Mitigation Options in Agricultural Soils

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Changing Agricultural Practices Can Produce GHG Offsets in 2 Ways

Reduce Direct GHG Emissions:

- Precision **nitrogen fertilizer use** reduces N_2O and CO_2
- **Inhibitors** and **diet manipulation** can reduce lower N_2O emissions
- **Clover** can reduce fert. inputs
- **Fuel use** reductions lower CO_2 emissions
- **Biofuel** reduces use of CO_2-intensive fossil fuels

Sequester Carbon:

- No or low **tillage**
- Diversified **rotations**
- Winter **cover crops**
- Change **soil inputs**
- Improved **grazing** practices
- **Convert** marginal agricultural land to grassland or forest

Teagasc Research Objectives

To Assess GHG Mitigation Options

– Nitrous oxide abatement

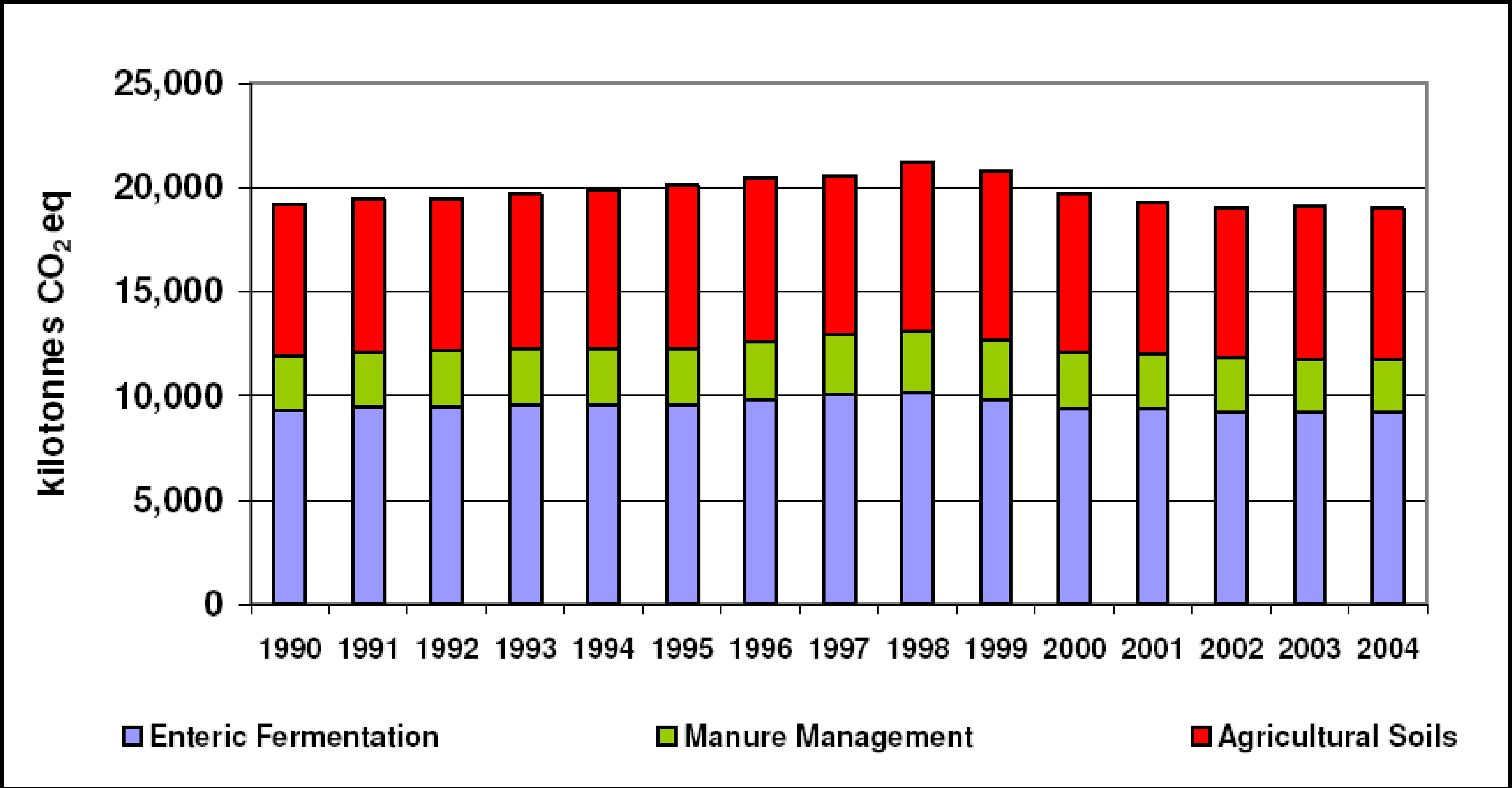
– Carbon sequestration

All set in the context of maintaining production potential

Nitrous Oxide

- ***Sources:***
  - Soils
  - Animal excreta
  - Legumes
  - Fertiliser

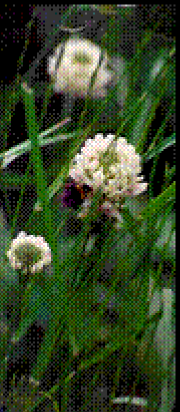
- ***Why is it important?***
  - 6.7Mt CO2-eq is from Agriculture Soils
  - N_2O lasts in the atmosphere for well over **118 ± 25 years**
  - N_2O not rapidly deposited like NO_x or NH_3.
  - GWP of 310 times that of CO_2
    - Direct infrared radiative forcing of 206 times that of CO_2 per molecule (Stein, 2003) - **troposphere**
    - Some N_2O makes its way up into the **stratosphere** where it is converted to nitric oxide through photolysis - which acts as a catalyst in the reactions in which chlorine and bromine destroy O_3.
  - A loss of N from the soil/plant/animal system = reduced efficiency



