USGS
science for a changing world

Greenhouse gas fluxes from wetland catchments located in native prairie, restored grasslands, and croplands in the Prairie Pothole Region

Robert A. Gleason[1], Brian A. Tangen[1], Raymond G. Finocchiaro[1], and Barry Botnen[2]
[1]U.S. Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, North Dakota
[2]Energy & Environmental Research Center, Grand Forks, North Dakota

BACKGROUND

- Restored wetlands and grasslands in the Prairie Pothole Region (PPR; Figure 1) have been shown to sequester atmospheric carbon (CO_2-C) in soils.
- During Phase I of the Plains CO_2 Reduction (PCOR) Partnership, we estimated that potentially restorable cropland wetlands could sequester 111,216,000 Mg of soil organic carbon (Gleason et al. 2005; Figure 2).
- There are concerns that the CO_2-C sequestration benefit may be offset by increased emissions of nitrous oxide (N_2O) and methane (CH_4) from restored wetlands.
- Though there is limited information on N_2O and CH_4 emissions from wetlands in the PPR, studies suggest that restoration of farmed wetlands may reduce emission of these greenhouse gases (GHGs; e.g., Bedard-Haughn et al. 2006, Gleason et al. 2009).

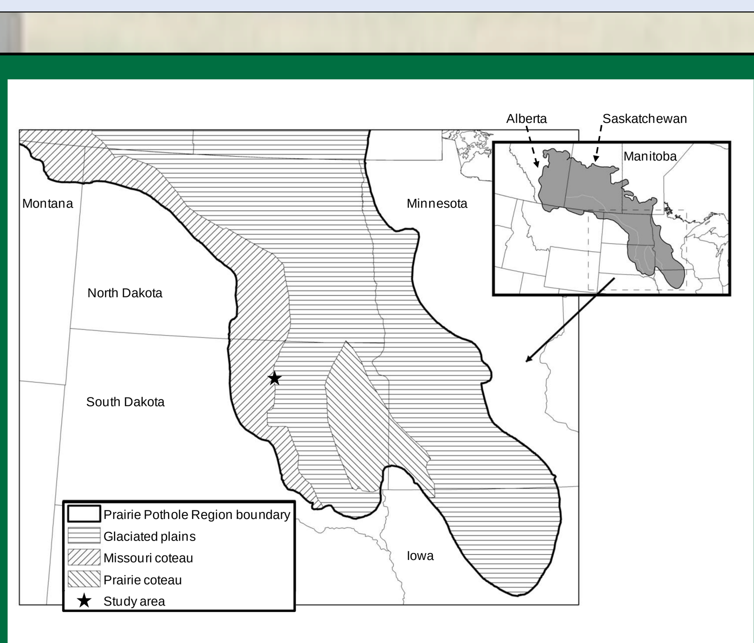

Figure 1. Location of study area in relation to the primary physiographic regions of the Prairie Pothole Region of North America.

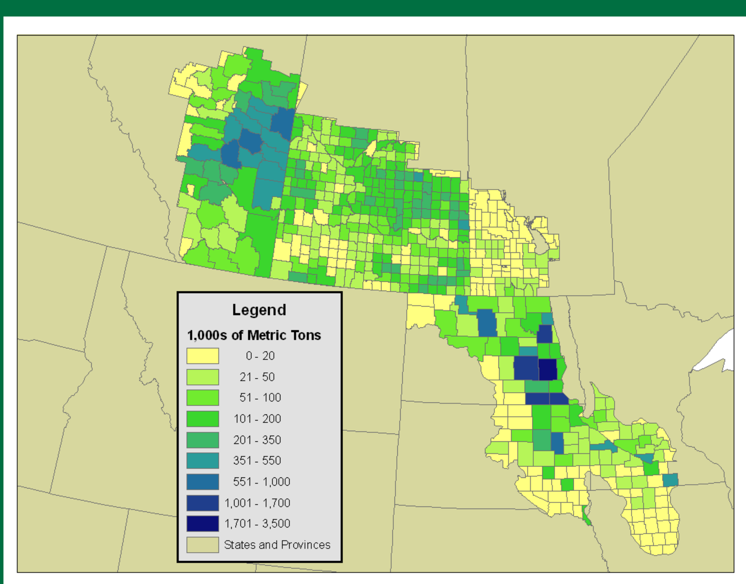

Figure 2. Carbon sequestration potential for counties and rural municipalities in the Prairie Pothole Region based on wetland restoration (from Gleason et al. 2005).

OBJECTIVES

- The primary objective during Phase II of the PCOR Partnership was to evaluate the impact of wetland and grassland restoration and subsequent land-management practices (i.e., grazing and haying) on emissions of GHGs.

METHODS

- We applied a reference-based approach to compare GHG (N_2O, CH_4, and carbon dioxide [CO_2]) fluxes from restored grassland catchments to native prairie and cropland reference conditions. We also compared native catchments that were grazed and idle, and restored catchments that were hayed and idle.
- Wetland catchments, which include the wetland and surrounding uplands, were located in north-central South Dakota (Figure 1).
- We monitored GHG fluxes using static chambers throughout the growing seasons of 2007 and 2008. Data were collected along an elevation and moisture gradient, with a transect extending from the wetland center to the catchment boundary; 5 sample locations were located in the wetland zone and 3 in the upland zone.

