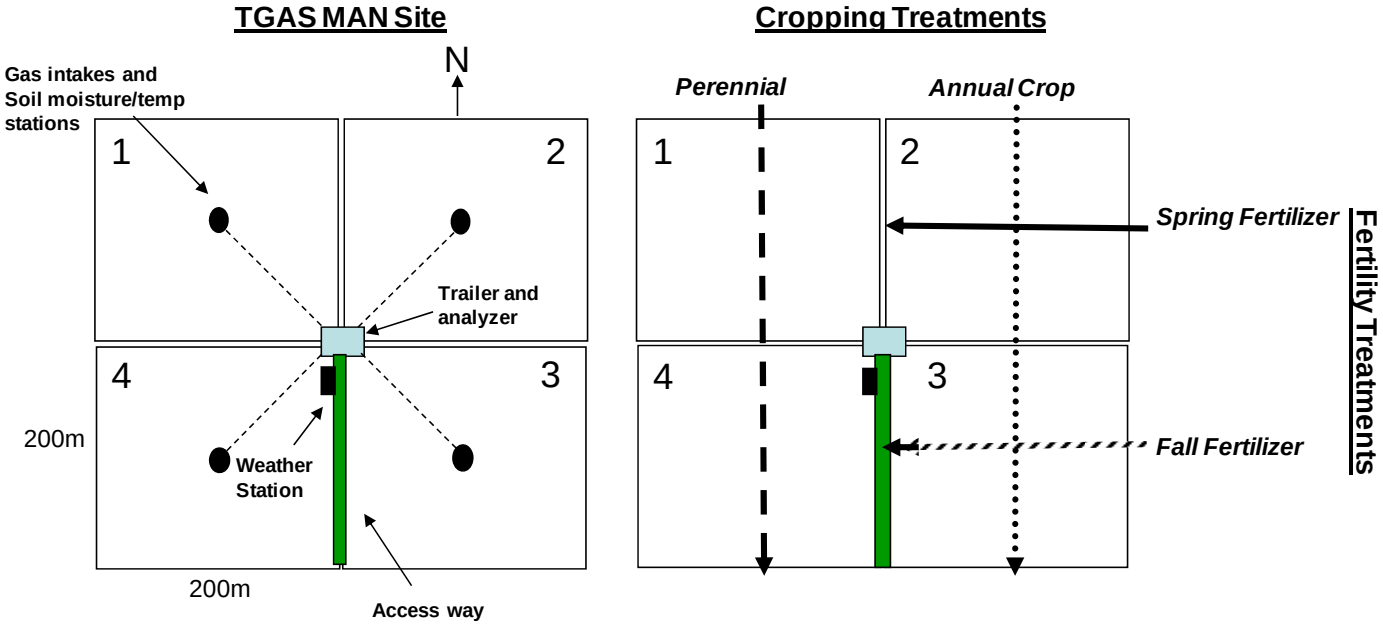
Trace Gas Manitoba (TGAS MAN) Greenhouse Gas Field Emission Site

Goal – to provide a location in Western Canada determining whole-season and multi-year soil greenhouse gas budgets of cropping and management systems

What are the Issues?

- Our concerns about global climate change are caused by the observed and predicted increases in greenhouse gases in our atmosphere.
- The main greenhouse gases (GHG) of concern are **carbon dioxide** (CO_2), **methane** (CH_4) and **nitrous oxide** (N_2O).
- Agriculture is responsible for about 10% of Canada's total greenhouse gas emissions, but this includes more than half of the N_2O emissions, and about 1/3 of the CH_4 emissions.
- CH_4 is mostly from livestock, but nitrous oxide is mostly from losses from fields associated with our need to apply fertilizers and manure to maintain productivity.
- N_2O has a greenhouse gas potential that is 300 times more powerful than carbon dioxide.
- Reducing N_2O emissions saves money and benefits the environment.
- Improved management of nitrogen such as spring application, banding, and slow-release products can reduce N_2O emissions, but by how much?
- Crop selection choices impacts soil C sequestration. Perennial crops may store carbon and when included in rotations allow creation of GHG neutral production systems.