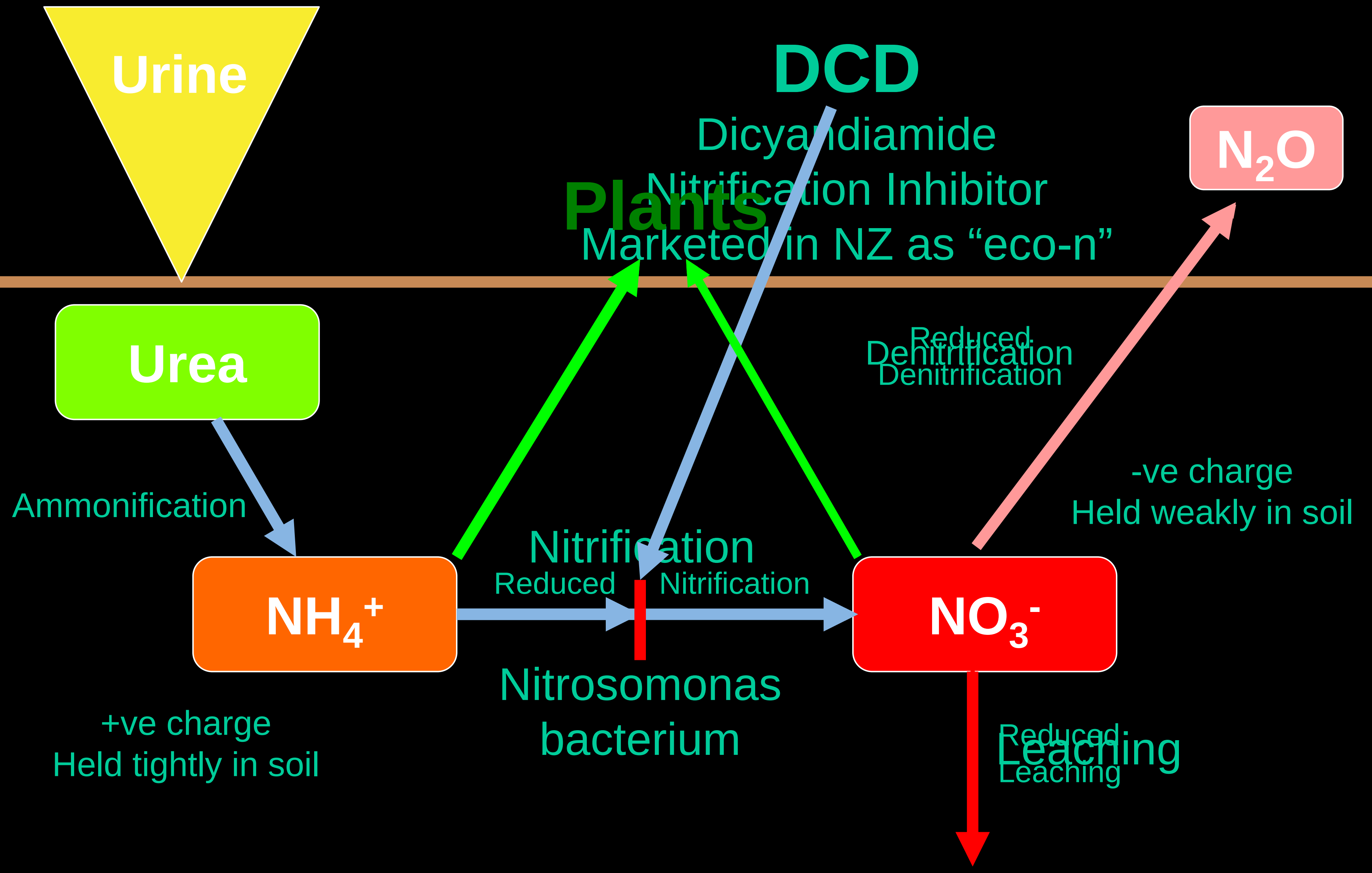
Source: NIR 2006, EPA

N_2O mitigation options – Teagasc Research

- Nitrification (DCD) & urease inhibitors in pasture and tillage
- Reduction in N excreted from animals
- Clover pastures
- Increasing N efficiency:
  - Use of alternative land-spreading strategies, timing of slurries, amendment of slurries




DCD


Urine
DCD
Dicyandiamide
Nitrification Inhibitor
Marketed in NZ as “eco-n”
Plants
N$_2$O
Urea
Reduced
Denitrification
Denitrification
Ammonification
-ve charge
Held weakly in soil
Nitrification
Reduced
Nitrification
NH$_4^+$
NO$_3^-$
Nitrosomonas
bacterium
+ve charge
Held tightly in soil
Reduced
Leaching
Leaching