REFERENCES

Bedard-Haughn, A., matson, A.L., and Pennock, D.J., 2006, Land use effects on gross nitrogen mineralization, nitrification, and N_2O emissions in ephemeral wetlands: Soil Biology & Biochemistry, v. 38, p. 3398–3406.
Gleason, R.A., Euliss, N.H., Jr., McDougal, R.L., and Kermes, K.E., 2005, Potential of restored prairie wetlands in the glaciated North American prairie to sequester atmospheric carbon: Plains CO_2 Reduction Partnership Topical Report, August 2005, Energy and Environmental Research Center, Grand Forks, North Dakota, USA.
Gleason, R.A., Tangen, B.A., Browne, B.A., and Euliss, N.H., Jr., 2009, Greenhouse gas flux from cropland and restored wetlands in the Prairie Pothole Region: Soil Biology & Biochemistry, v. 41, p. 2501–2507.

RESULTS

Land use

- Fluxes of all gases varied considerably throughout the growing season. Emissions of N_2O and CH_4 were highly influenced by soil water-filled pore space, and N_2O also showed a positive relation with soil nitrate (NO_3) concentration. Native catchments exhibited the lowest average water-filled pore space during the study; NO_3 was highest in croplands, followed in decreasing order by restored and native catchments.
- Fluxes of CO_2 were lower in cropland than restored and native catchments (both upland and wetland zones) during both years (Figure 3).
- Upland zones were dominated by negative CH_4 fluxes, with native sites exhibiting greater seasonal average uptake rates than restored and cropland during both years. During 2007, mean seasonal fluxes of CH_4 from wetland zones did not vary by land use. Within wetland zones during 2008, CH_4 flux was lower in native sites than restored and cropland (Figure 3).
- During 2007, mean seasonal fluxes of N_2O in upland and wetland zones did not vary by land use. N_2O fluxes during 2008 from upland and wetland zones were highest in cropland sites, followed in descending order by restored and native (Figure 3).
- Excluding the contribution of CO_2 and considering only the Global Warming Potential (GWP) of N_2O and CH_4, N_2O contributed the most to GWP in the uplands for both years; the GWP of CH_4 was negative for uplands. In contrast, within the wetland zones, CH_4 contributed the most to overall GWP during 2007, whereas during the drier 2008 season, N_2O was the dominant contributor to GWP.

Grazing / haying

- No consistent trends emerged when comparing mean seasonal flux of CH_4 and N_2O between native grazed and non-grazed catchments and between restored hayed and non-hayed sites (Figures 4, 5).
- Excluding the wetland zone of restored hayed and non-hayed sites, idled sites showed greater CO_2 fluxes than did grazed and hayed sites (Figures 4, 5).

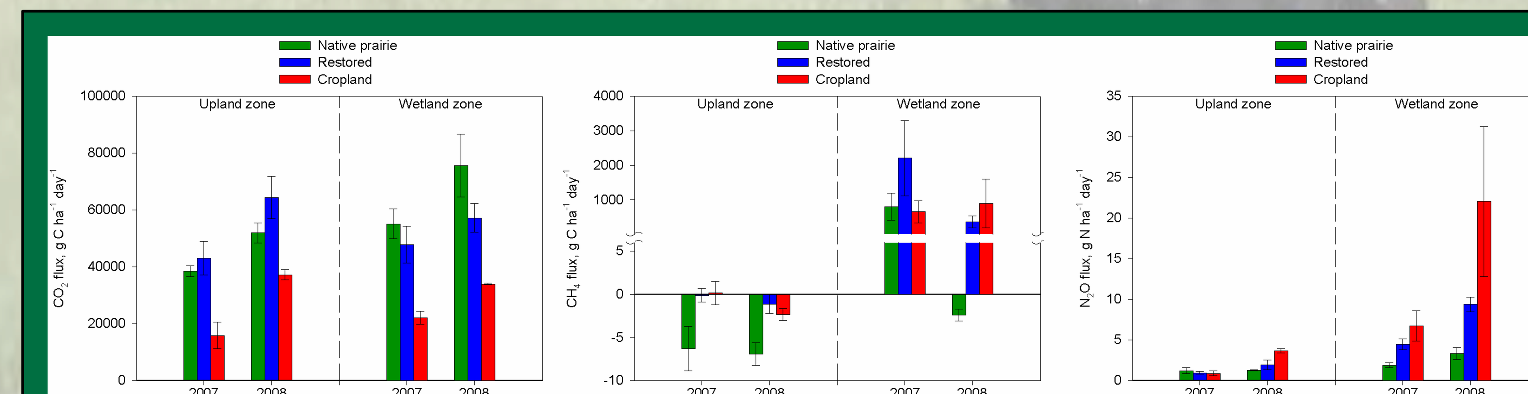

Figure 3. Mean seasonal flux of CO_2, CH_4, and N_2O for wetland catchments in native prairie, restored grassland, and cropland .

