C2 - Manipulation Experiments

Ecosystem manipulation to understand N interactions with global change

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C2 - Manipulation Experiments

C1

provide fluxes of N and GHG (ecosystem types, climates and land use conditions)

C3 (plot scale modelling) + C4 and C5

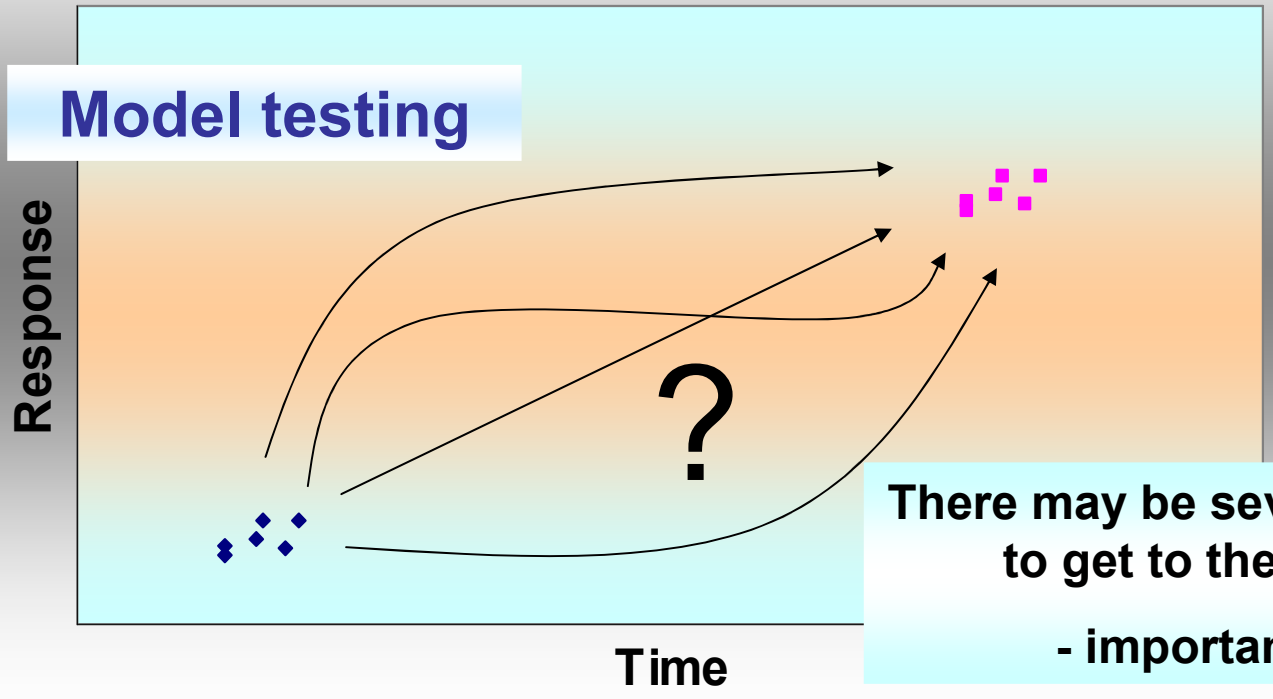
model applications at various scales – to predict changes over time

What happens if drivers change?

C&N interactions, N sequestration, atmosphere-biosphere exchange of N and GHG etc. are sensitive to changes in drivers but we still know relatively little and C1 will not provide all the answers

C2 - Why experiments

Ecological response to change in drivers over time



There may be several ways to get to the goal

- important!!

C2 - Manipulation Experiments - aims

Quantify the **impacts of changes** in external drivers (global change, N deposition, management, land use change etc.) on fluxes and exchange of N, C and GHG in terrestrial ecosystems (relative change rather than absolute budgets)

Provide an improved scientific **understanding of the underlying processes** and their interactions at different scales (Process understanding & model improvements).

Provide **data for evaluation and validation of plot scale models** – processes and ecosystem scale (model validation).