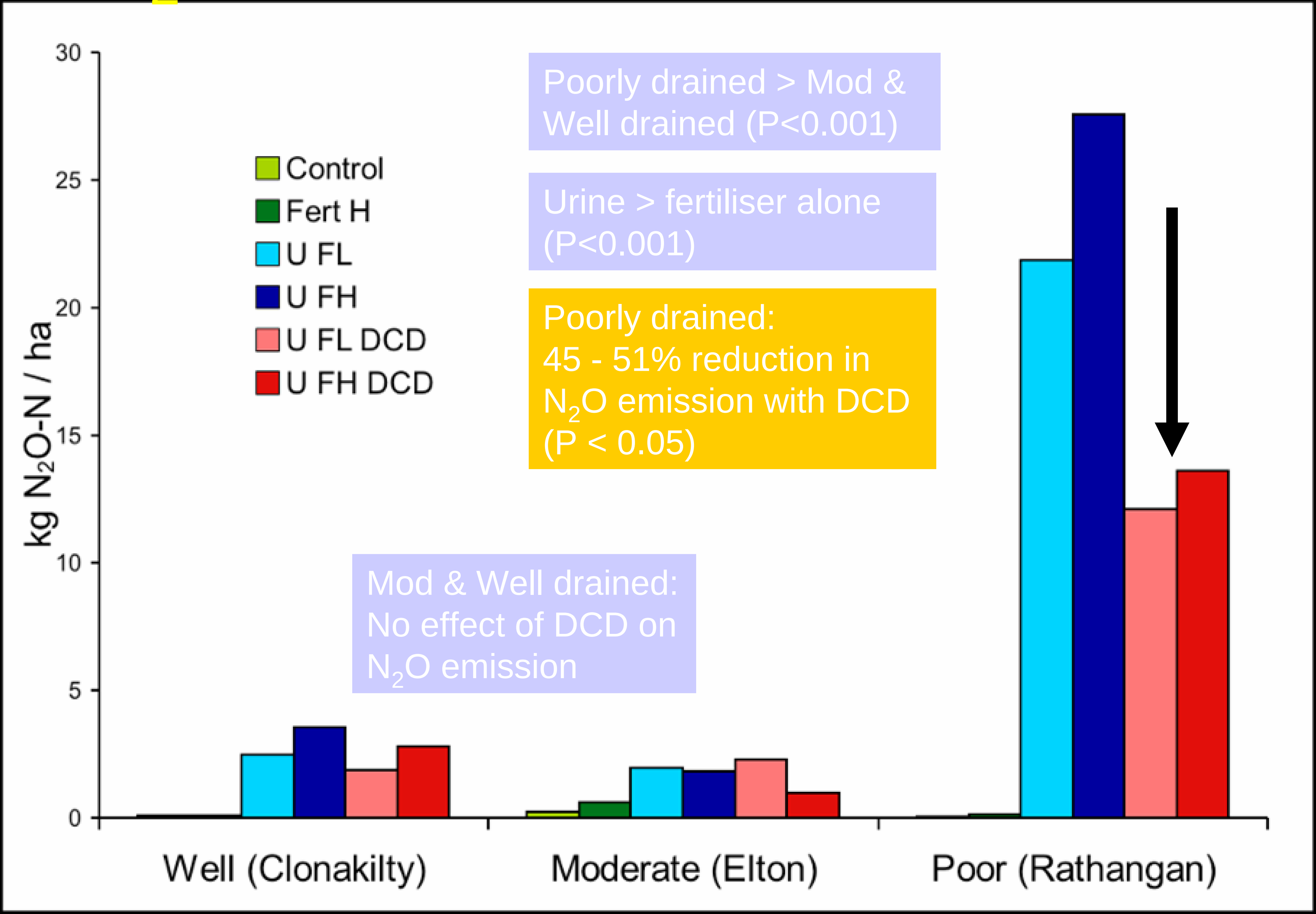
N_2O emission from grassland

- Cow urine patch major source
  - Fertiliser 100 - 300 kg N ha^{-1}
    - Small applications over year
  - Urine 300 - 1000 kg N ha^{-1}
    - One large application, plus fertiliser
    - Large quantity of N available to be lost
- Higher stocking rate
  - more urine patches
- Expect
  - High losses from poorly drained soil
  - Lower losses from well drained soil

Methodology

- N_2O emission
  - Closed chamber technique
  - 2 - 3 measurements per week when emissions high
  - Weekly measurements thereafter

N_2O emission Nov 06 - Mar 07



Use of urease/DCD in combination with urea

Objectives

- To evaluate the influence of urea size with or without urease either alone or coupled with nitrification inhibitors on:

- N transformations
- N_2O emissions

DCD/UI in tillage

- Application in association with NIT and CP, residue incorporation, cover cropping
- Timing of application

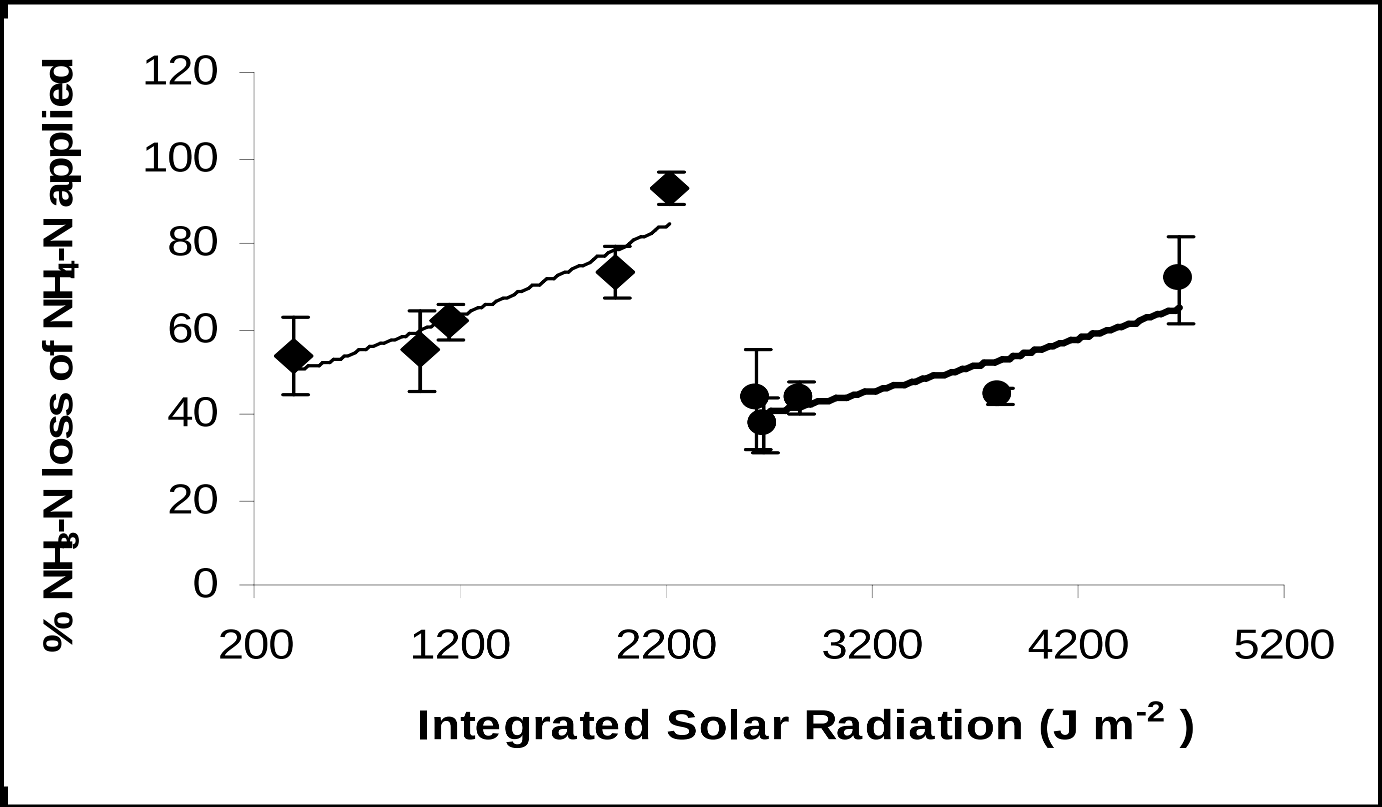
Urea size with or without inhibitors	Under cropped conditions			
	Relative loss of added N (%)	Increase (+)/decrease (-) over urea size (%)		
		PU	GU	USG
PU	0.16			-42
GU	0.23	42		-16
USG	0.27	69	-17	
UI_GU	0.12	-23	-47	-55
UNI_GU	0.11	-31	-52	-59
$LSD_{0.05}$	0.20			

