TITLE: Effects of Nitrogen Fertilizer Types and Rates and Irrigation on Nitrous Oxide Fluxes in Turfgrass

OBJECTIVES: 1) Quantify the magnitude and patterns of nitrous oxide (N_2O) fluxes in turfgrass; and 2) determine how nitrogen (N)-fertilization rates, N-fertilizer types, and irrigation affect N_2O fluxes.

PERSONNEL: Dale Bremer

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Note: This report is an abbreviated version of last year's report with the same name (in the 2005 K-State Turfgrass Research Report, Report of Progress 946). In that report, a calculation error resulted in the reporting of N_2O fluxes that were higher than they actually were. This report corrects those errors and adds data not included in last year's report.

INTRODUCTION:

Anthropogenic activities have contributed to an increase in concentrations of atmospheric nitrous oxide (N_2O), a greenhouse gas, and agriculture is considered a significant source. A number of studies have determined that N_2O fluxes into the atmosphere are high in croplands, which are fertilized with nitrogen (N) and irrigated (Figure 1). Urbanization in the United States and elsewhere, however, is replacing with turfgrass significant tracts of land that were once occupied by natural or agricultural ecosystems. Because turfgrass is often irrigated and fertilized with nitrogen (N), urban areas may represent an unappreciated, but increasingly significant, contributor to atmospheric N_2O. In this study, the impacts on N_2O fluxes of N (including fertilizer types and rates) and irrigation-management factors were quantified.

MATERIALS AND METHODS:

Thirty-six plots were arranged in a previously established sward of perennial ryegrass (*Lolium perenne* L.) (Figure 2). Two rates and two types of N fertilizers were applied to the plots: 1) urea, high rate (UH; 250 kg N ha^{-1} yr^{-1} [5 lb N 1,000 ft^{-2}]); 2) urea, low rate (UL; 50 kg N ha^{-1} yr^{-1} [1 lb N 1,000 ft^{-2}]); and 3) ammonium sulfate, high rate (AS; 250 kg N ha^{-1} y^{-1} [5 lb N 1,000 ft^{-2}]). Soil fluxes of N_2O were measured weekly for 1 year by using static surface chambers and analyzing N_2O by gas chromatography. After the 1-year study, irrigation was withheld from half of all plots for 1 month to investigate irrigation effects on N_2O emissions.

RESULTS:

Fluxes of N_2O ranged from -22 mg N_2O-N m^{-2} h^{-1} during winter to 407 mg N_2O-N m^{-2} h^{-1} after fall fertilization. Nitrogen fertilization increased N_2O emissions by up to 15 times within 3 days (Figure 3), although the amount of increase differed after each fertilization. Cumulative annual emissions of N_2O-N were 1.65 kg ha^{-1} (1.47 lb N $acre^{-1}$) in UH, 1.60 kg ha^{-1} (1.43 lb N $acre^{-1}$) in AS, and 1.01 kg ha^{-1} (1.31 lb N $acre^{-1}$) in UL (Figure 4). Thus, greater N fertilization increased annual N_2O emissions by 63%, but fertilizer type had no significant effect. The amount of N volatilized into the atmosphere as N_2O ranged from 0.6 to 2.6% of N-fertilizer applications.

Withholding irrigation reduced N_2O fluxes significantly in all N-fertility treatments (Figure 5). Cumulative N_2O fluxes were reduced 64 to 89% by drought (Table 1). The effects of drought were also evident in clippings biomass, which was 61 to 70% less in dry than in wet plots.

Recent research and surveys have indicated that as many as 50 million acres in the United States are covered with turfgrasses. These data suggest that emissions of N_2O from turfgrasses in the United States may be as much as 36,750 tons of N annually. Results indicated significant annual N_2O emissions from turfgrasses, similar to emissions from intensively managed croplands, and suggest that management practices such as irrigation and N fertilization may be adapted to mitigate N_2O emissions in turfgrass ecosystems.

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Table 1. Cumulative aboveground biomass (clippings from mowing) and N_2O-N emissions from perennial ryegrass during a 22-day period in which "dry" plots were not irrigated.