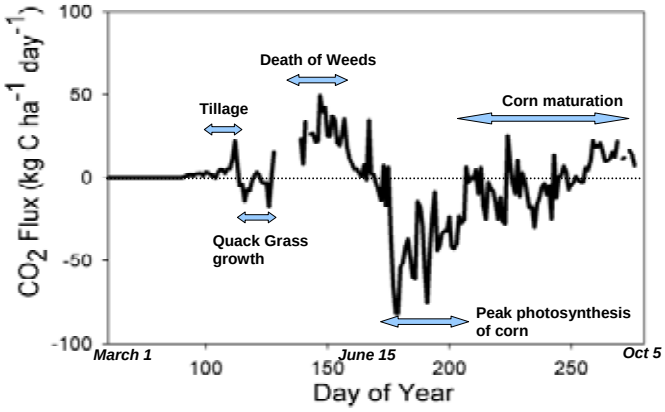
What are we doing?

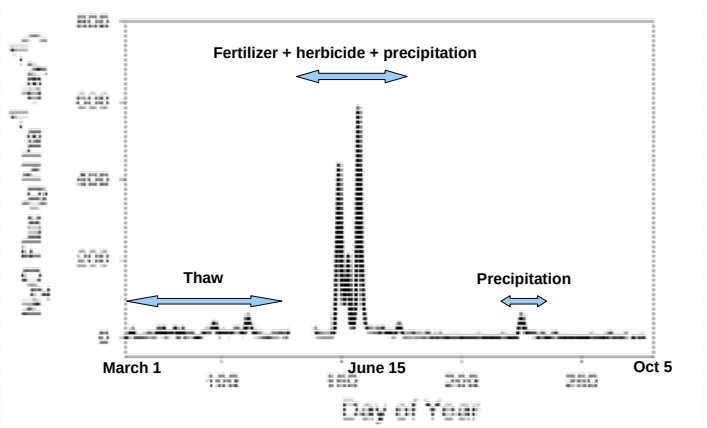
- Quantify the emissions of N_2O CO_2: how does the emission relate to climate, soil type, cropping system and form of nitrogen application?
- Direct measurement method using tunable diode laser instrument: measure direct emissions from the field continuously.
- Experiment has 4 very large plots being monitored since fall 2005. Annual plots have been in rotation of 2005-fallow, 2006-corn, 2007-faba, 2008-wheat, 2009-rapeseed, 2010-barley, 2011-wheat, 2012-corn, 2013, soybean, 2014-wheat. The perennial plots have been in

rotation of 2005-fallow, 2006-corn, 2007-faba, 2008 through 2011-alfalfa/grass and then into the same crops as the annual rotation.

- Track GHG budgets and soil health during perennial phase (4 years) and conversion phase of perennial to annual cropping.
- Determine effect of anhydrous ammonia application in fall and spring on N_2O emissions.

Example of Results at the Research Site in 2006





The above figures show daily average fluxes of carbon dioxide (CO_2) and nitrous oxide (N_2O) at the TGAS MAN site for March through October 2006. Positive values represent a net gaseous flux from the soil-crop system into the atmosphere, negative values represent net uptake by the crop system. Events occurring during the period affecting both gases are indicated.

What will be the outcome?

- Continuous measurements tell us what is really happening: N_2O emissions are episodic with the high emissions occurring during fertilization and precipitation events, the annual rotation is losing carbon.
- But what are the biological processes controlling this, and can we change them?
- Does spring fertilizer application reduce emissions?
- Do perennial cropping systems reduce GHG emissions?
- Does the benefit of perennial cropping carry into the conversion phase to annual cropping?
- This is the only site in western Canada where N_2O and CO_2 emissions are measured continuously from an agricultural field.
- Inclusion of the perennial legume forage reduced N_2O emissions because of lack of synthetic fertilizer addition. Apparently, biological N fixation of the alfalfa of the order of 100-200 kg N ha^{-1} y^{-1} did not produce N_2O.
- Harvest removal of grain, straw, silage and hay resulted in net negative loss of C from soil. The losses are low (< 1 Mg C ha^{-1}), but nevertheless show soils in the Red River Valley are not gaining or neutral losses of C.
- The perennial legume forage did help reduce the loss of C.
- The termination of the perennial legume forage resulted in accelerated loss of C from soil as CO_2 emission thus some of the gain of C during the years of the forage was lost soon after transition to annual cropping.