N efficiency

- Ammonia-N volatilised during landspreading can be re-deposited
- Associated ‘Fugitive’ N_2O emissions
- Reducing ammonia emissions = larger N pools….maybe higher N_2O emissions

Teagasc Research

- Land-spreading techniques (trailing shoe vs. splashplate)
- Spring vs. summer application
- Addition of slow release gels containing UI



- Consistently lower emissions associated with trailing shoe (average reduction = 28.9%)
- Lower emissions associated with early spreading for both application techniques.
- Associated GHG emissions will be investigated

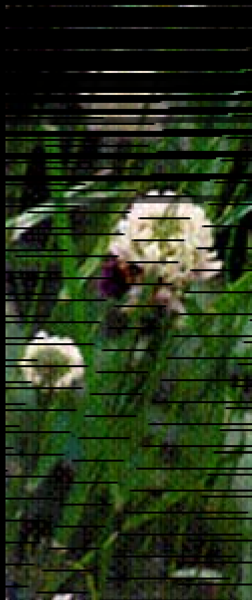
Clover

- Increases digestibility – less methane
- Legumes fix atm. N reducing the need for inorganic N fertilizer
- Clover pastures may be effective at C sequestration

Research

- Quantify the EF associated with clover

In pasture mixes



Animal diet

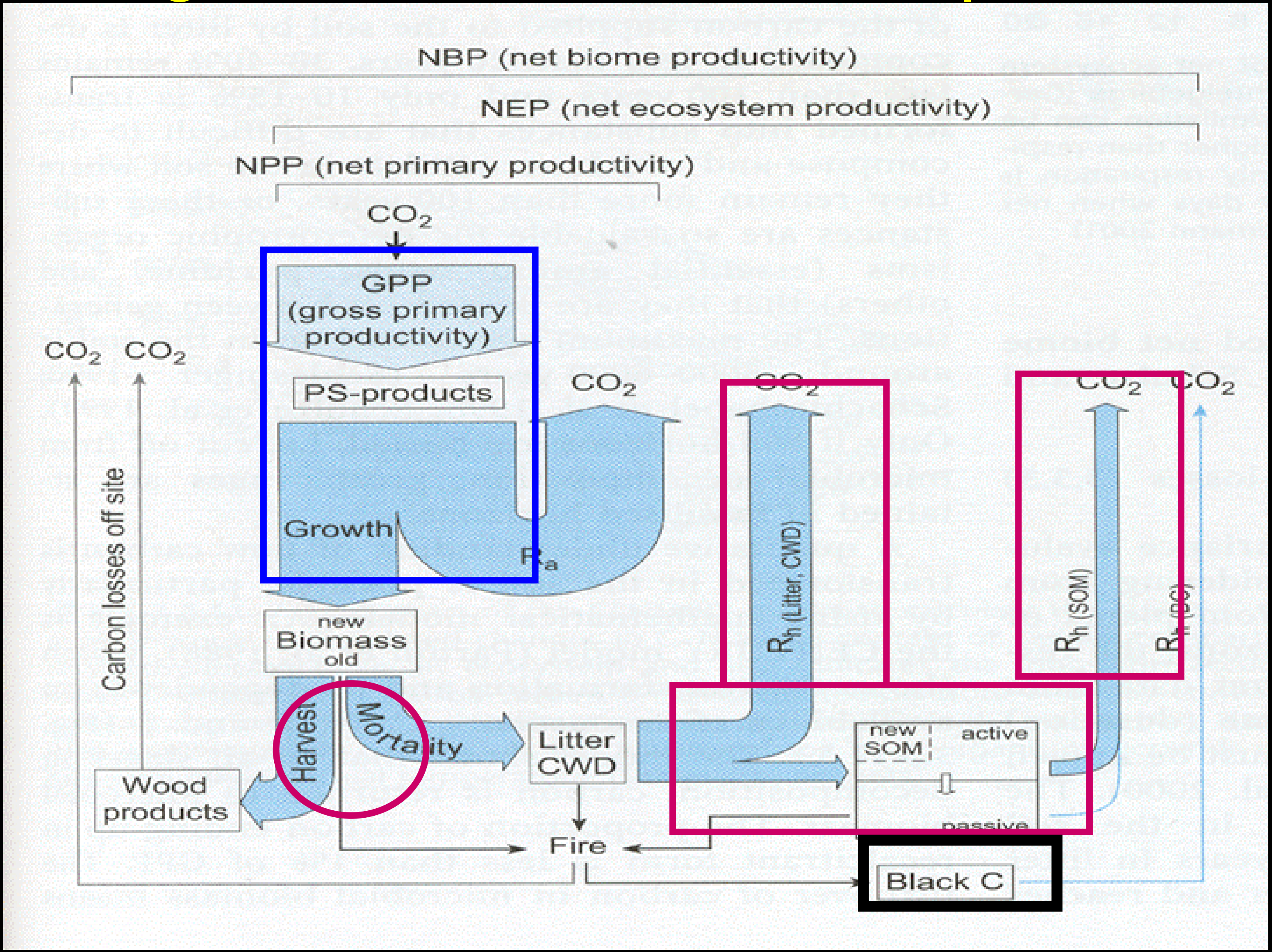
- Investigate the effects of diet manipulation on urine/faecal N
- Obtain N_2O emission factors over a urine N response curve