	Clippings			Cumulative N_2O-N Fluxes		
	Wet	Dry	% Reduction	Wet	Dry	% Reduction
	-------- g m^{-2} --------			-------- kg ha^{-1} --------		
UH	19.9a	6.2b	69	0.172a	0.019b	89
UL	10.1a	3.0a	70	0.121a	0.044b	64
AS	19.8a	7.6b	61	0.144a	0.025b	82

[1]Means followed with the same letter within a row are not significantly different ($P<0.05$).

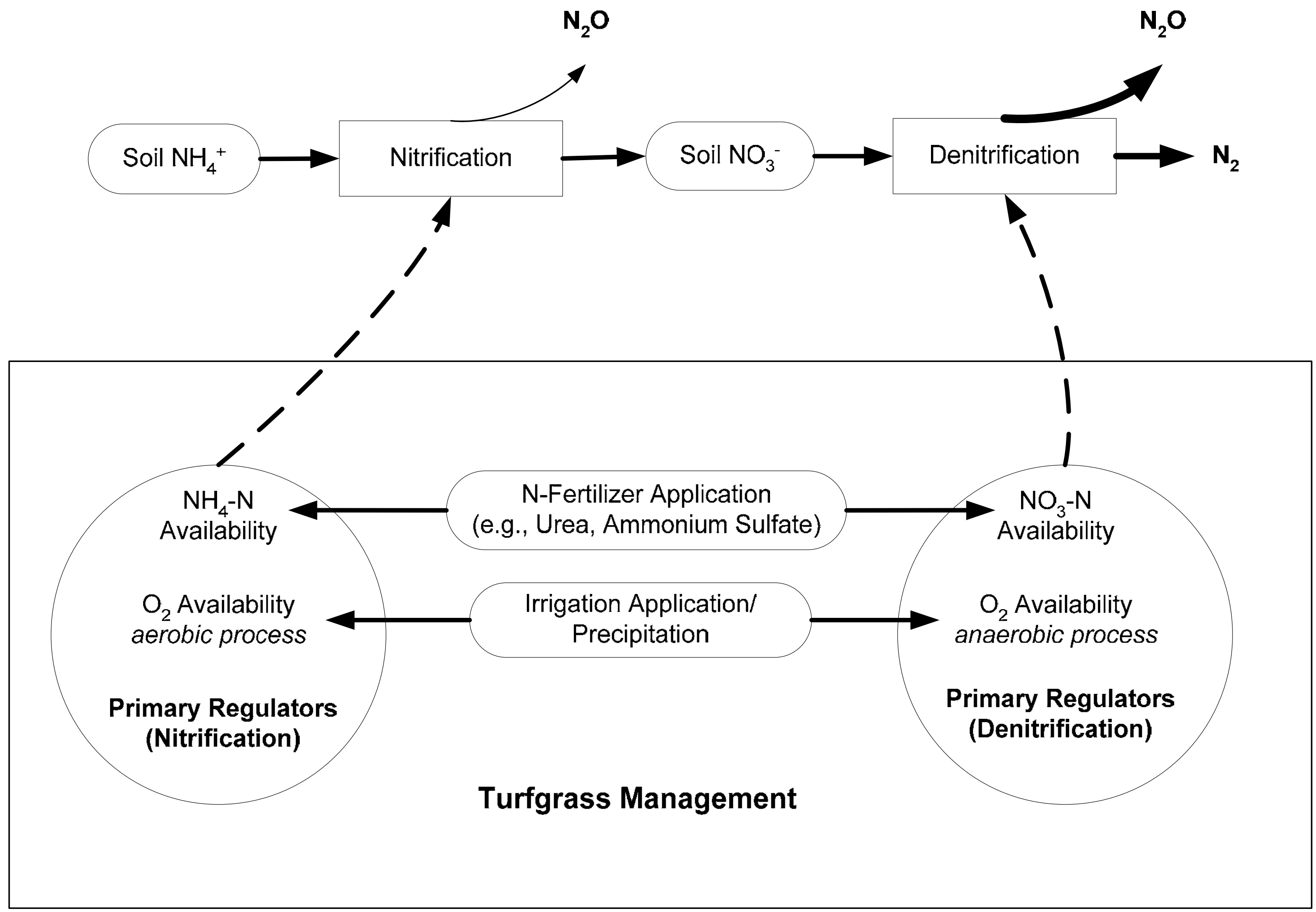

Figure 1. Simplified conceptual model illustrating the effect of fertilization and irrigation or precipitation on N_2O emissions from the soil.

