Emission of the greenhouse gas nitrous oxide (N_2O) from riparian forest buffers, warm-season and cool-season grass filters and crop fields

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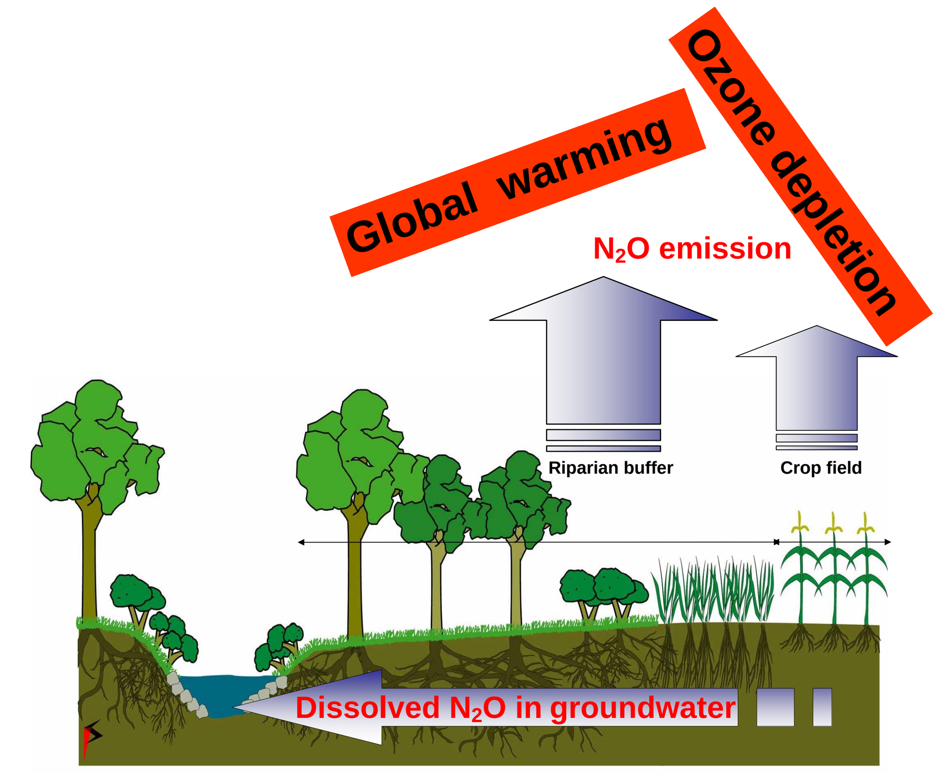
Why is nitrous oxide (N_2O) gas emission from riparian buffers important?



Source: http://www.buffer.forestry.iastate.edu/, illustrated by Tom Schultz

Denitrification is the major mechanism for reducing nitrate in riparian buffers, which are designed to mitigate non-point source pollution (NPS) entering surface water bodies (Hubbard et al. 2004). It recently has been argued that the increased denitrification rates in riparian buffers may be trading the problem of NPS pollution of surface waters for atmospheric deterioration and global warming problems (Groffman et al. 1998) because denitrification produces nitrous oxide (N_2O), a greenhouse gas (Wang et al. 1976) also involved in stratospheric ozone depletion (Crutzen 1970). Therefore, studies should be conducted to quantify the emission of N_2O from different kinds of buffer systems and to identify ways to reduce that emission.

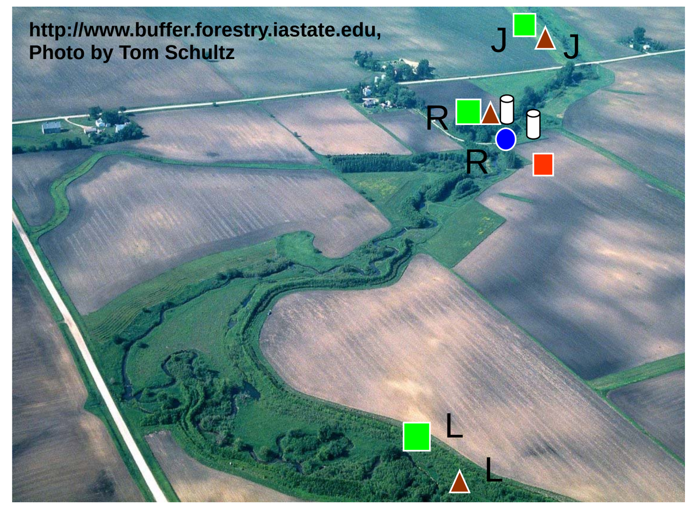
What questions do we have?

This study attempts to answer the following questions.

- Do different kinds of riparian buffer vegetation produce varying amounts of N_2O?
- Are riparian buffers a more significant source of N_2O than adjacent crop fields?
- Is underground water exported to the creek from riparian buffers a significant source of dissolved N_2O?

