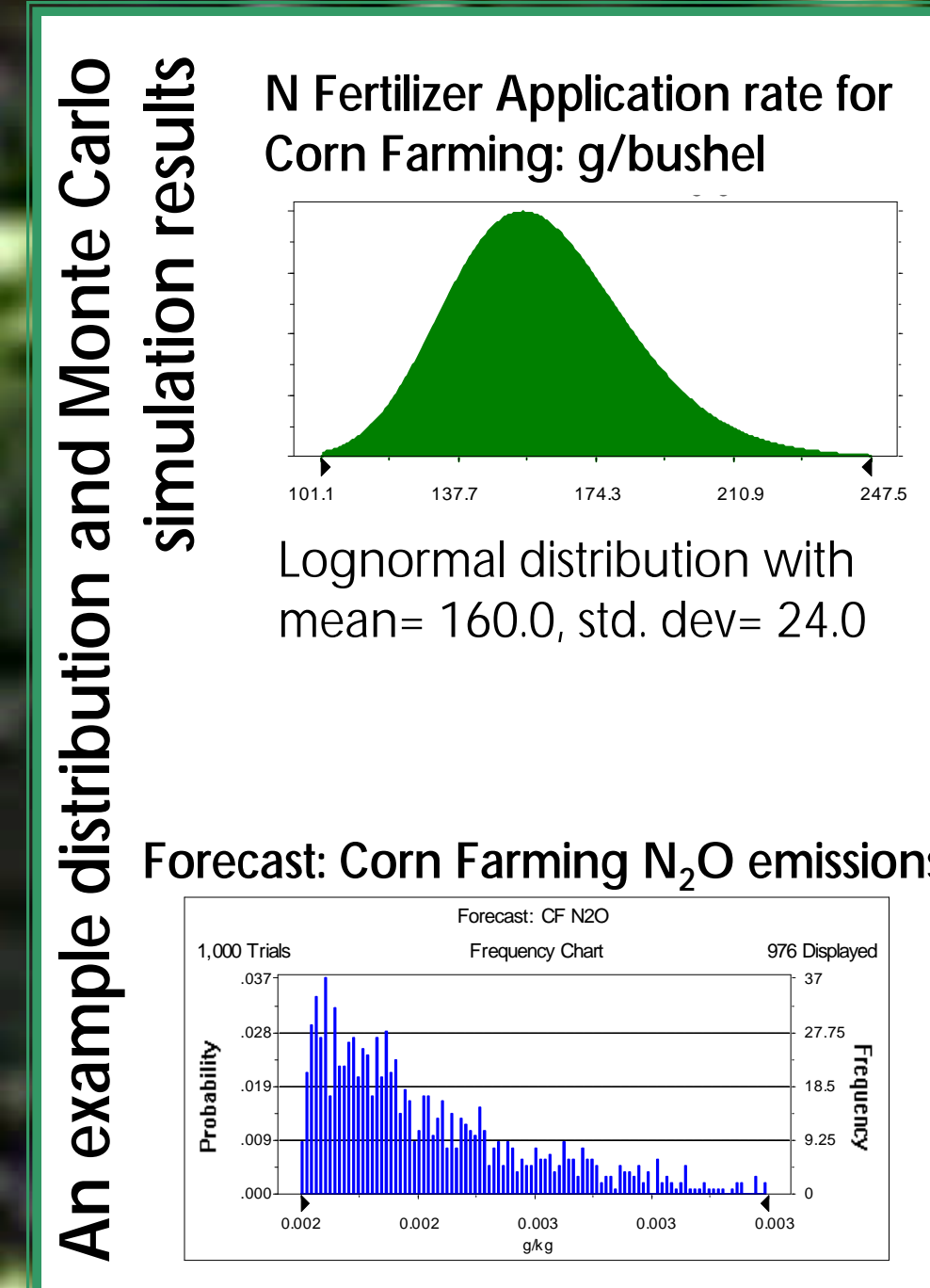


Nitrate emissions and Total Nitrogen exports were modeled via Monte Carlo simulations that incorporated data (and the associated appropriate distributions) for fertilizer input, deposition, volatilization, grain and residue nitrogen contents, and mineralization, for all forms of nitrogen present in the agroecosystem. Data is representative of the Nitrogen flows contained within the farm. Upstream emissions are accounted for to the left.



Capturing Data Variability: Monte Carlo

Monte Carlo analysis within a LCI framework allows for the capture of parameter variability. It is important to make the distinction between the natural variability that this model attempts to capture (i.e. crop yields naturally vary from year to year) and uncertainty associated with data collection. Natural extremes, such as low yields due to draught conditions or variations of crop yield from state to state, are captured within the analysis. Crystal Ball Software can be used to assess the uncertainty in GREET and other databases modeled within Microsoft Excel using a Monte Carlo simulation (Decisioneering 2003). Monte Carlo simulation is a technique used to quantify uncertainty by propagating known uncertainties from probability distributions to the output variable. All parameters with a range of estimates or possible values are assigned a probability distribution. The software then calculates multiple scenarios of a model by repeatedly and randomly sampling values from the probability distributions.



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