Soil carbon sequestration

- Carbon sequestration implies transferring atmospheric CO_2 into non-labile pools and storing it securely so it is not immediately re-emitted

1. Additionality and Leakage
2. Monitoring & Verification (Measuring)
3. Permanence
4. Value of Carbon

Teagasc Research – C sequestration

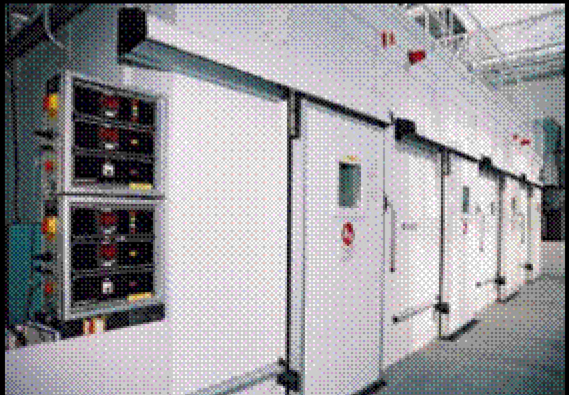


Relevance to agriculture

- Under Kyoto, ‘Sinks’ can be counted towards meeting targets.
- Absorption by sinks to be measured as verified changes in carbon stocks.
- Count net removals of carbon by afforestation, reforestation and deforestation (Article 3.3)
- Other activities, known as ‘additional human-induced’ (those relating to agricultural soils, land-use change and forestry) may be included. (Article 3.4)
- Default values are unfavourable to tillage

Teagasc Research – C sequestration

- Tillage management: NIT, cover-crops, straw incorporation
- Pasture management
- Sequestration of C in soils *via* land-use change/land-use management
- Use of biomass/biofuels?? to replace fossil fuels.
- Alternative uses for grass – biogas, biorefinery, insulation

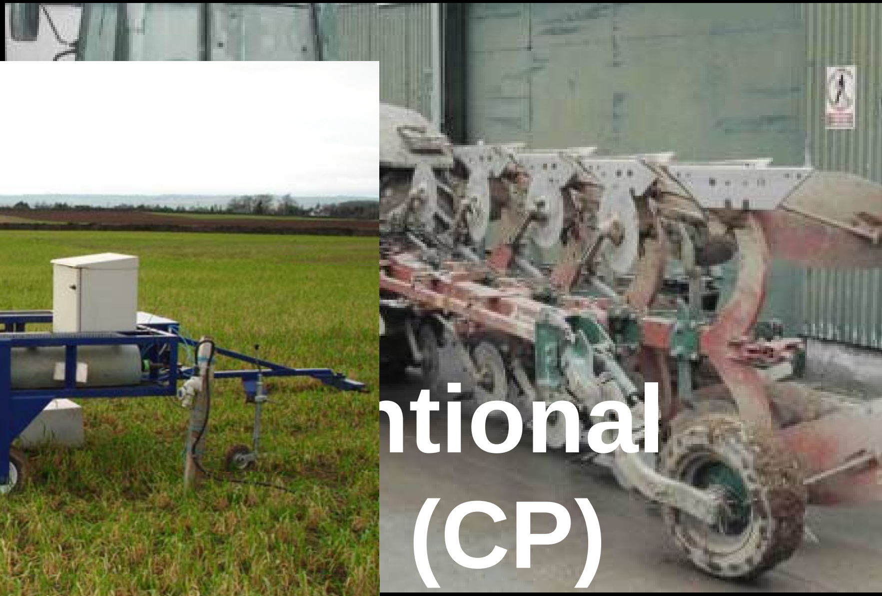




Tillage

- Can different management practices increase C sequestration: Conventional tillage and Non Inversion Tillage.
- Management factors for enhancing C sequestration in agricultural ecosystems involve increasing crop residue inputs and decreasing soil organic matter (SOM) decomposition.

Tillage Management

- Conventional ploughing (25 – 30cm) – March
- NIT (10-15cm) – August (post-harvest) & March
- Measured using eddy covariance