What are we doing to find the answers?

Study sites Three riparian forest buffers, three warm-season and one cool-season grass filters, and one crop field (a soybean and corn rotation) on the same soil mapping unit (Coland) in the Bear Creek watershed, Iowa, United States (42° 11' N, 93° 30' W) are being studied.



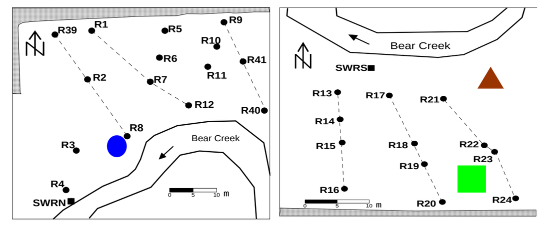
Crop | Forest buffer | Well transects
Cool season grass filter | Warm season grass filter

Nitrous oxide (N_2O) gas emission is sampled with static vented chambers in 5 sampling plots at each site. N_2O concentration in the gas sample is analyzed using electron capture gas chromatography (ECD-GC).

Soil and air temperature and soil moisture are measured around each chamber site.

Dissolved N_2O and nitrate in the groundwater is sampled with a peristaltic pump from 6 well transects in a combined forest buffer and warm-season filter and a cool-season grass filter.

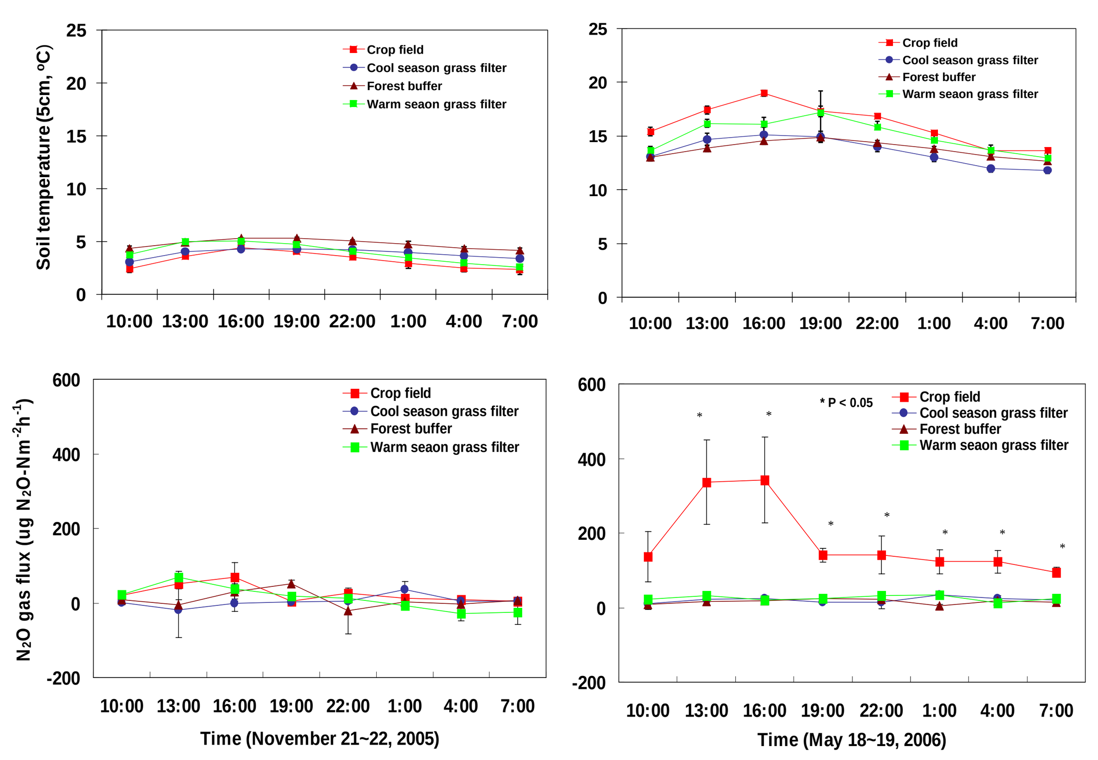
Dissolved N_2O is analyzed with an ECD-GC and nitrate concentration with an UV-spectrophotometer.



Monitoring well
Transect
Cool season grass filter
Warm season grass filter
Forest buffer

What have we found ?

