Effect of cropping systems and water on N_2O emissions from soil as influenced by fertilization and crop residues in the Northern Great Plains

Dr. Richard Engel
Dr. Perry Miller
Dept. of Land Resources and Environmental Sci.
Montana State Univ.
Bozeman, MT

USDA-NRICP Air Quality program:
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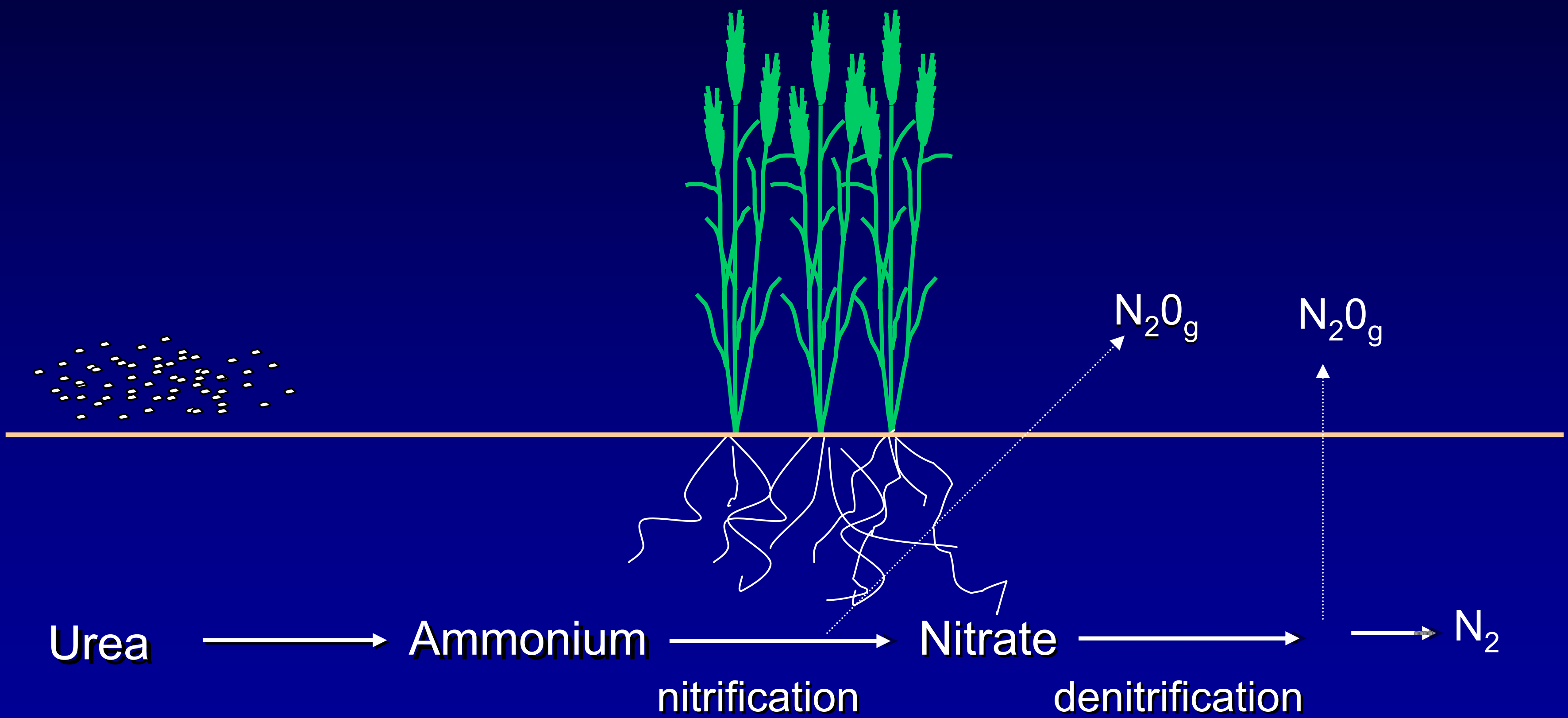
Nitrous oxide emissions



- *emitted from soils – naturally occurring process*

Soil emissions of N_2O – Why care ?

- greenhouse gas – 310x powerful as CO_2
- destruction of ozone layer
- agricultural soils = 2/3 of anthropogenic N_2O emissions globally according to IPCC
- high emissions from agric. soils are blamed on N inputs
  - N fertilization (commercial & organic sources)
  - production of N_2 fixing crops

Reducing

Greenhouse gasses

MSU taking part in study to see if changes in farming, forestry practices can reduce carbon emissions

By RON TSCHIDA
Chronicle Staff Writer

Montana State University is one of 10 U.S. universities taking part in a $15 million study to see if changes in farming and forestry practices could reduce greenhouse gasses.

