Nitrous Oxide Emissions from the Wisconsin Integrated Cropping Systems Trial (WICST)

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Introduction

- Nitrous oxide (N_2O) is a powerful greenhouse gas (GHG), and increases in atmospheric concentrations are due to anthropogenic emissions (Park et al. 2012). Agricultural soils have been identified as a major source of N_2O, and enlightened management of these soils may present significant GHG mitigation options (Johnson et al. 2007).
- Rotation effects can lead to significant differences in area-based N_2O emissions from cropping systems (Drury et al. 2008).
- The effect of cropping system on area-based and yield-based N_2O emissions from agroecosystems was examined over two growing seasons at the Wisconsin Integrated Cropping Systems Trial (WICST).
- Area-based emissions were compared to emissions calculated using IPCC methodology.

Methods

- Static chambers measurement methodology was employed (Parkin and Venterea 2010).
- Fluxes of N_2O were measured for two years from April-November. Sampling occurred bi-weekly and more frequently following fertilization.
- Calculation of cumulative fluxes was achieved by linear interpolation and integration of instantaneous flux measurements.
- Calculation of IPCC estimates was done using Tier II methodology (IPCC 2007). Inputs of N to the cropping systems were calculated using field records, and employing the default emission factor of 1% of applied N emitted as N_2O.

WICST

- Established in 1990.
- Six cropping systems (CS) representing a range of production strategies along a gradient of perenniality and diversity (Fig. 3).
- Three systems are cash grain-based systems.
- Three systems are dairy-based and include forages and manure application.
- In the six cropping systems there are a total of 14 crop phases, and all phases are present in each year. The phases are replicated four times, arranged in a randomized complete block design.
- Located at the Arlington, WI Research Station (43°20'N, 89°21'W) on Plano silt loam soil (mollisols).
- Large plot size (170 m x 20 m, ~0.3 ha), and field-scale machinery was used in all aspects of the farming operations.
- Further experiment details can be found in Posner et al. (1995).