C2 – Key questions

- …. *the quantitative components of* ***ecosystem N budgets*** *and* ***how do these respond to global change?*** *How much does the* ***form of reactive N*** *(oxidized vs. reduced, wet vs. dry, agricultural application vs. atmospheric deposition) affect* ***ecosystem response****, N and C budgets and Net Greenhouse gas Exchange (NGE)?*

- ….. *the* ***effect of*** ***changes*** *in* ***atmospheric N deposition*** *and agricultural* ***N inputs*** *over recent decades on the* ***net CO2 uptake and NGE of European ecosystems?*** *Can we* ***simulate the effects*** *of land-management, land-use and climate change on NGE at plot, landscape, regional and European scales?*

- ….. *can independent* ***measurement and modelling*** *be used to* ***verify greenhouse gas (GHG) and Nr emission inventories*** ……*?*

- …. *would a more* ***integrated*** ***management of the N-cycle*** *and its* ***interactions with the C-cycle*** *have* ***potential to reduce greenhouse gas and Nr emissions*** *simultaneously?*

C2 – Primary objectives

PO1

*to establish **robust datasets** of N fluxes and net greenhouse-gas exchange (NGE) in relation to C-N cycling of representative European ecosystems, as a basis to investigate interactions and assess long-term change (primarily C1 plus input from C2, C4),*

PO2

*to quantify by measurements the **effects of past and present global changes** (climate, atmospheric composition, land-use/land-management) on C-N cycling and NGE (primarily C2, plus input from C1),*

C2 – Technical objectives

TO3

*to **establish and integrate a European network of ecosystem manipulation experiments** (C2) related to N and NGE, building on well-established national and EU infrastructures*

TO4

*to establish **common measurement protocols** (C7) ensuring **comparability** between the flux (C1) and manipulation (C2) networks and provide **essential inputs for plot-scale** models (C3), and to establish common modelling protocols (C7) for quality assurance and uncertainty assessment in the different plot-, landscape- and European models (C3, C4, C5, C6),*