"We're trying to put together the pieces of the puzzle," said John Antle, a Montana State University agricultural economist.

The work could give farmers a new "crop" to sell: carbon emissions credits.

For example, a wheat farmer here, agreeing to use no-till practices that keep carbon in soil, could sell carbon emission credits to a factory in the Midwest.

Antle has helped create a tradeoff analysis computer program that can simulate the complex variables present in all sorts of environmental problems.

The work could help create a new market in which agriculture is "a producer not just of food commodities but of environmental services," Antle said.

To Antle, keeping carbon in soil — called carbon sequestration — is just one example of how looking at far flung connections could lead to healthier, sustainable agricultural practices.

He's used the model to evaluate pesticide use by potato farmers in Ecuador and is evaluating soil rebuilding efforts in Africa.

"The whole issue of sustainable agriculture is about understanding the system better," Antle said. "If we really understood how it worked, we wouldn't do unsustainable practices on purpose."

For example, using less pesticide could result in lower crop yields but better water quality.

"Is that a tradeoff farmers want to impose on themselves or is that a tradeoff consumers and governments want to impose on farmers?" Antle asked.

Or in the case of sequestering carbon, is it a tradeoff someone else is willing to pay for?

Apparently, yes. Some producers have already signed carbon contracts in a pilot project in the Northwest, said Perry Miller, an agronomist at MSU.

The potential market for carbon emissions credits is $1 billion to $5 billion per year for the next 30 to 40 years, according to the research consortium.

But researchers have to solve a few technical problems before a broader market develops, including gaining a better understanding of how much carbon can be stored.

One study is looking at no-till farming, in which seeds are planted in the stubble of the preceding crop. By leaving the soil undisturbed, less carbon is released into the atmosphere.

No-till hasn't caught on well on Montana's high, arid plains, Miller said, where farmers typically keep land fallow in between crop years in order to accumulate water and control weeds. But keeping fields black warms the soil, activating microbes that release carbon.

And lack of a crop misses another opportunity to store carbon, Miller said.

"When it comes to carbon accumulation it's absolutely critical that that soil is fed some biomass, some crop residue, each year," Miller said.

A change in farming practices, such as switching to no-till, generally costs money for new equipment and usually entails some risk — new techniques may not work as well as traditional methods.

Understanding the risks is especially critical in Third World countries.

In sub-Saharan Africa, where Antle recently spent three weeks, there's no margin for error.

"We're not talking about, 'oh, I might go broke; we're talking about, 'I might die,'" Antle said. "The real challenge is to get them over that short-term hump."

That's where tradeoffs can help. If Antle's model can demonstrate environmental advantages, farmers could receive payments for adopting better practices. The cash can help them offset costs and short-term risk.

Ron Tschida is at rtschida@gomontana.com

- *Best management practices for C sequestration in Northern Great Plains – no-till and annual cropping need to be balanced against effects on other GHG, e.g. N_20*

Objectives – abbrev.

- Illustrate seasonal patterns of N_2O emissions and periods of peak losses in several cropping systems adapted for NGP.
- Impact of best management practices (no-till & annual cropping) on N_2O emissions.
- Estimate total season losses of N_2O and fertilizer induced losses of N_2O under these cropping systems.
- Contrast measured losses of N_2O against predicted losses using IPCC methodology (particular fertilizer N induced).

Intergovernmental Panel Climate Change (IPCC)

- Advisory Council to UN Framework Convention on Climate Change
  - implications for policy-making (Kyoto Protocol)
- Default value: 1.25% of applied N lost as N_2O
  - findings based on a review of literature
- Observed values range from 0.2 – 15%
- Regional differences

Field sites - 2005

- Cropping system study (●)
  - two-yr rotations: 2004 = 2nd yr
  - no-till vs. conventional till
  - annual vs. summer-fallow
  - available N gradient

- Water gradient study (●)
  - two year rotation
  - spring wheat (0, 70, and 140 kg N/acre)
  - spring pea

Annual cropping systems ……

- diversified rotations

- continuous wheat

Fallow-wheat cropping systems ……..