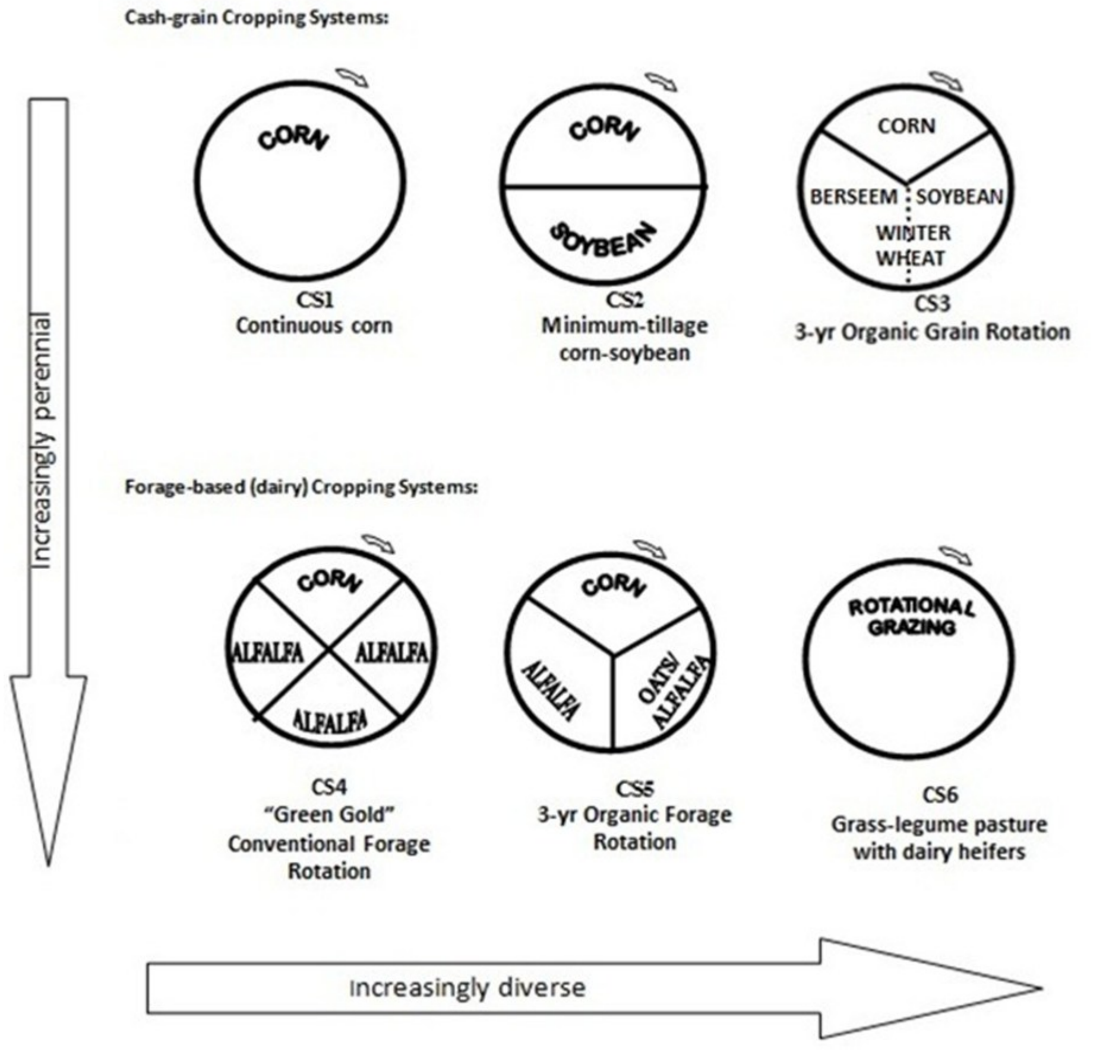

Figure 1. The six cropping systems of WICST.