C2 - Overall strategy

Choice among two

New experiments

C1 sites, all drivers, expensive, short term change

Existing experiments

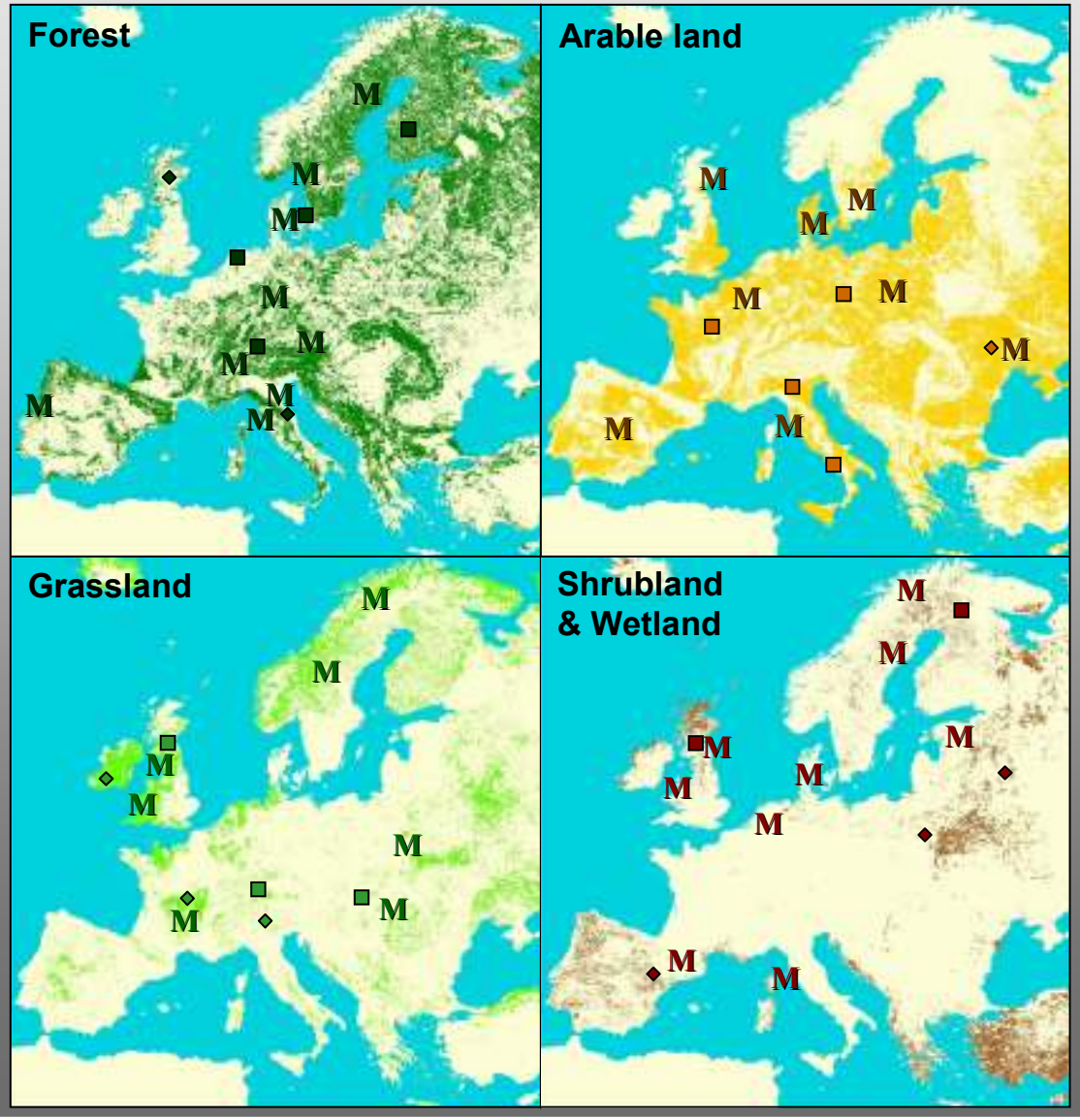
existing knowledge and networks, long term change, relatively cheap