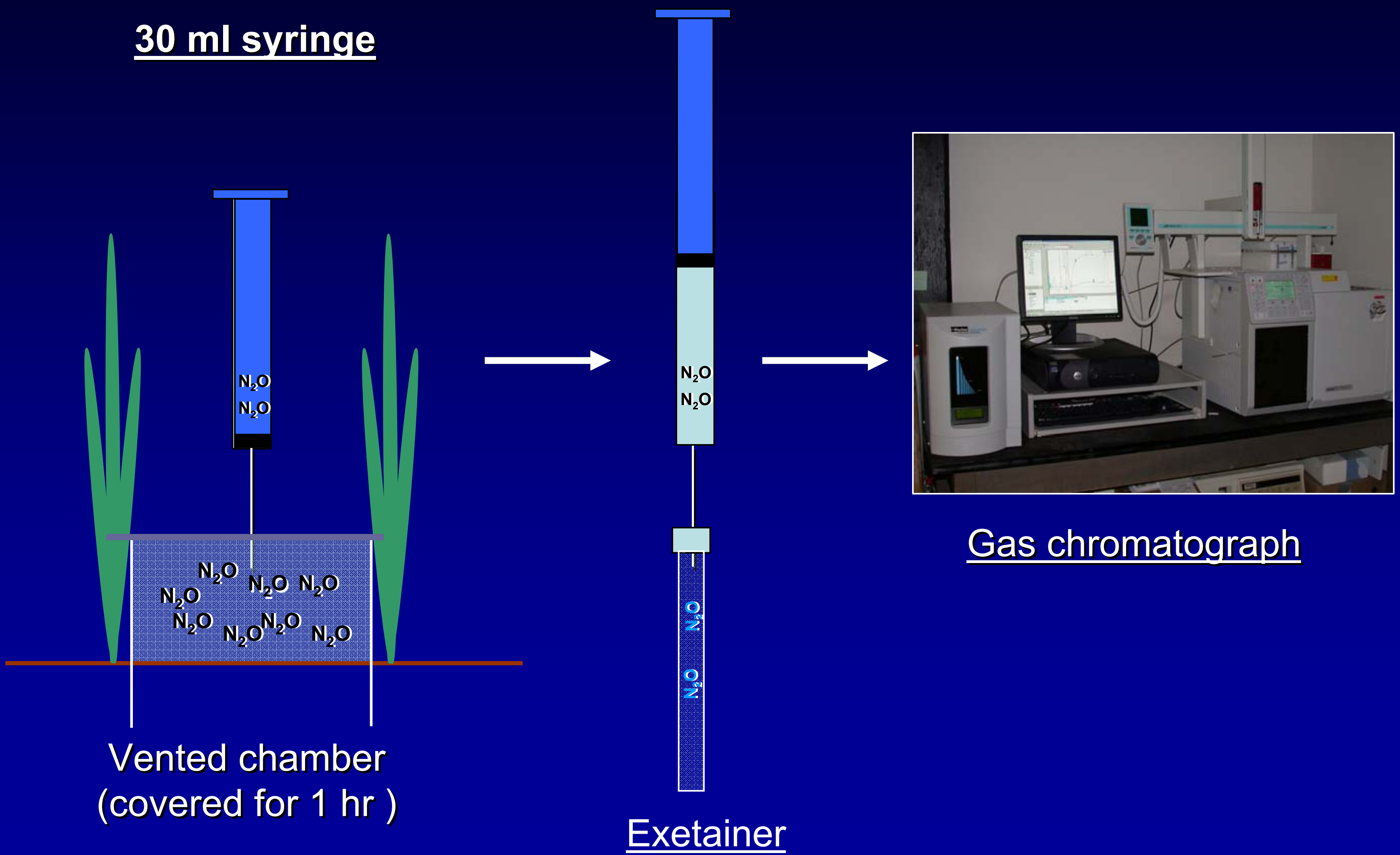
- no-till

- conventional till

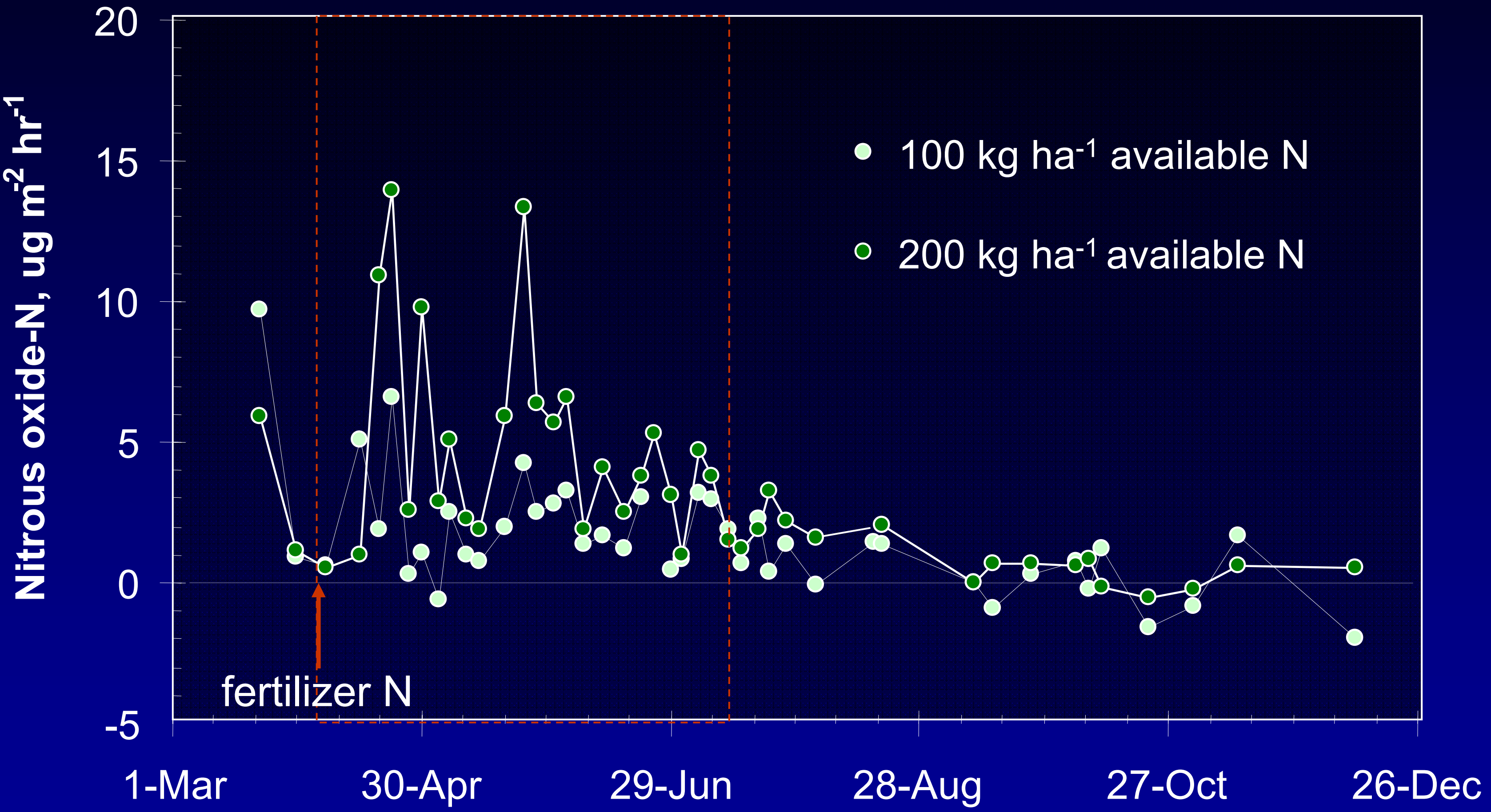