Results

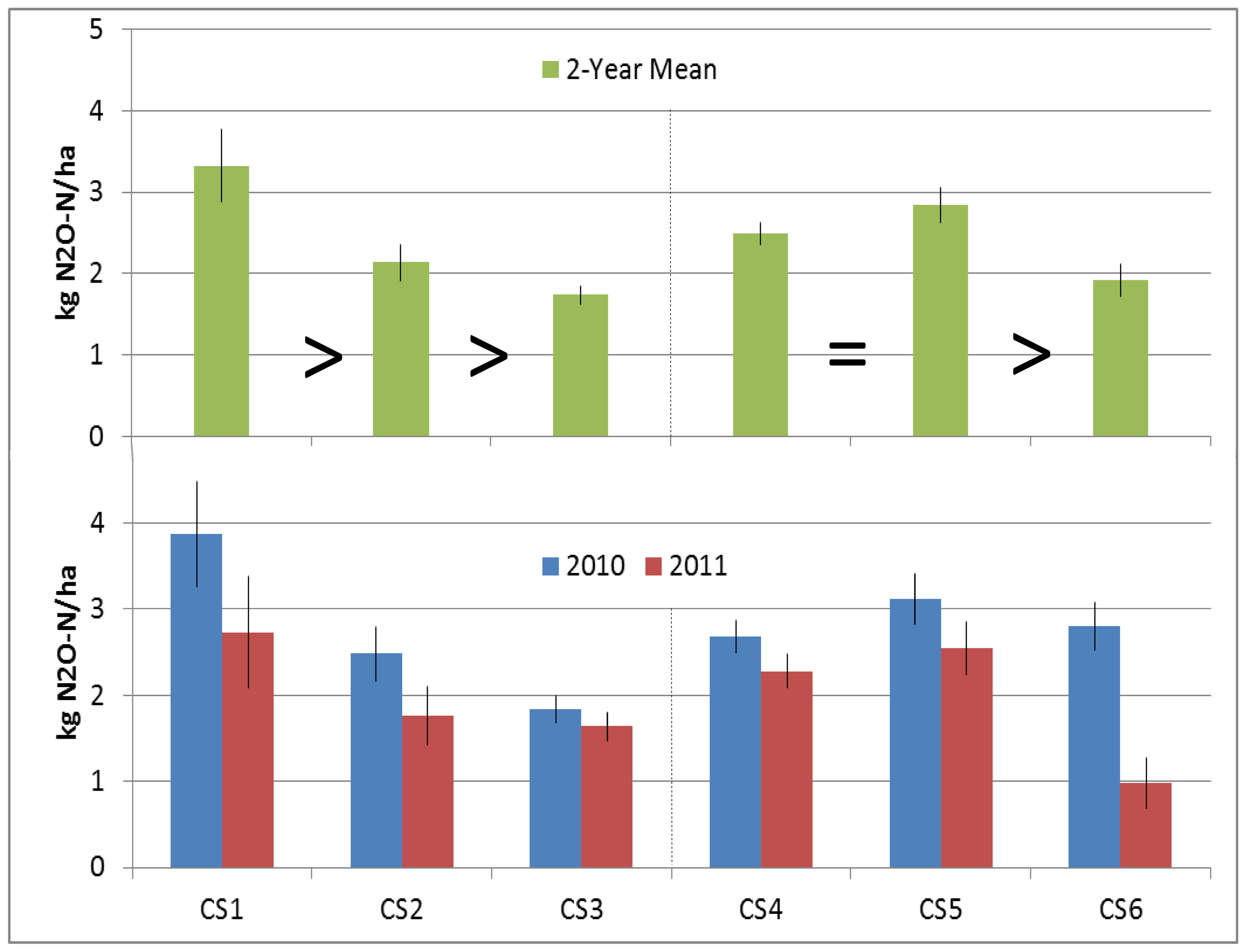

Figure 2. Annual area-based N_2O emissions for the 6 cropping systems in 2010, 2011, and the 2-year mean. Differences between systems that were significant at the α=0.05 level are indicated by >. Bars represent mean ± S.E. (n=4).

Within the grain-based systems CS1 (continuous corn) had the greatest area-based emissions, CS2 (corn-soy minimum tillage) had intermediate emissions, and CS3 (organic corn-soy-wheat) had the least emissions. Within the forage-based systems CS6 (rotational pasture) had the least emissions.