C2 – Ecosystem and drivers

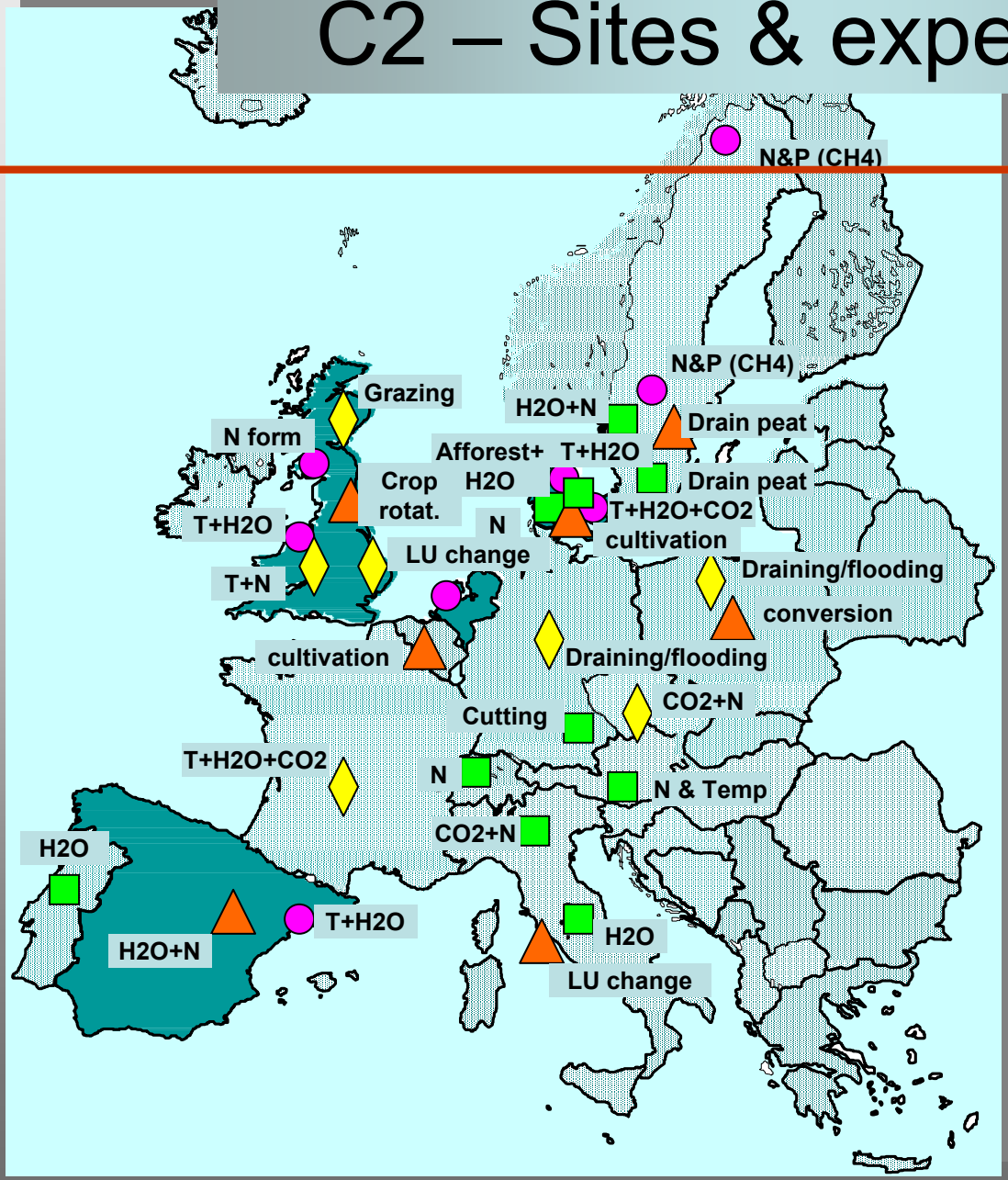
	Forests	Arable	Shrub & Wetland	Grassland
Atmospheric change (C&N)	***			**
Climate cha	**	*	***	**
La manag				
Land use change	**	**	**	***