Nitrous oxide sampling procedure

<u>vented chamber techniques</u>

N_2O sampling procedure

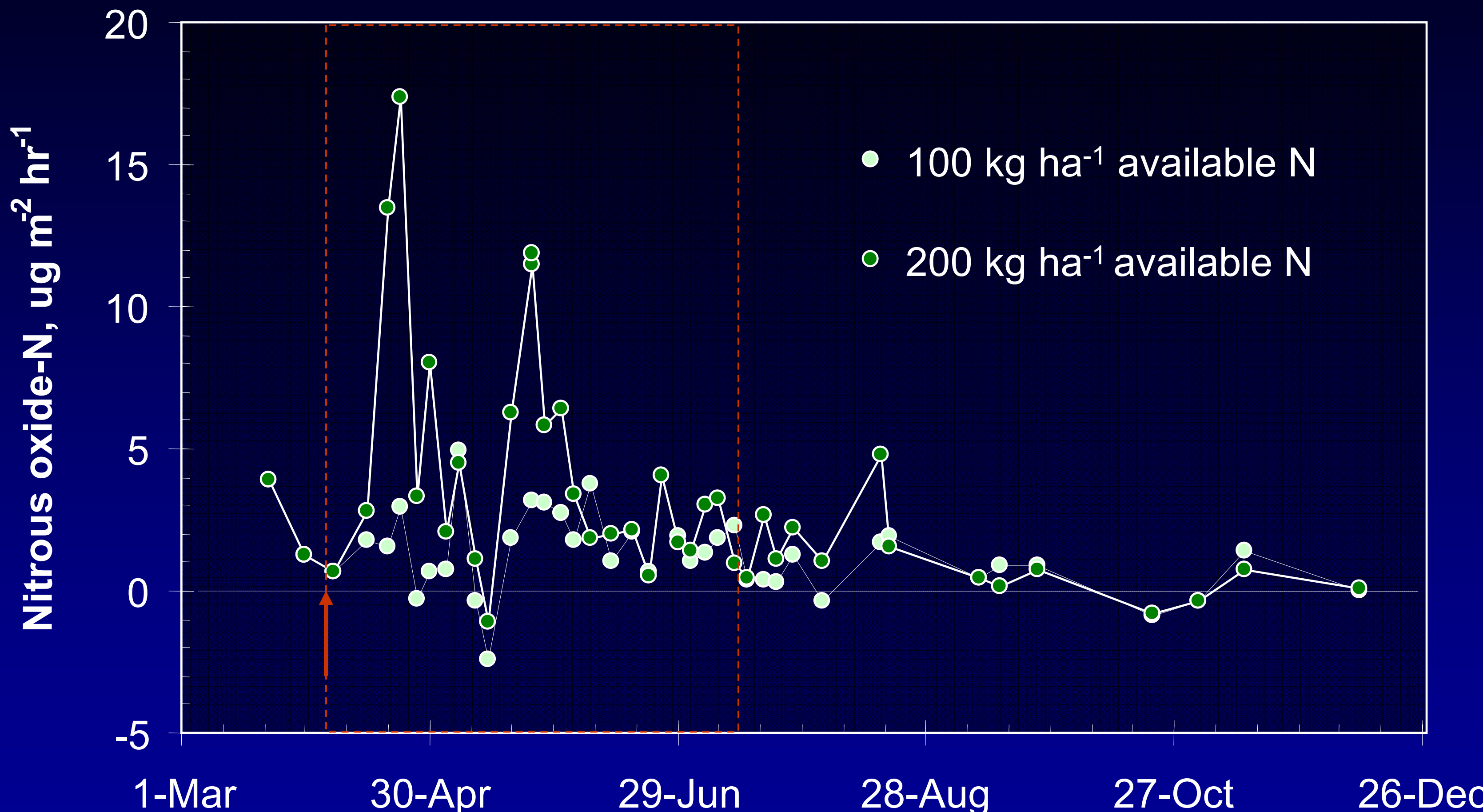


Fallow-wheat (conventional)