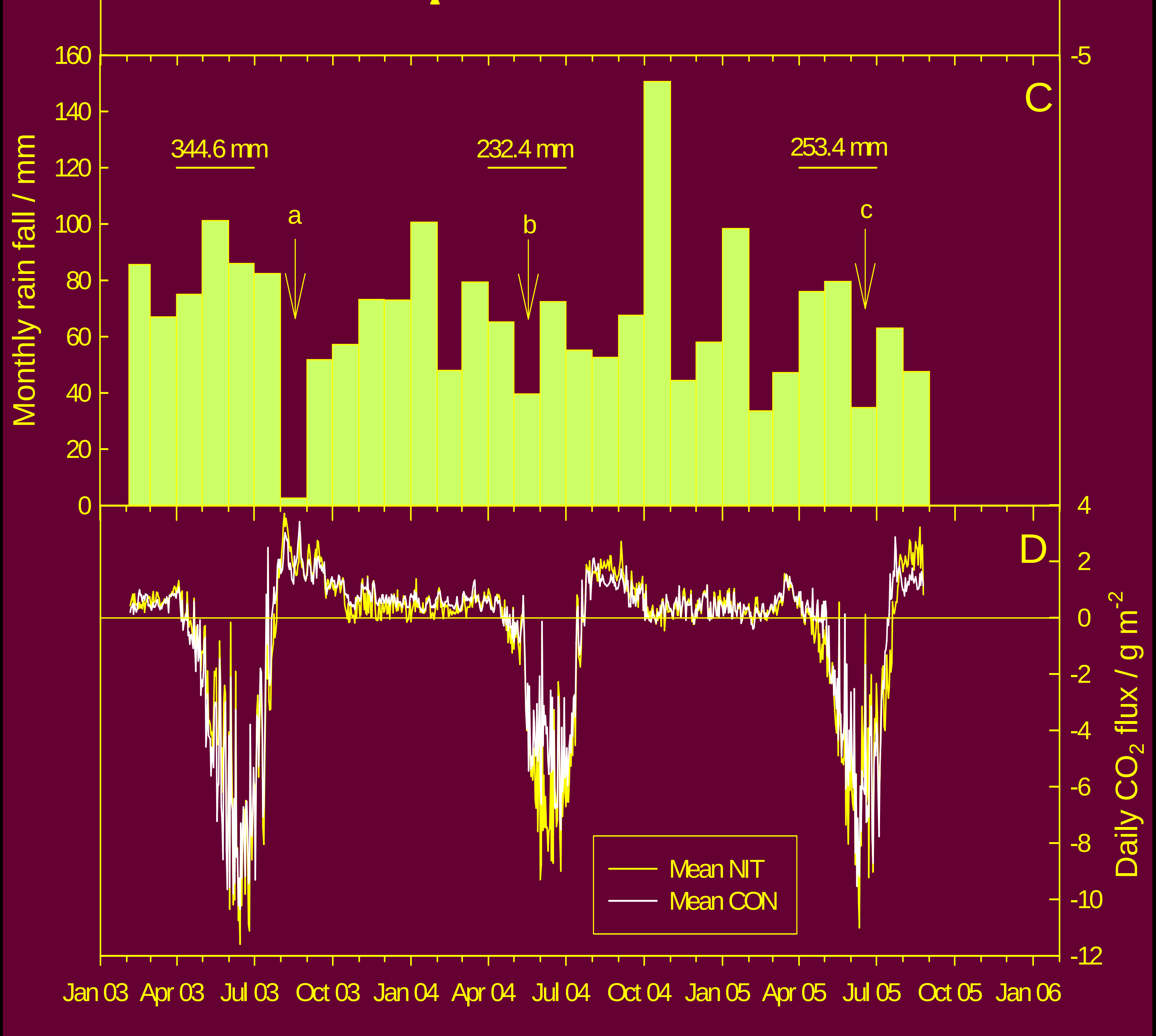
Carbon Budget

CP

	t C ha^{-1} a^{-1}
GPP	-8.87
Respiration	7.02
NEE	-1.85
C exported in grain	2.17
C emissions during tillage	0.27
NBP	0.59
NBP + N_2O	1.20

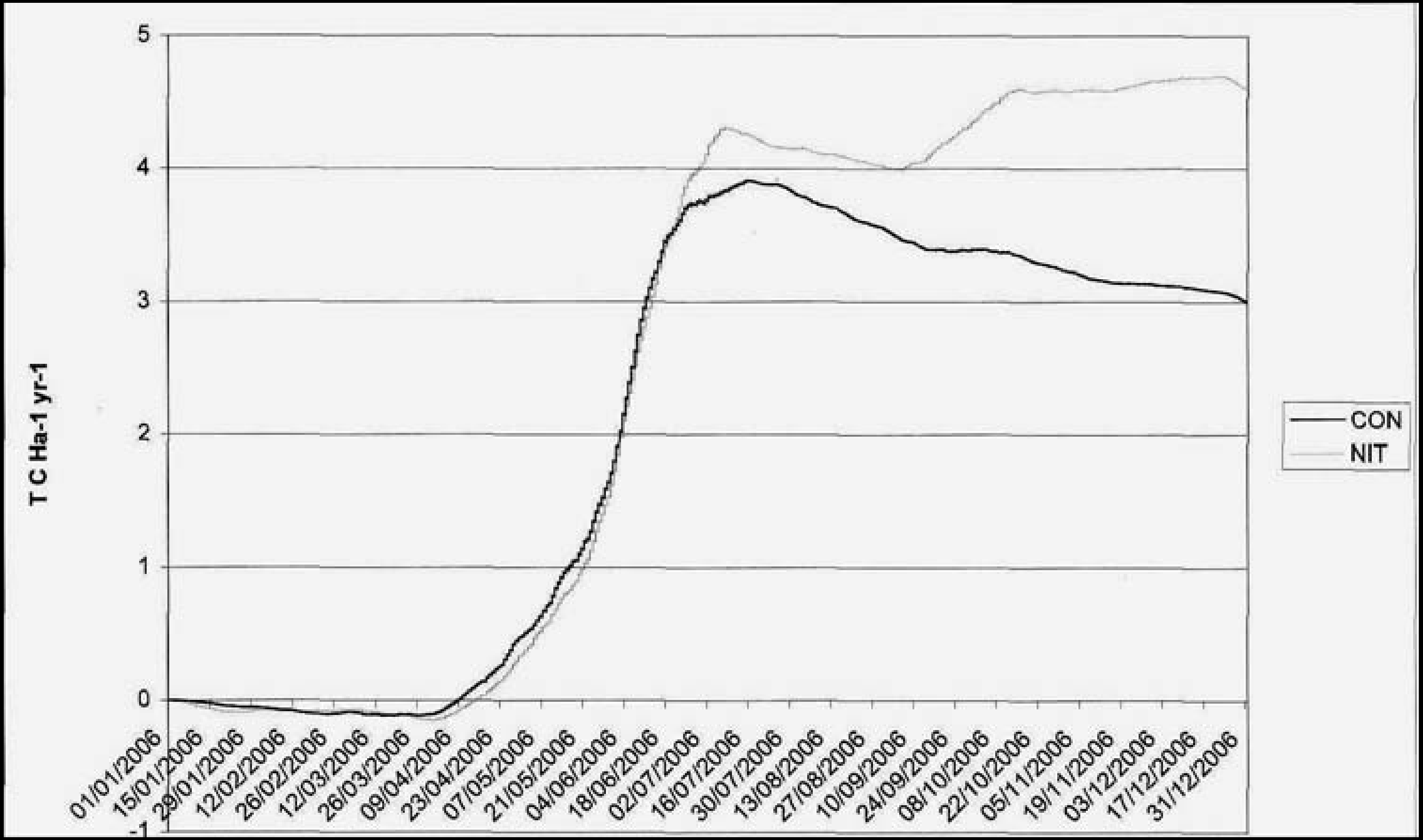
NIT

GPP	-9.00
Respiration	6.55
NEE	-2.45
C exported in grain	2.13
C emissions during tillage	0.17
NBP	-0.15
NBP + N_2O	0.46