We have chosen an ecosystem specific approach

C2 - Manipulation sites and level 3 sites



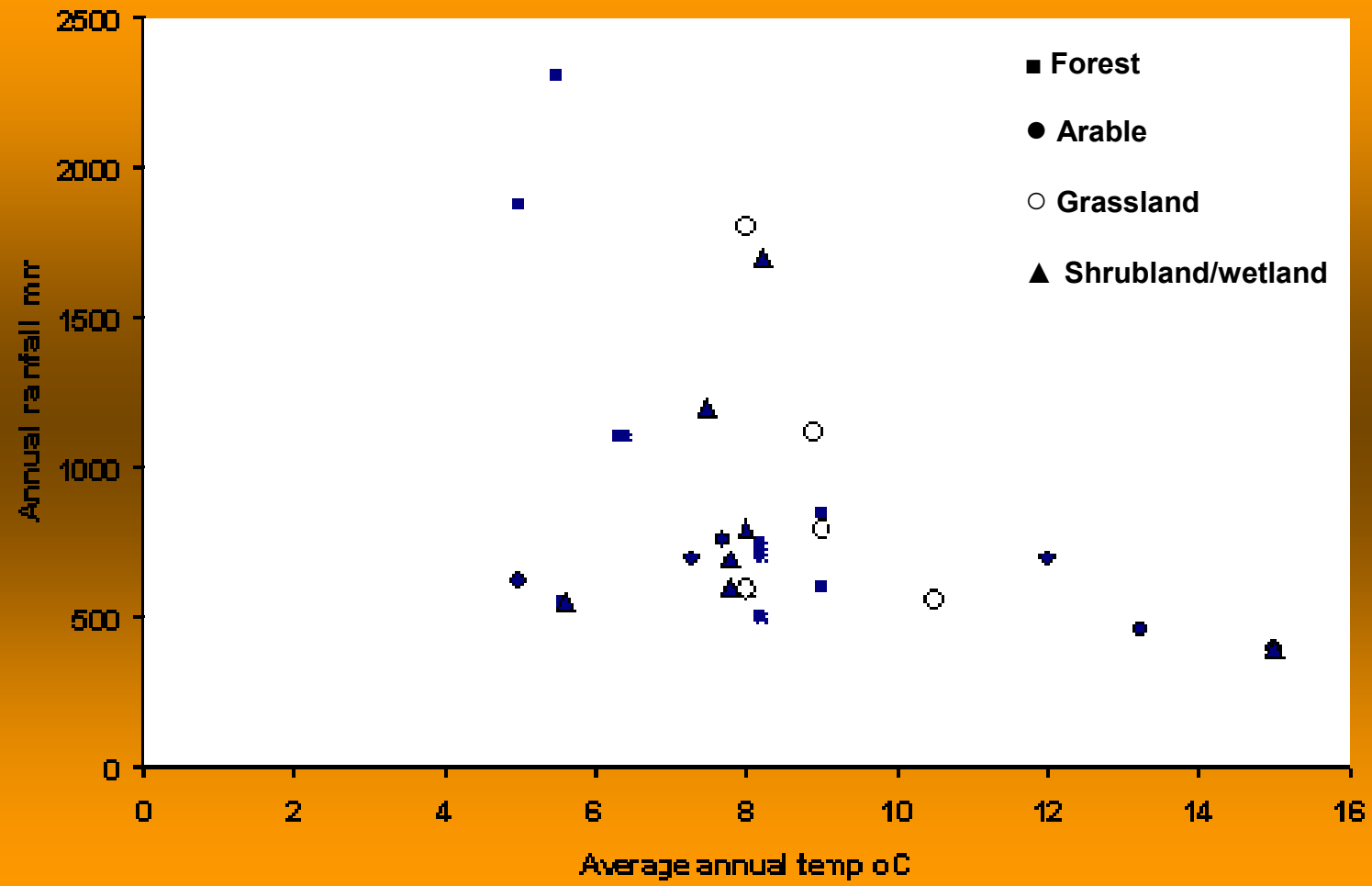
C2 – Sites & experiments



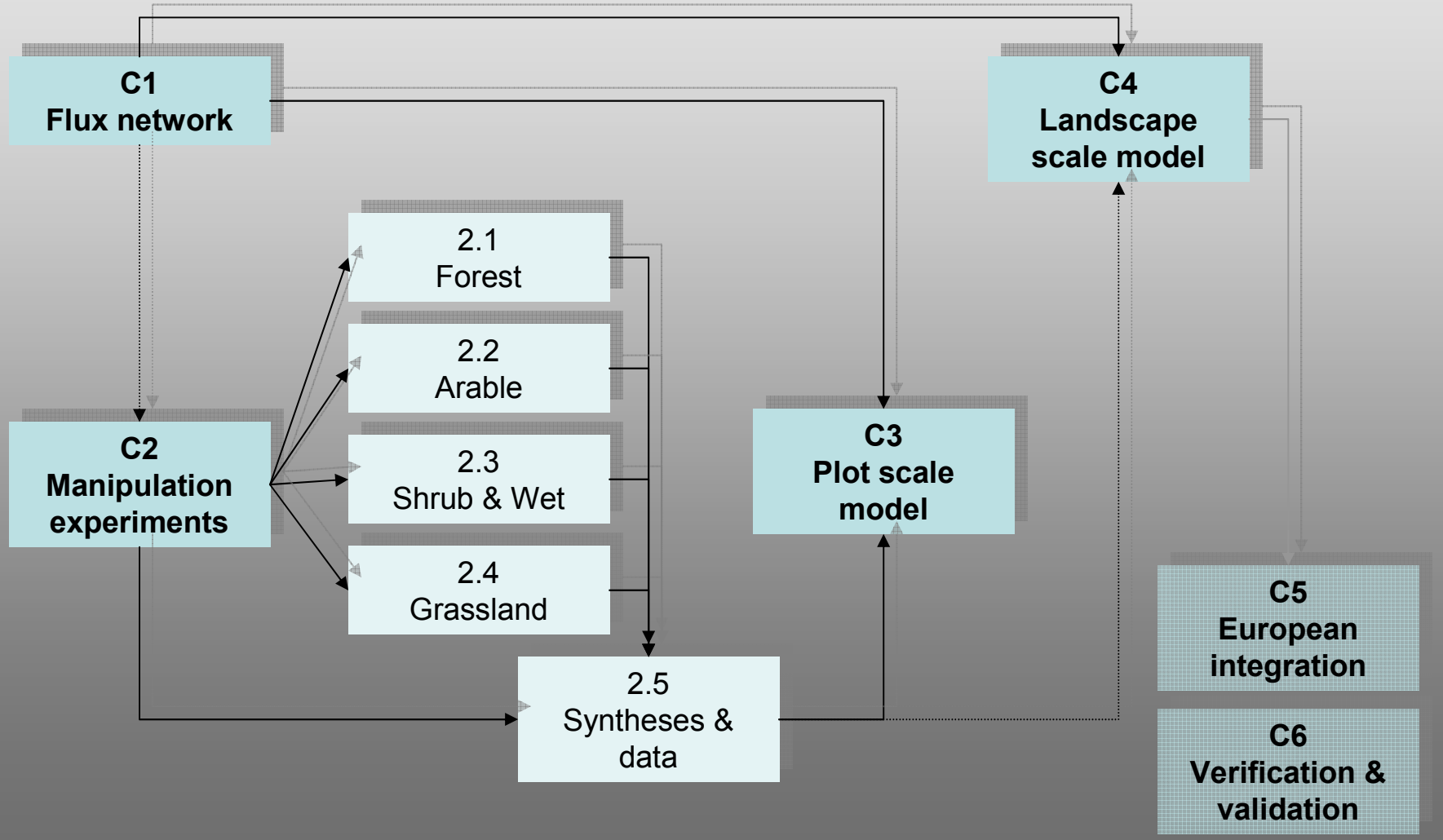
Sites and experiments

- Arable
- Forest
- Shrub/wet
- Grass

C2 sites
- rainfall and temperature



C2 - linkages to other NEU components



2.1 - Forests

Forests - knowledge gaps

- long-term impact of N deposition
- impact of climate changes
- effect of afforestation/abandonment on N rich arable land
- effect of draining/flooding in wet forest soils.

C2- Forest experiments

Site	Climate, ecosystem, soil	Treatments	Network
Klosterhede, DK	Atlantic, Conifer, podzol	N dep.	NITREX, CNTER
Klausenleopoldsdorf, AT	Continen., Decid., cambisol	N dep.	National
Gårdsjøn, SE	Atlantic, Conifer, podzol	N dep.	NITREX, CNTER
Alptal, CH	Continen., Conifer, gleysol	N dep.	NITREX
Achenkirchen, AT	Continen., Conifer, cambisol	Temperature	National
Tolfa, IT	Medit., forest, clay loam	+/- water	MIND
Herdade de Mitra, Evora, PT	Medit., Evergreen oak, lixisol	+/- water	MIND
Vestskoven DK (Chrono)	Atlantic, Decid.&conifer, sandy loam	Afforestation & water	AFFOREST
Grevindeskov, DK	Atlantic, Decid.&conifer, sandy loam	Drainage	National
Gottåsa, SE	Atlantic, Conifer, org. soil	Drainage of peatland	National
Högelwald, DE	Continen., Conifer, cambisol	Management (cutting)	National