Who supports this research?

- National Science and Engineering Research Council (NSERC) Discovery Grant Program, Canada Research Chair Program in Applied Soil Ecology, Canadian Fertilizer Institute, Manitoba Rural Adaptation Council, the AAFC Agriculture Greenhouse Gas Program.
- Canada Foundation for Innovation for NCLE

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visit http://www.umanitoba.ca/afs/ncle/index.html

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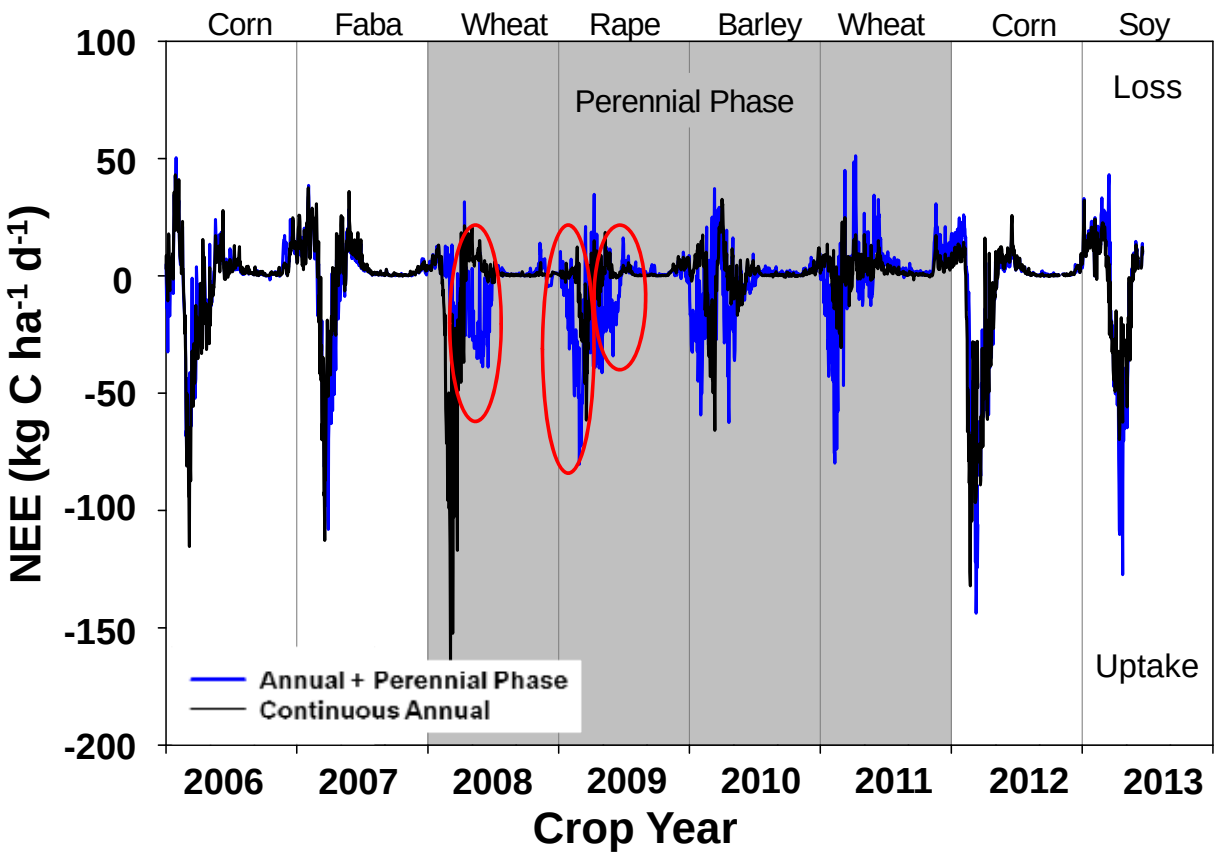
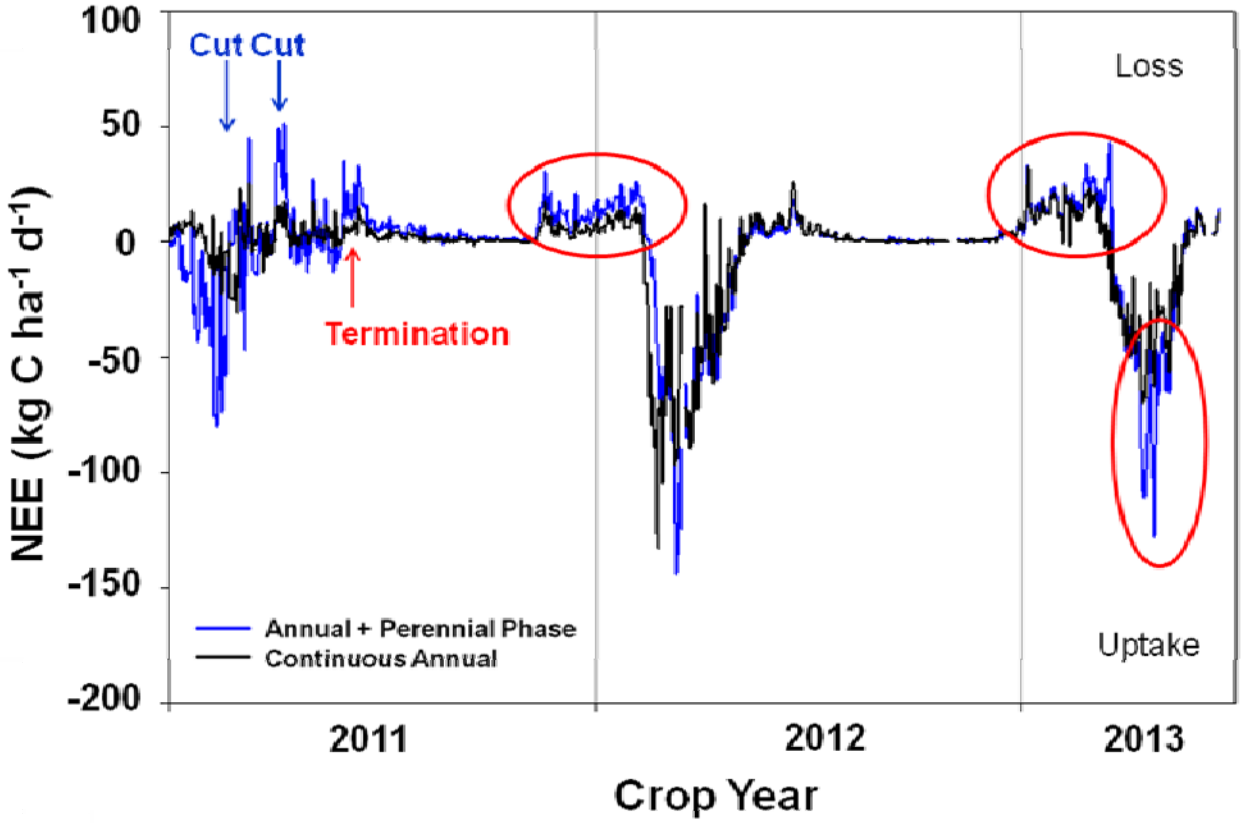
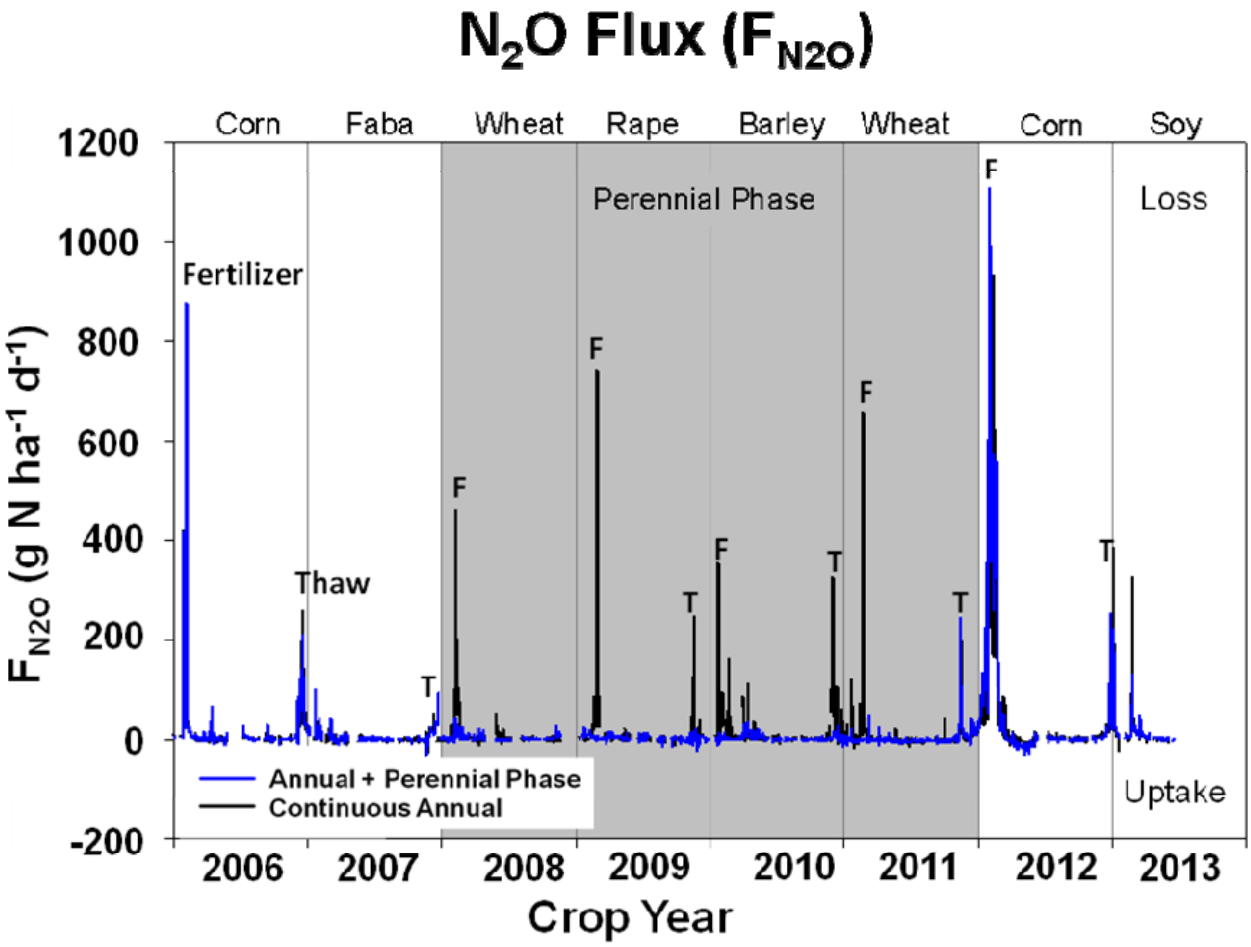
CO_2 Flux (NEE)