C
D
344.6 mm
232.4 mm
253.4 mm
a
b
c
Monthly rain fall / mm
Daily CO_2 flux / g m^{-2}
Mean NIT
Mean CON
Jan 03
Apr 03
Jul 03
Oct 03
Jan 04
Apr 04
Jul 04
Oct 04
Jan 05
Apr 05
Jul 05
Oct 05
Jan 06

Cover crops



5
4
3
2
1
0
-1
T C Ha-1 yr-1
CON
NIT
01/01/2006
15/01/2006
29/01/2006
12/02/2006
26/02/2006
12/03/2006
26/03/2006
09/04/2006
23/04/2006
07/05/2006
21/05/2006
04/06/2006
18/06/2006
02/07/2006
16/07/2006
30/07/2006
13/08/2006
27/08/2006
10/09/2006
24/09/2006
08/10/2006
22/10/2006
05/11/2006
19/11/2006
03/12/2006
17/12/2006
31/12/2006

Shifting pasture to biomass

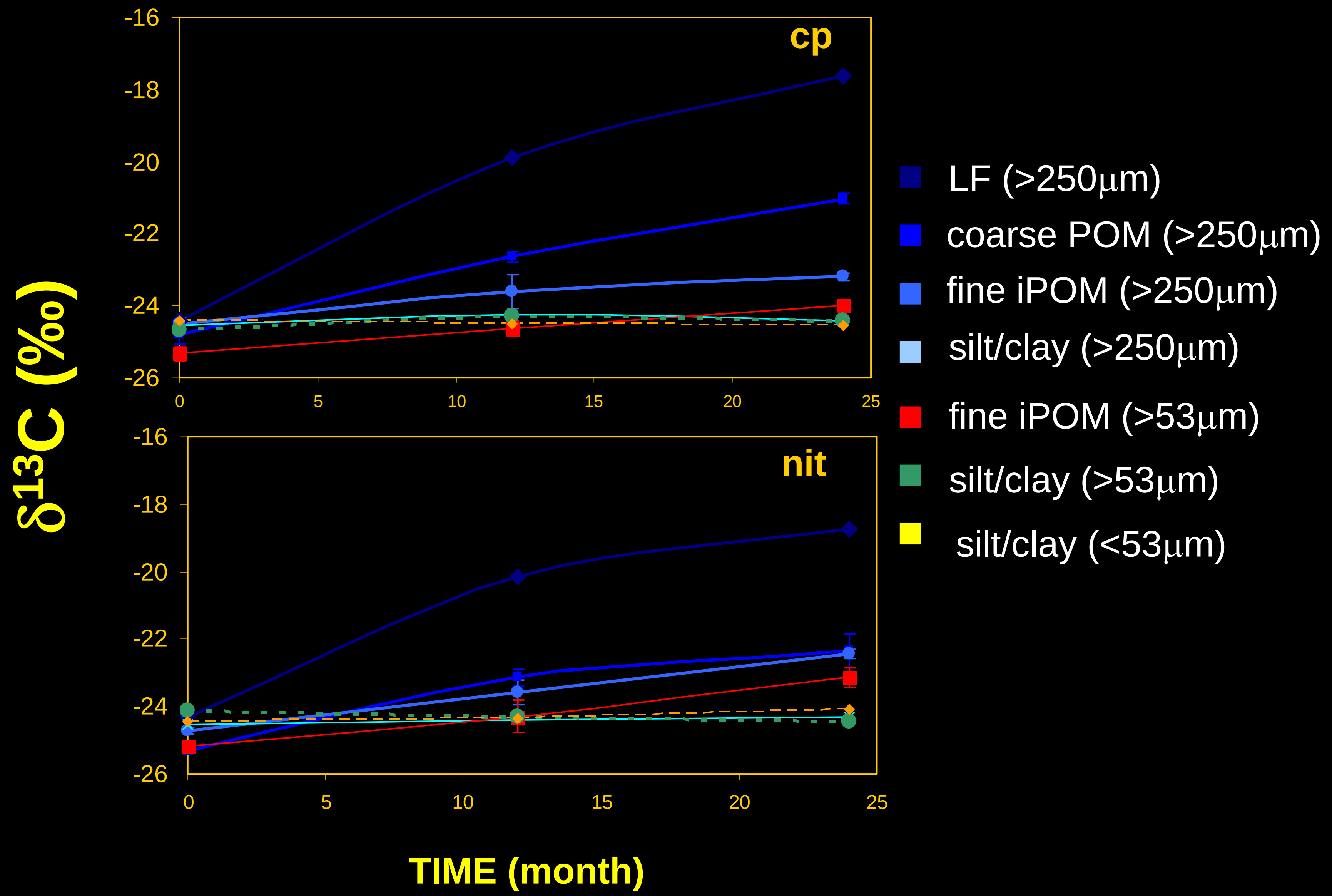
- Sequestration potential of perennial biomass crops could be high
- However SOC loss due to ploughing of pasture is high
- Assessment of GHG balance across a 'chronosequence' of crops and a range of crops – including ploughing events
- Need to include below-ground biomass

	tC ha^{-1}
Arable	**-1.69**
Grassland (Oak Park)	**-2.14**
Grassland (Johnstown)	**-3.34**
Miscanthus	**-10.27**