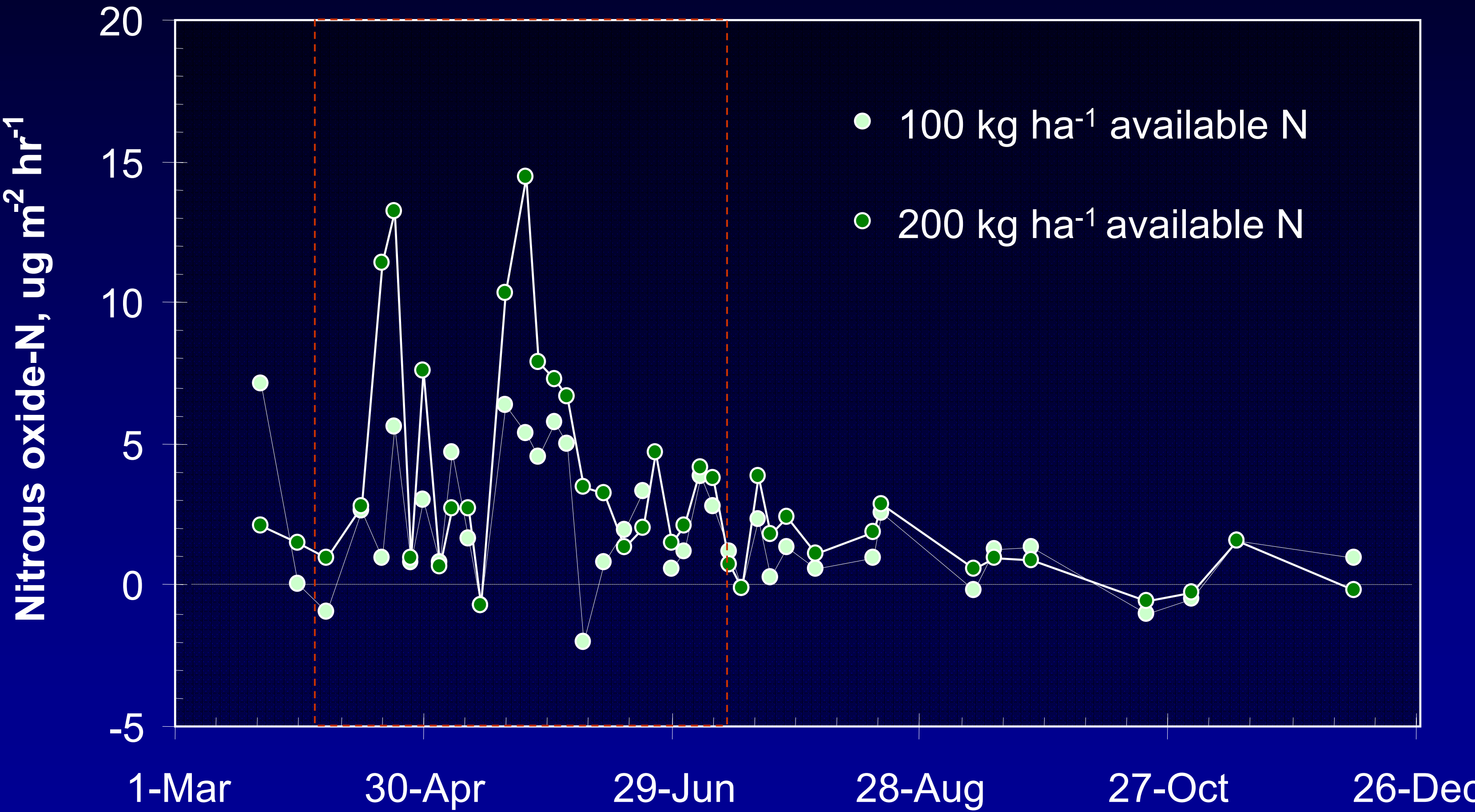
- ***most of emission activity occurred over 10 wk period following fertilization***

Fallow-wheat (no-till)



- ***Emissions under conventional