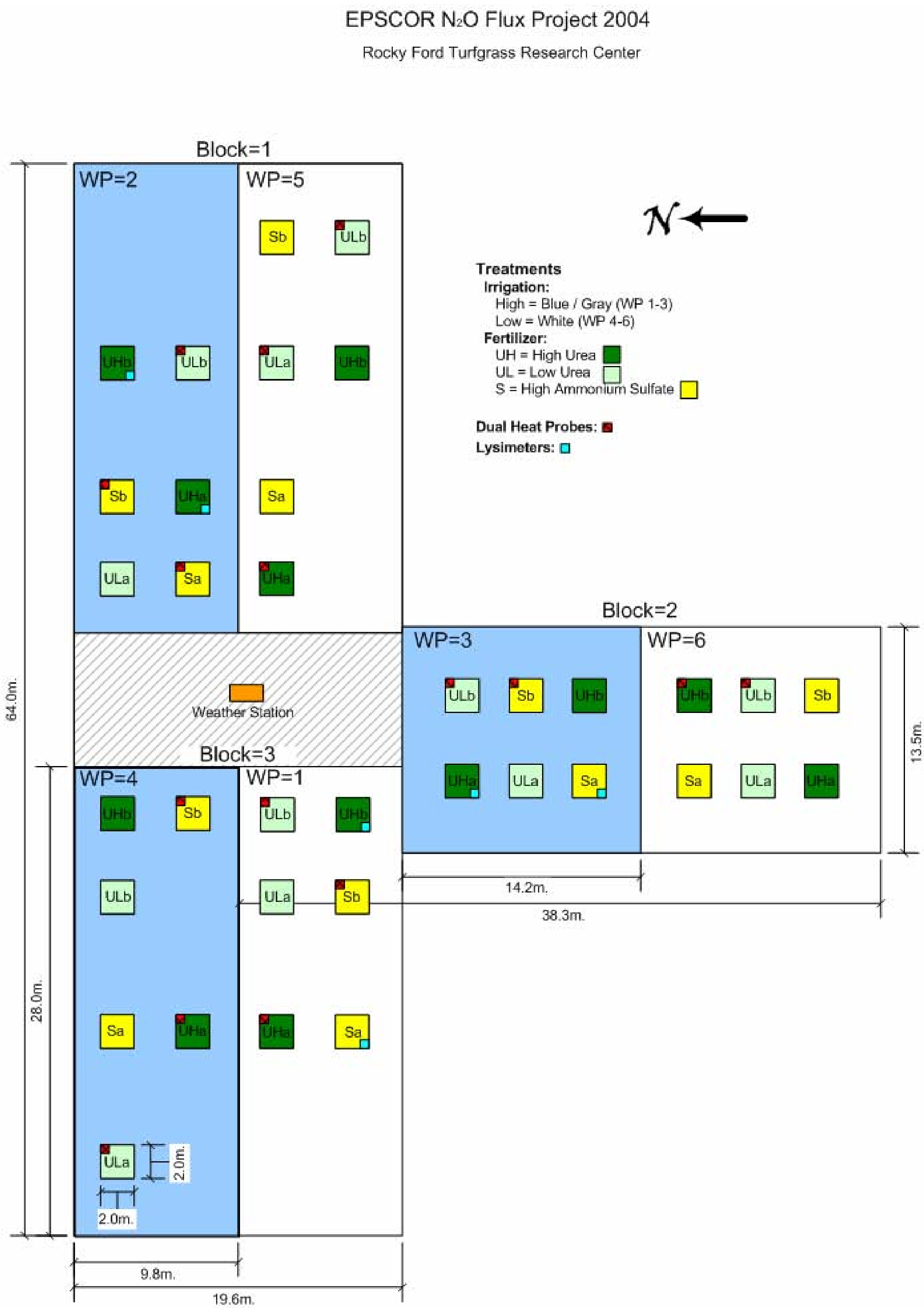

Figure 2. Schematic of plot layout in turfgrass nitrous oxide study.