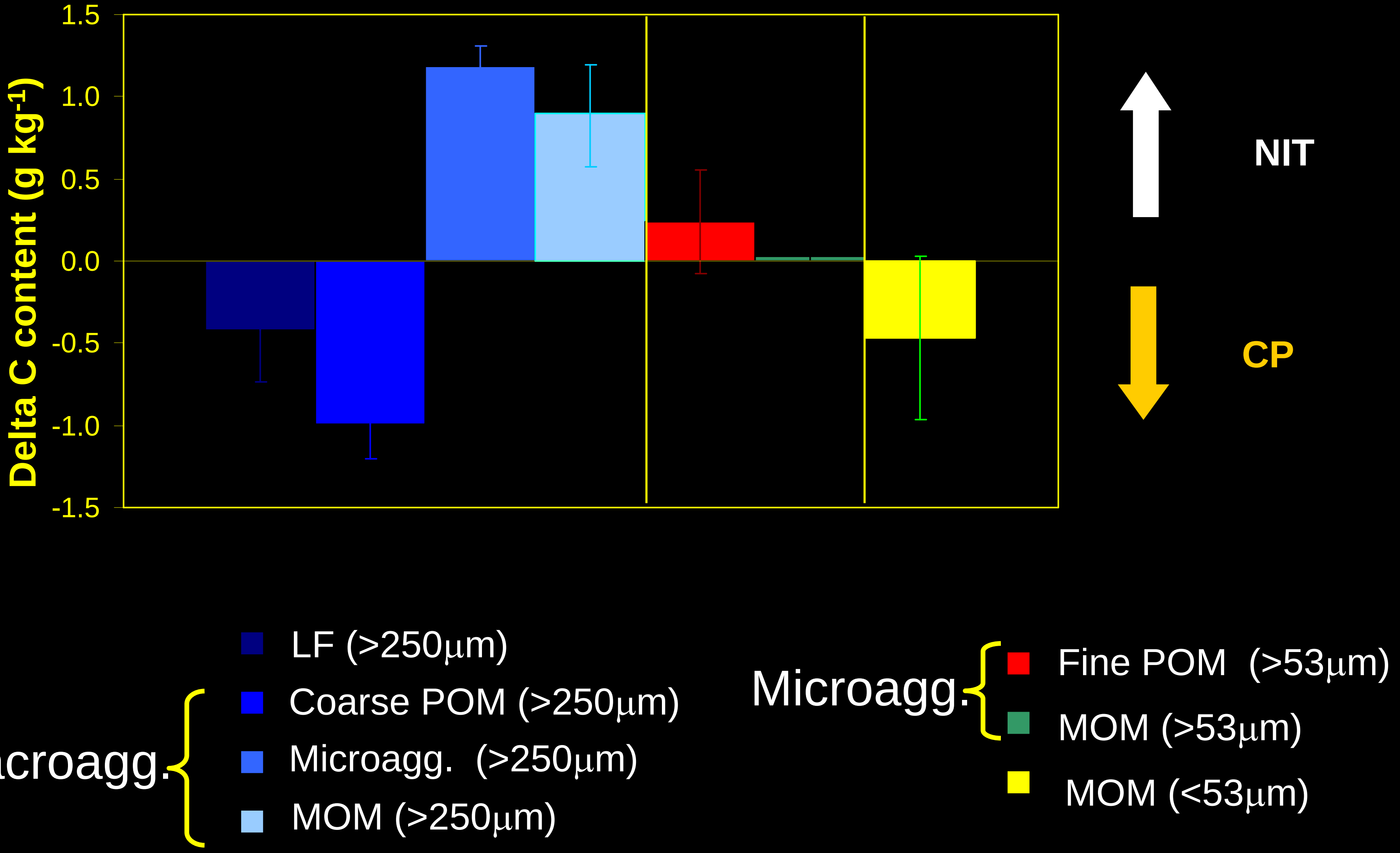
Problems

- Current input rates of organic C into most soil systems are hard to quantify
- Use size aggregate distribution to assess labile and resilient C pools
- Can use stable isotope tracers to track soil C dynamics

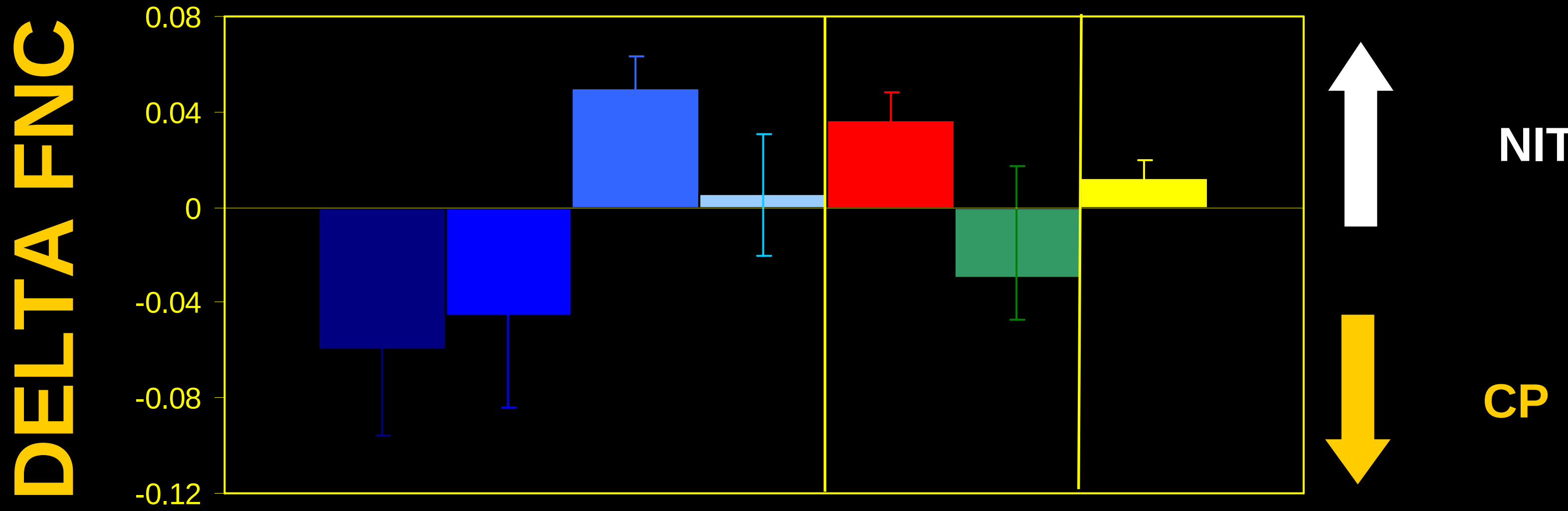
Can use isotopes to track C



Difference between NIT & CP



Difference between NIT & CP



Use data to constrain process models (DAYCENT, DNDC, RothC, PASIM)

Macroagg.
- LF (>250µm)
- Coarse POM (>250µm)
- Microagg. (>250µm)
- MOM (>250µm)

Microagg.
- Fine POM (>53µm)
- MOM (>53µm)
- MOM (<53µm)

Conclusions

- A mosaic of solutions – no ‘magic bullet’