Diurnal variation of N_2O emission

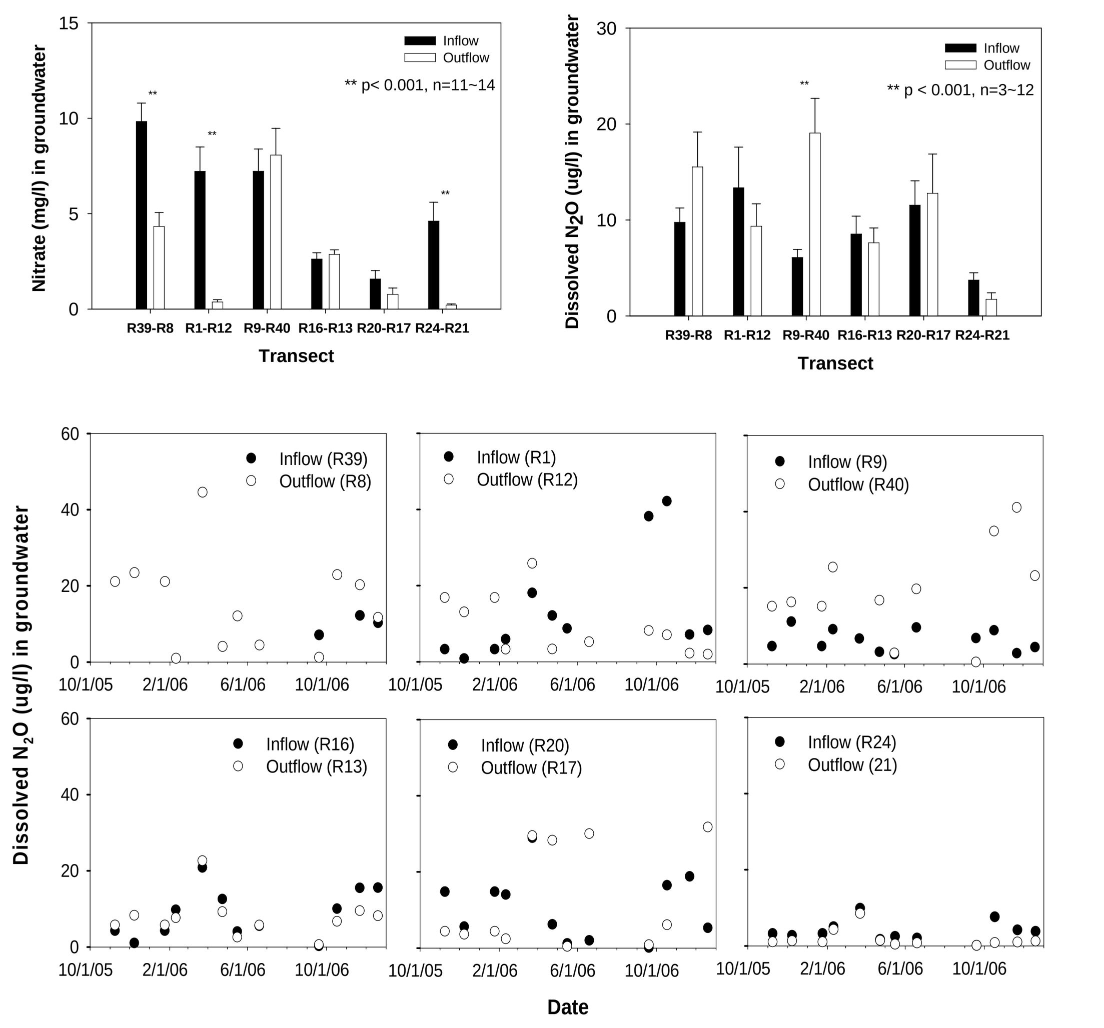


There was no significant diurnal variation of N_2O emission from the crop field and riparian buffers in either November 2005 or May 2006 (One way ANOVA all $p > 0.05$, Tukey's Studentized Range Test).

In May 2006, N_2O emission in the crop field was significantly higher (7~13 times) than in riparian buffers during 24hrs (One way ANOVA all $p < 0.05$, Tukey's Studentized Range Test).

In May 2006, N_2O emission in the crop field was significantly correlated to soil temperature (5 cm) (Pearson coefficient $r = 0.77$, $p = 0.02$); however, soil temperature in the crop field was not significantly higher than riparian buffers (Tukey's Studentized Range Test).