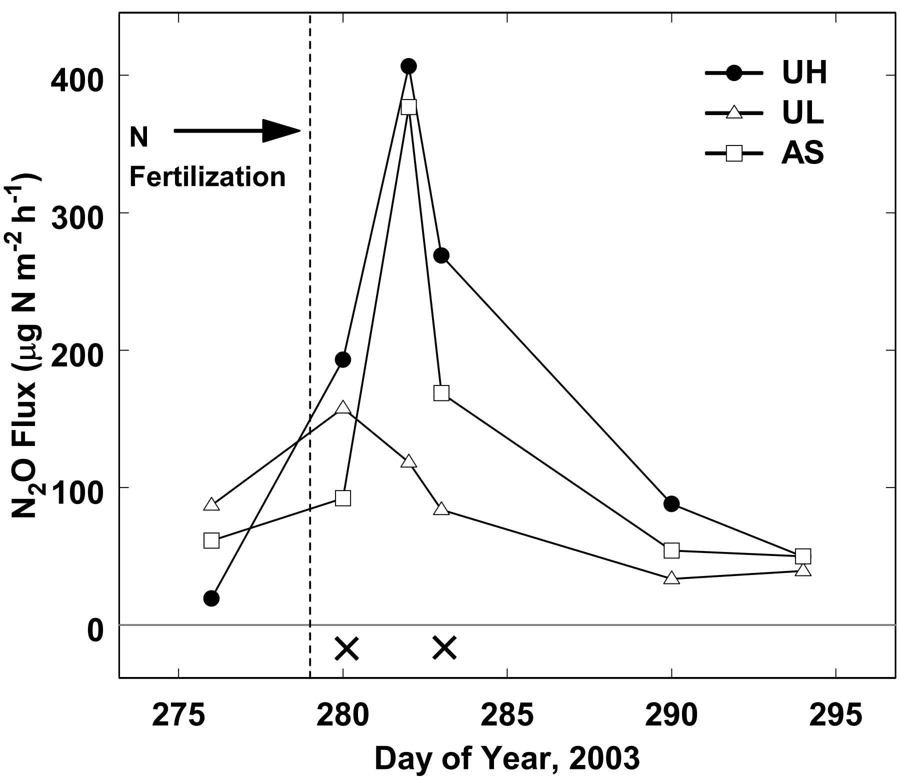

Figure 3. Fluxes of nitrogen (N_2O-N) from perennial ryegrass in fall of 2003. Vertical dashed lines represent N-fertilization date. Symbols (x) along the abscissa indicate significant differences between at least 2 treatments (*P*<0.05).

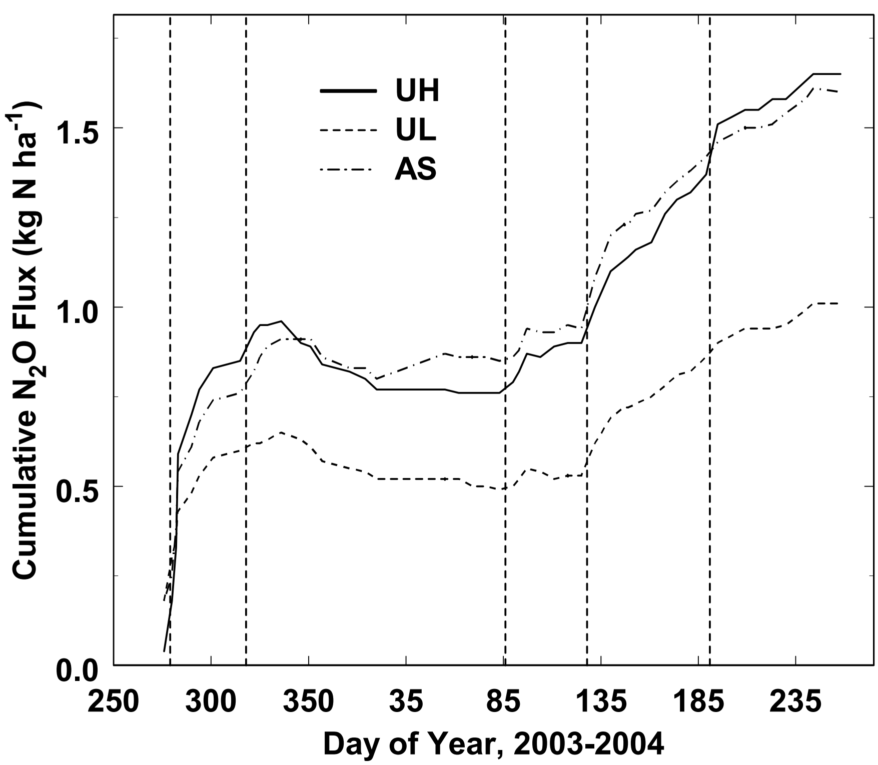

Figure 4. Cumulative fluxes of N_2O-N from plots treated with high rates of urea (UH), low rates of urea (UL), and high rates of ammonium sulfate high (AS). Vertical dashed lines represent fertilization dates.