till = no-till for 2004 sampling period***

Spring pea-wheat (no-till)



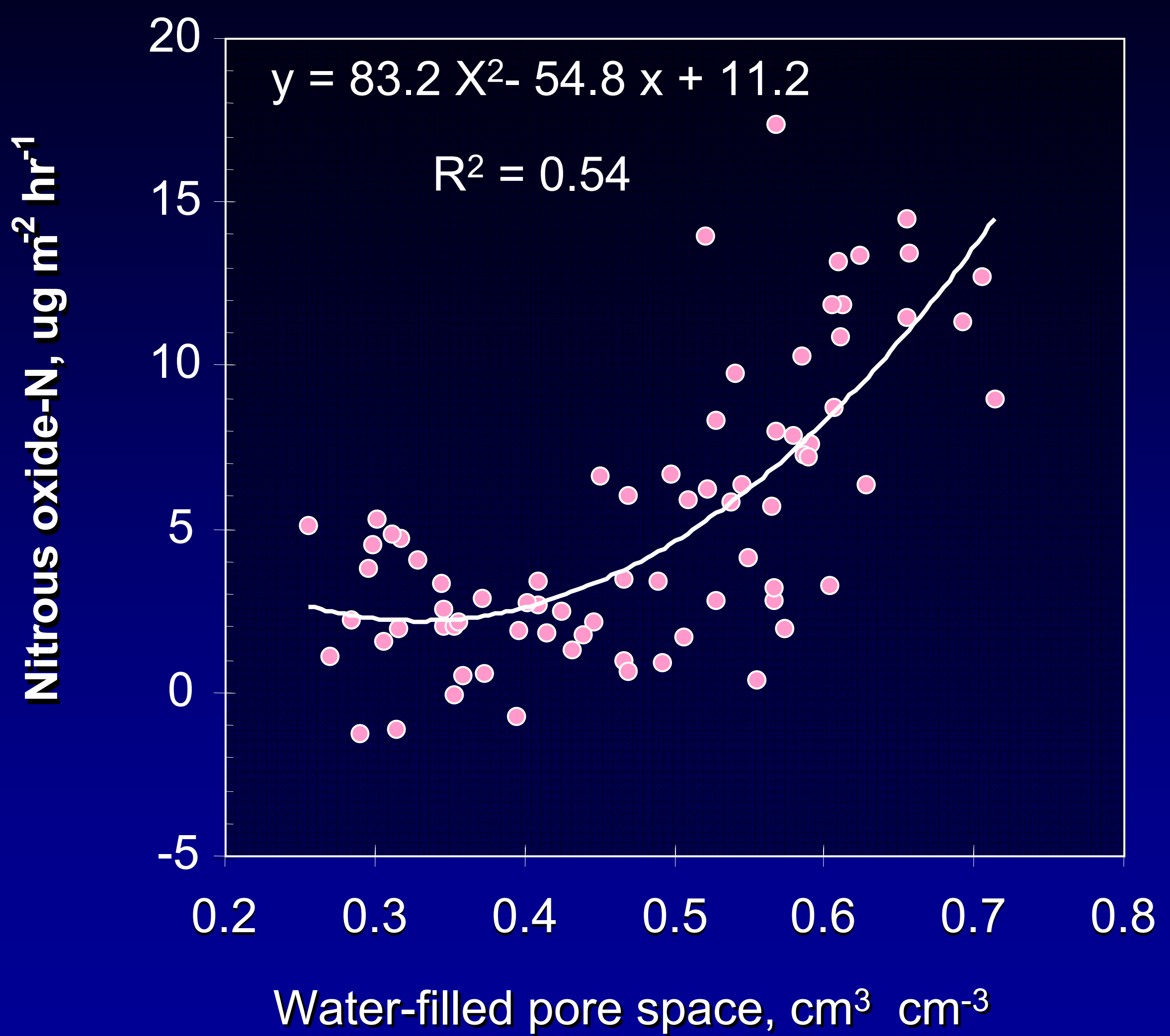
- *emissions from diversified rotations = summer-fallow > continuous wheat*