Nitrate and dissolved N_2O gas in groundwater

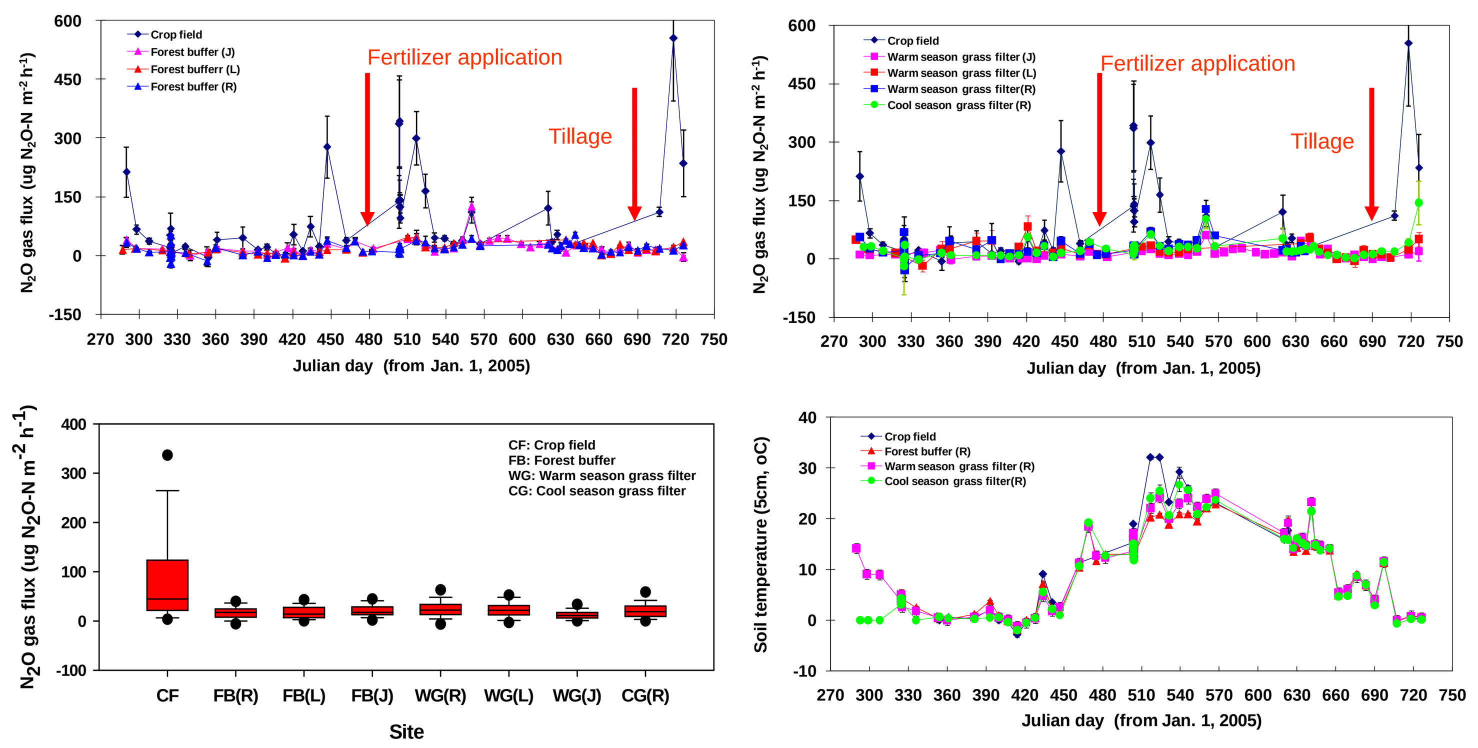


Groundwater nitrate in outflow from the buffer (adjacent Bear Creek) was significantly lower than nitrate in inflow groundwater (adjacent crop field) in the transects R38-R8, R1-R12 and R24-R21 (T-test all $p < 0.001$).

Dissolved N_2O in inflow and outflow groundwater were not significantly different (T-test all $p > 0.1$) in all transects but a transect R9-R40 (T-test $p < 0.001$).

In the transects groundwater nitrate was significantly reduced (R38-R8, R1-R12 and R24-R21), dissolved N_2O in inflow and outflow groundwater were not significantly different (T-test all $p > 0.1$).

Temporal variation of N_2O emission



N_2O flux of all sites was significantly correlated to soil temperature in the crop field and riparian buffers (Pearson coefficient $r = 0.41$~0.79, $p < 0.05$), however, soil temperature of the sites were not significantly different (One way ANOVA $p = 0.15$).

N_2O emission in the crop field was increased after fertilizer application (475 Julian day) and tillage (690 Julian day).

N_2O emission in the crop field (92.6 ± 16.3 ug N_2O-N m^{-2} h^{-1}) was significantly larger than one in all riparian buffers (13~28 ug N_2O-N m^{-2} h^{-1}) (One way ANOVA $p < 0.0001$, Tukey's Studentized Range Test).

There was no significant difference of N_2O emission by vegetation type and by site in riparian buffer (One way ANOVA all $p > 0.05$).

Take home message

1) Crop fields were a more significant source of N_2O than riparian buffers. Considering the small area occupied by buffers in an agricultural landscape they should be viewed as an insignificant source of N_2O. 2) Amounts of N_2O in different kinds of riparian buffer vegetation were not significantly different. 3) Groundwater exported to the creek from riparian buffers was also not a significant source of dissolved N_2O.

References

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