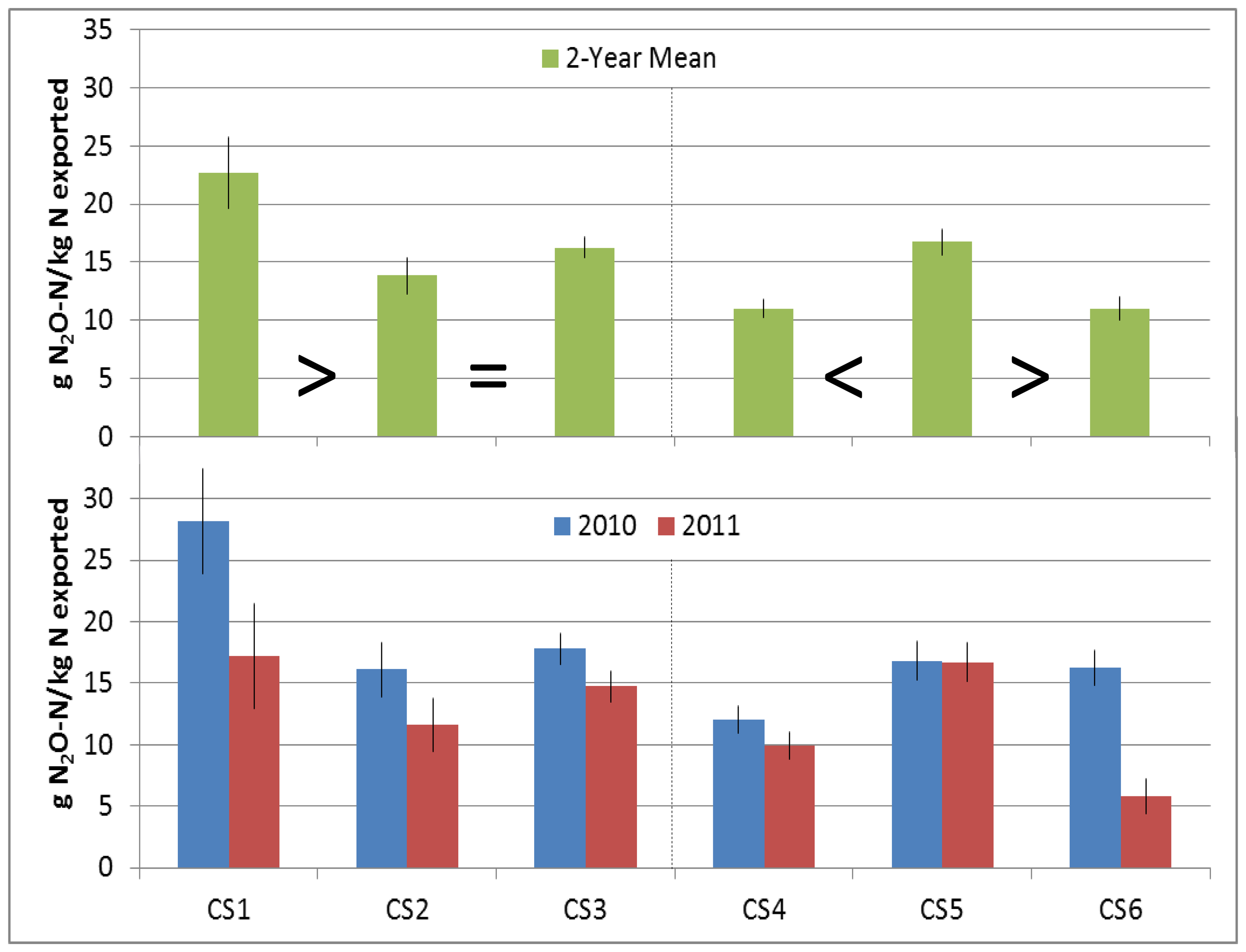

Figure 3. Yield-scaled N_2O emissions (N_2O emitted per unit of N exported in crop yield) for the 6 cropping systems in 2010, 2011, and the 2-year mean. Differences between systems that were significant at the α=0.05 level are indicated by >. Bars represent mean ± S.E. (n=4).

Within the grain-based systems CS1 (continuous corn system) had the greatest yield-scaled emissions. Within the forage-based systems CS5 (organic corn-alfalfa) had the greatest emissions.