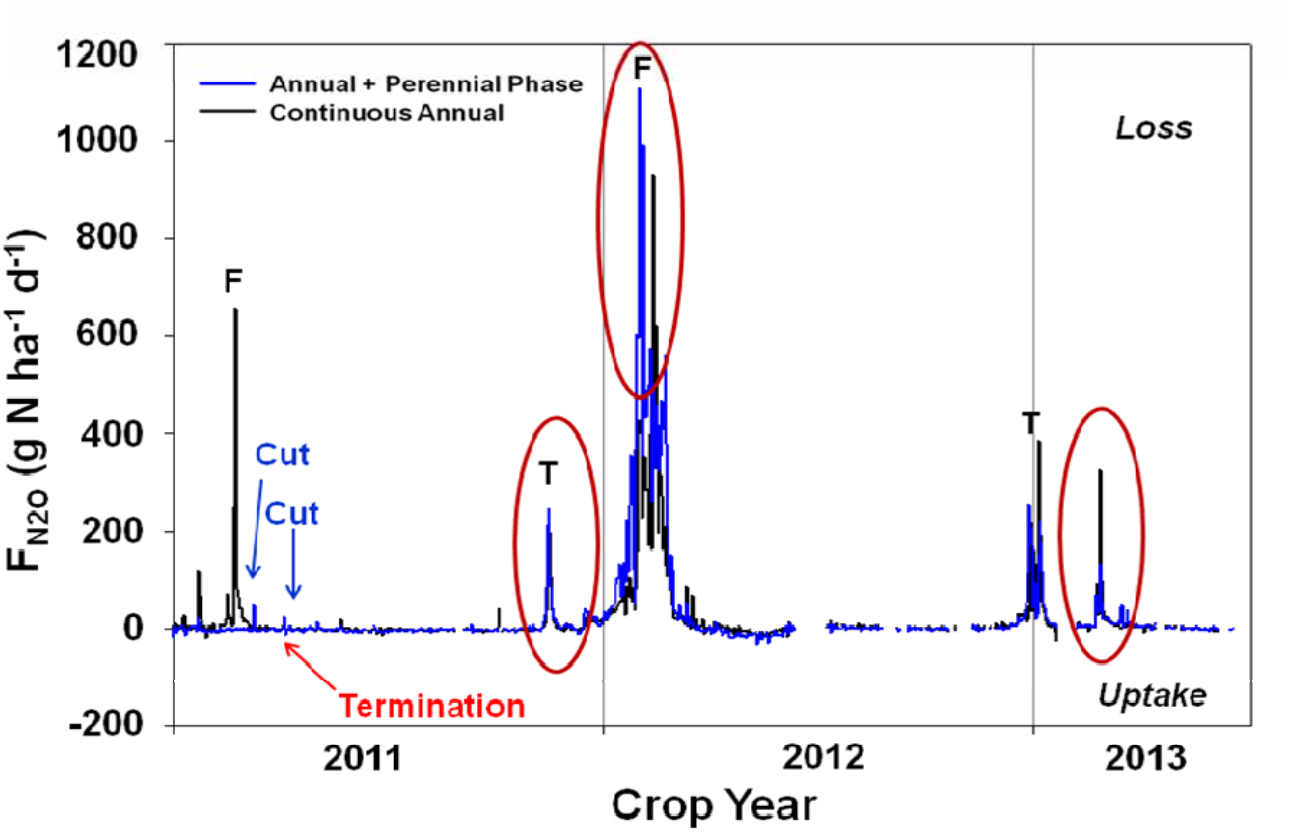

Corn
Faba
Wheat
Rape
Barley
Wheat
Corn
Soy
Perennial Phase
Loss
Uptake
100
50
0
-50
-100
-150
-200
NEE (kg C ha-1 d-1)
Annual + Perennial Phase
Continuous Annual
2006
2007
2008
2009
2010
2011
2012
2013
Crop Year