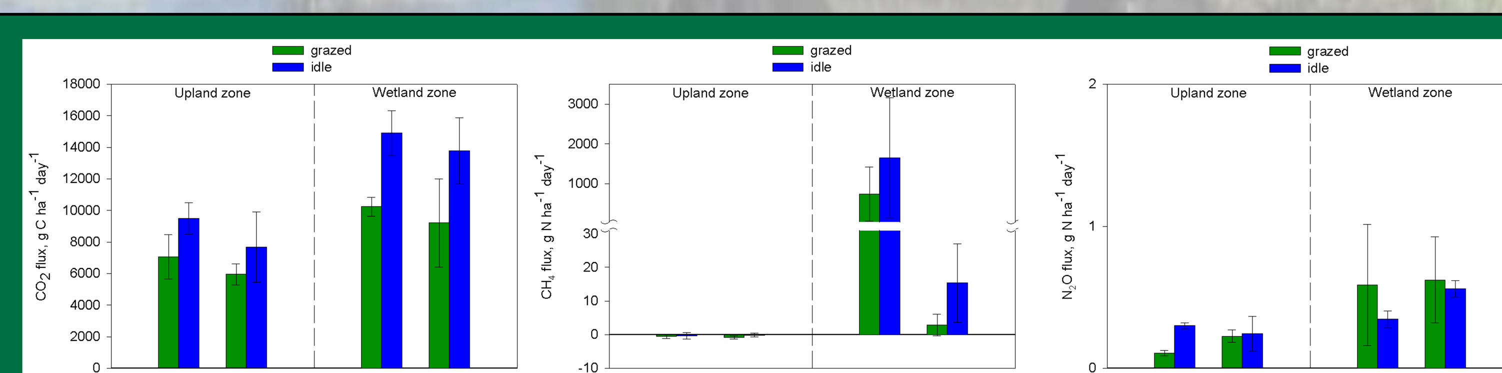

Figure 4. Mean seasonal flux of CO_2, CH_4, and N_2O for grazed and idle wetland catchments in native prairie.

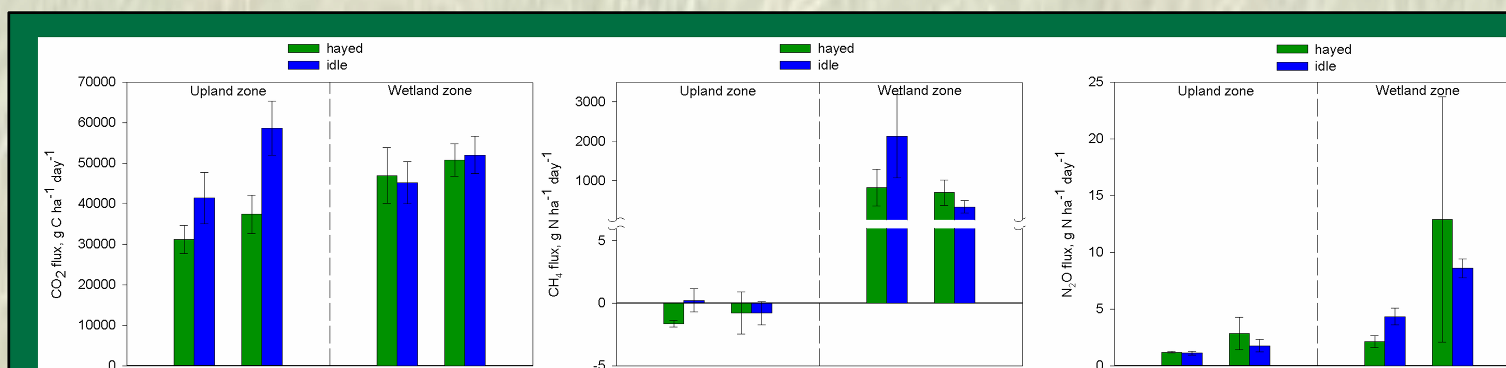

Figure 5. Mean seasonal flux of CO_2, CH_4, and N_2O for hayed and idle wetland catchments in restored grasslands .

CONCLUSIONS

- Overall, restored catchments exhibited N_2O and CH_4 fluxes that did not differ from, or were lower than those observed in cropland sites.
- Higher CH_4 and N_2O fluxes in cropland and restored sites, relative to native sites, were associated with differences in water-filled pore space and NO_3.
- Overall, non-grazed and non-hayed sites showed greater CO_2 emissions than did grazed and hayed sites; this pattern is probably linked to biomass removal because CO_2 emissions represent both plant and soil respiration.
- Our results suggest that restoring wetland catchments or implementing grazing or haying management practices would not offset potential soil carbon sequestration benefits through increased emissions of GHGs.
- Our data show that GHG emissions are temporally variable, and highly influenced by soil moisture conditions. Future research should expand to include different wetland types and should focus on clarifying relationships between land use, land-management practices, and climate.

PCO2R Partnership
EERC Energy & Environmental Research Center® Putting Research into Practice
Ducks Unlimited World Leader in Wetlands Conservation