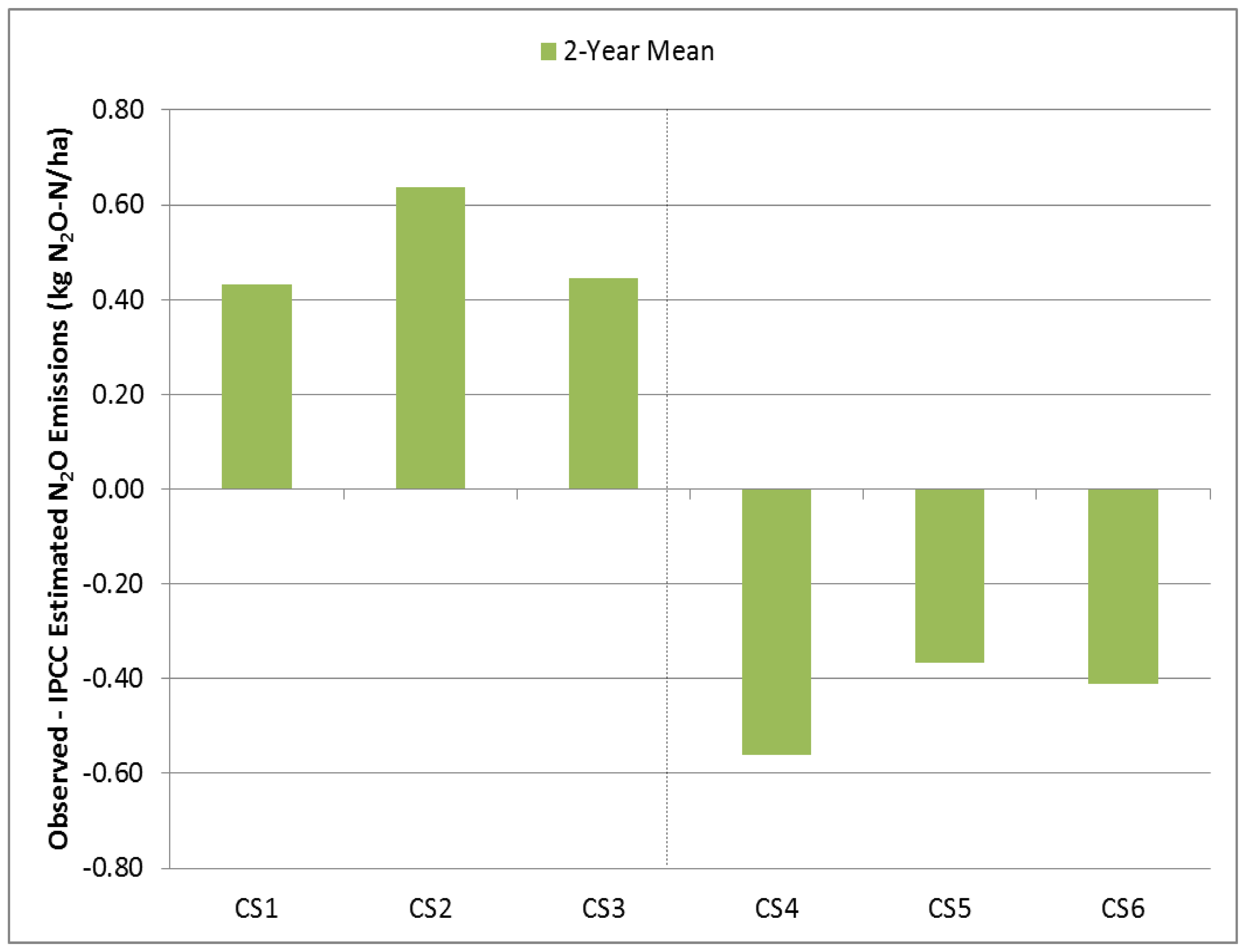

Figure 4. Average differences between IPCC Tier II estimated emissions and observed emissions in the 6 cropping systems over the 2-year study period. Emissions are area-based.

Observed emissions appear to have differed significantly from the IPCC estimates that employ a standard 1% emission factor. The emissions calculated using the IPCC methodology were overestimates in the grain-based systems, and were underestimates in the forage-based systems.

Conclusions

- Cropping system significantly influenced area-based N_2O emissions. Shifting high-input continuous corn systems to medium-input corn-soybean or low-input organic grain systems, and organic corn-alfalfa systems to conventional corn-alfalfa or rotational pasture systems could reduce the total area-based global warming impact of agroecosystems on Wisconsin mollisols.
- Cropping system significantly influenced yield-based N_2O emissions. Organic management resulted in low yield-scaled emissions in a grain-based system but not in a forage-based system. Yield-scaled emissions from cropping systems on Wisconsin mollisols may be minimized by managing for high crop yields with moderate N inputs, and by growing crops with greater N content, such as legumes, more frequently
- IPCC estimated emissions were different from the observed emissions. Distinct emission factors for N derived from organic fertilizers, mineral fertilizers, and legume crops could potentially improve the accuracy of the IPCC methodology.

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