Summary of N_2O emission for high available N (200 kg ha^{-1}) - 2004

Cropping system	Total for period measure	10 wks post-N	Fraction lost in 10 wks
	---------- gm N_2O-N ha^{-1} ----------		%
fallow-wheat (conv)	134	95	70.9
fallow-wheat (NT)	116	84	72.1
wheat-wheat (NT)	70*	49*	72.5
spr pea-wheat (NT)	134	93	69.9
winter pea-wheat (NT)	155	87	57.2
LSD (0.05)	34.9	22.1	

- *emissions were generally lower at 100 kg N ha^{-1}*

Nitrous oxide flux vs. soil water



- *high available N trts only & 10-wks post N fertilization*

Calc. fertilizer N_2O induced losses

- N_2O emissions from unfertilized subplots = $N_2O_{backgrd}$
- N_2O emission from fertilized N subplots = $N_2O_{backgrd+fert}$
- Calculate difference = N_2O_{fert}
- $$\frac{N_2O_{fert}}{\text{fertilizer N}} \times 100$$

Estim. fertilizer-induced N_2O emissions - 2004

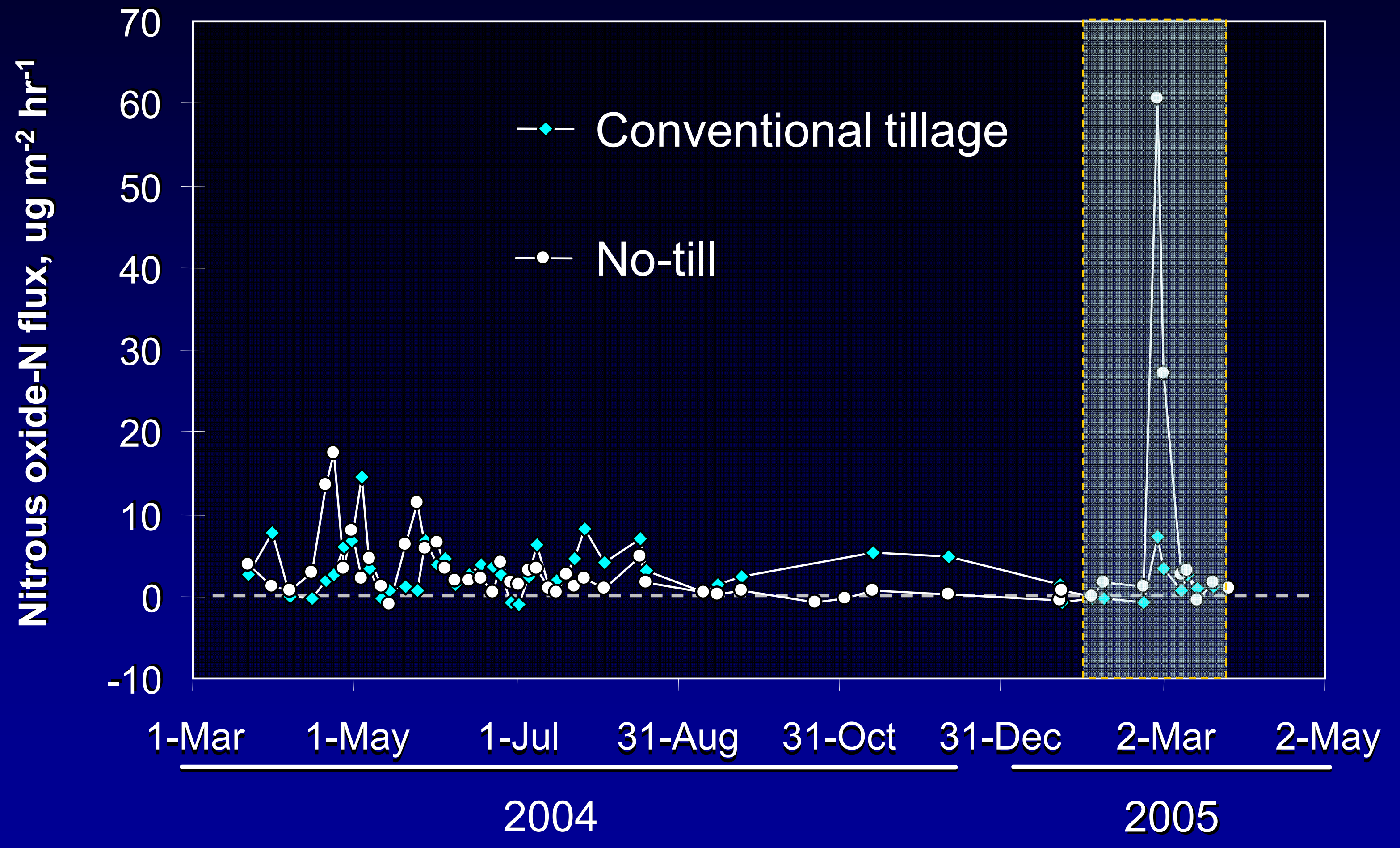
Cropping system	Fertilizer induced N_2O-N losses		IPCC predicted: measured
	gm ha^{-1}	% applied	
fallow-wheat (conv)	87	0.12	10
fallow-wheat (NT)	67	0.08	17
wheat-wheat (NT)	22*	0.02	50
spr pea-wheat (NT)	76	0.06	22
winter pea-wheat (NT)	94	0.09	13
wheat-wheat (NT)-2003	*223*	*0.22*	*5.6*

- *High available N (200 kg ha^{-1})*

Summary (outcomes & impacts)

- Emissions at two field sites are greatest following N fertilization (7-10 wks) = 70% of total
- Emissions for no-till ≈ conv. till *
- Emissions wheat-wheat < fallow-wheat & pea-wheat
- Fertilizer N induced emissions an order of magnitude below IPCC predictions (1.25% default value) were common at Bozeman; Conrad ranged from 0.10 to 0.20%
- Consistent with results with results from semi-arid prairies in Canada

Fallow-wheat (conv. till vs. no-till)



Presentations

- Engel, R. M. Dusenbury, P. Miller, and R. Lemke. 2005. A first check of nitrous oxide emissions under cropping systems adapted for the Northern Great Plains. Proc. Western Nutrient Management Conf.   3-4 March. Salt Lake City, UT.

- Dusenbury, M.P, R.E. Engel, P. Miller and R. Lemke. 2005. Nitrous oxide emission from soils under cropping systems adapted for the semi-arid Northern Great Plains. USDA Symposium on Greenhouse Gases and Carbon Sequestration in Agriculture and Forestry. 21-24 March. Baltimore, MD.

- Dusenbury, M.P, R.E. Engel, P. Miller, and R. Lemke. 2005 Soil nitrous oxide emissions as influenced by fertilization and cropping systems in the Northern Great Plains.   WSCS, CSSA, WWW Joint Summer Conference. 19-22 June. Bozeman, MT.

Progress – new equipment

- Varian 3800 GC with combi-Pal autosampler
- 3 detectors (ECD, FID, TC)
- NRICGP Soil and soil biology program: 2004-35107-14951