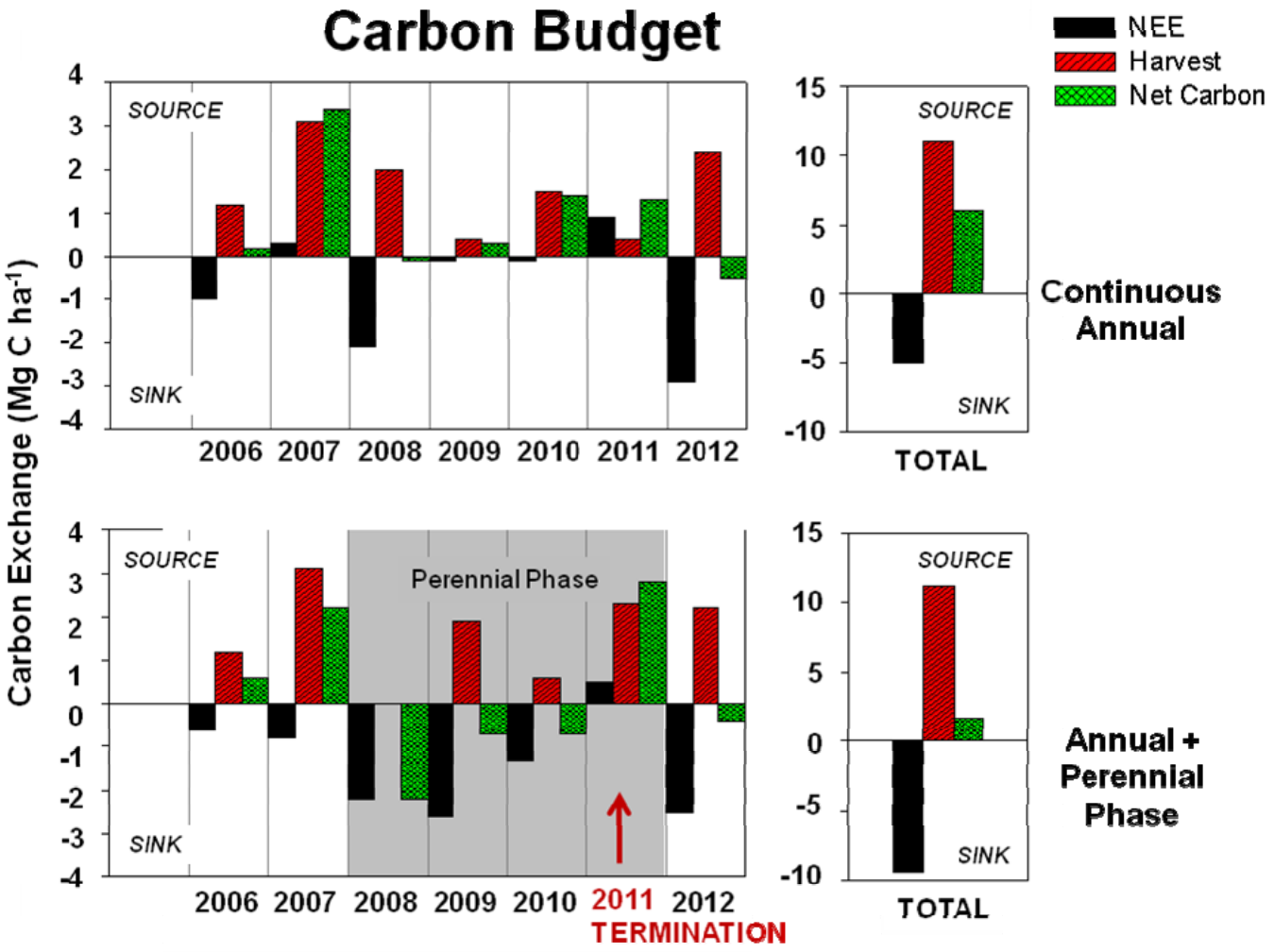
CO_2 Flux (NEE) Perennial Termination

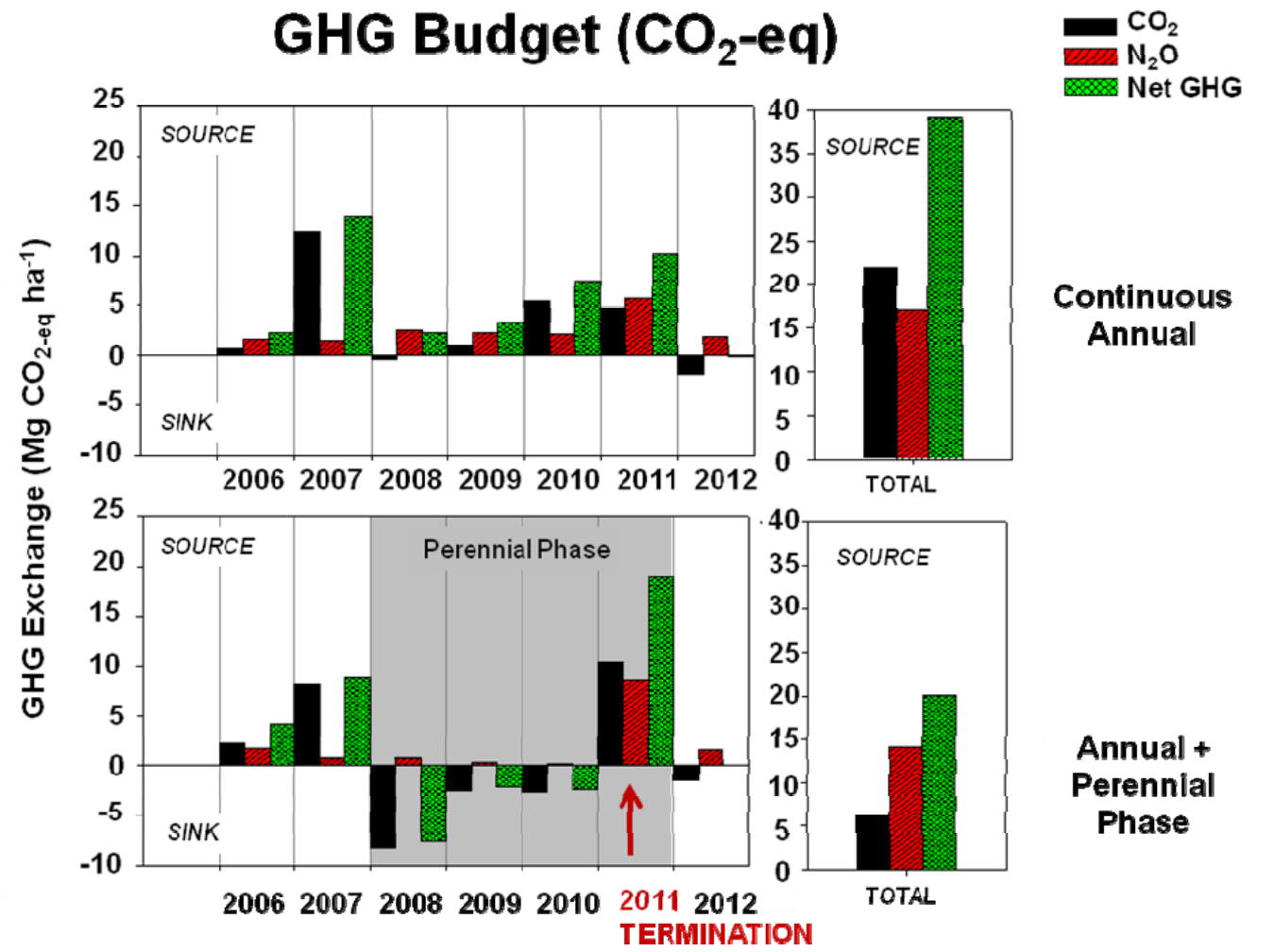



N2O Flux (FN2O)
Corn
Faba
Wheat
Rape
Barley
Wheat
Corn
Soy
Perennial Phase
Loss
Fertilizer
Thaw
Uptake
F
T
Annual + Perennial Phase
Continuous Annual
FN2O (g N ha-1 d-1)
1200
1000
800
600
400
200
0
-200
2006
2007
2008
2009
2010
2011
2012
2013
Crop Year

N_2O Flux (F_{N2O}) Perennial Termination




Carbon Budget
NEE
Harvest
Net Carbon
Carbon Exchange (Mg C ha-1)
SOURCE
SINK
2006 2007 2008 2009 2010 2011 2012
TOTAL
Continuous Annual
Perennial Phase
TERMINATION
Annual + Perennial Phase


GHG Budget (CO_2-eq)
CO_2
N_2O
Net GHG
GHG Exchange (Mg CO_{2-eq} ha^{-1})
SOURCE
SINK
2006 2007 2008 2009 2010 2011 2012
TOTAL
Continuous Annual
Perennial Phase
TERMINATION
Annual + Perennial Phase