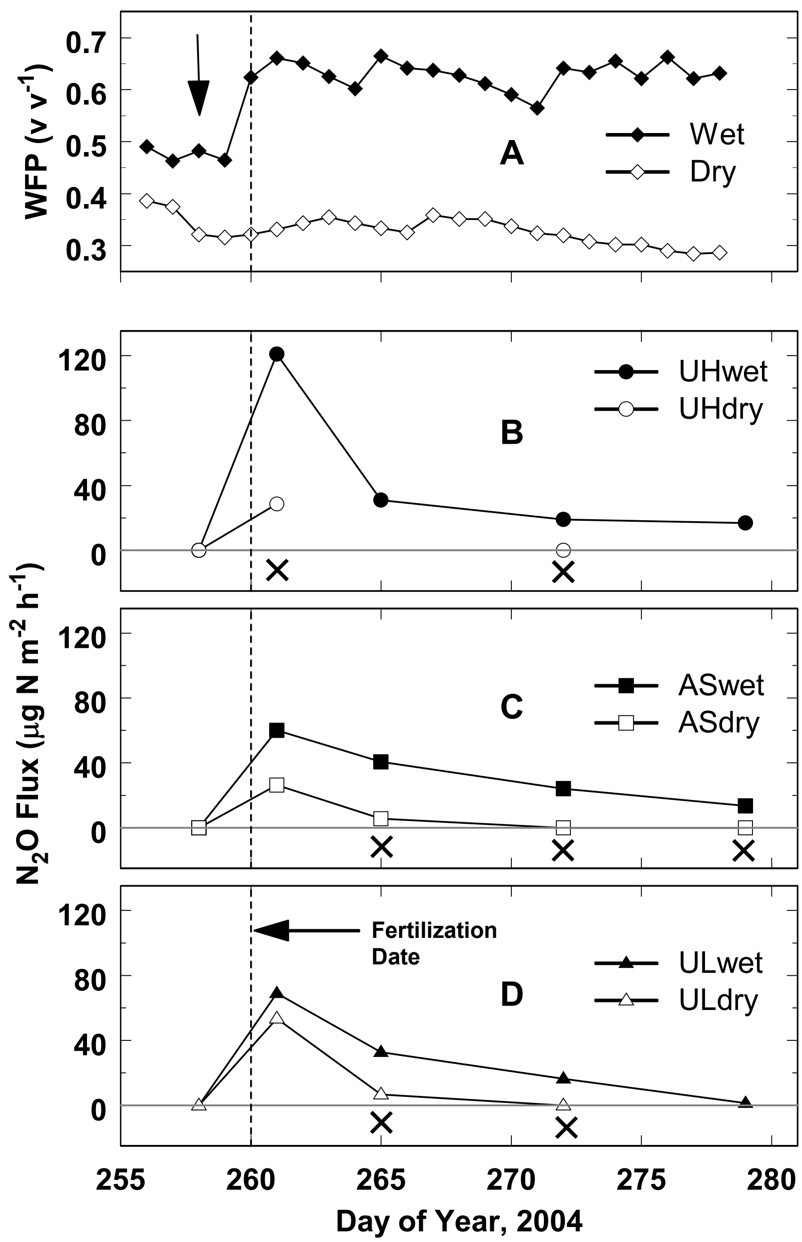

Figure 5. Average soil water-filled porosity (WFP) at 5 cm among irrigated (wet) and non-irrigated (dry) plots, respectively, of perennial ryegrass during irrigation study (A); and fluxes of N_2O from wet and dry plots treated with high rates of urea (UH)(B); high rates of ammonium sulfate (AS)(C); and low rates of urea (UL)(D). Arrow in A indicates beginning of period when differences in WFP were significant between irrigation treatments. Vertical line represents fertilization date.