C2- Forest experiments

Forests	Site	System	Cntry	Exp.	Age	Climate	Soil	Partner
N deposition	Klosterhede	Conifer	DK	N deposition	12	*Atlantic*	Podzol	KVL/Gundersen
	Klausenleopoldsdorf	Decidious	AU	N deposition	8	*Continental*	Dystric cambisol	BFW/Zechmeister
	Gårdsjøn	Conifer	SE	N deposition	12	*Atlantic*	Podzol	IVL/Moldan
	Alptal	Conifer	SC	N deposition	10	*Alpine*	Gleysol	WSL/Schleppi
Climate	Achenkirchen	Conifer	AU	Temperature	6	*Continental*	Cambisol	BFW/Zechmeister
	Tolfa	Mediterranean forest	IT	+/- water	4	*Mediterranean*	Clay-loam	IBIMET-CNR/Miglietta
	Herdade de Mitra, Evora	Evergreen oak	PO	+/- water	4	*Mediterranean*	lixisoils/stacnic	ISA/Pereira
	EUROFACE	Poplar	IT	+CO2, +N	5	*Mediterranean*	?	UNITUS/Scarzia-Mugnozza
Land use	Vestskoven	Decidious and conifer	DK	Afforest. and Wet/dry	1-200	*Atlantic*	Sandy loam	KVL/Gundersen
Management	Grevindeskov	Decidious and conifer	DK	Drainage	42	*Atlantic*	Sandy loam	KVL/Gundersen
	Gottåsa	Conifer	SE	Drainage of peatland	1	*Atlantic*	Organic	Gothenburg University/Klemmetson
	Höglwald	Conifer	GE	Clearcut, selective cutting		*Continental*		IMK-IFU/Butterbach

Manipulations
(established in former EU or national projects)

- Chronic N addition (AT, CH, DK, SE), partly NITREX/CNTER sites
- Increased temperature (AT), NOFRETETE site
- Drought and precipitation increase (IT,PT), MIND sites
- Afforestation chronosequences (DK), AFFOREST sites
- Drainage, wet/dry gradients (SE, DK)
- Clear-cut at high N deposition (DE)

Impact of N addition on GHG

N_2O:

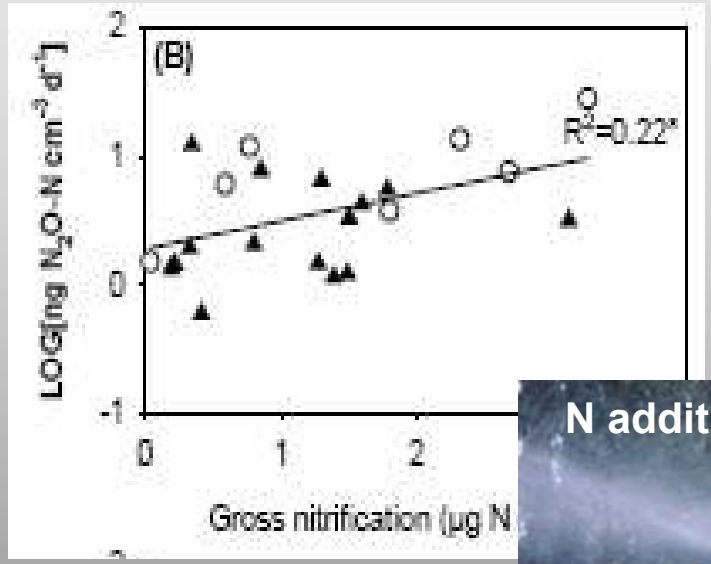
- Increased emission with increased N indicated empirically.
- In NEU - verification in long-term manipulations

CH_4:

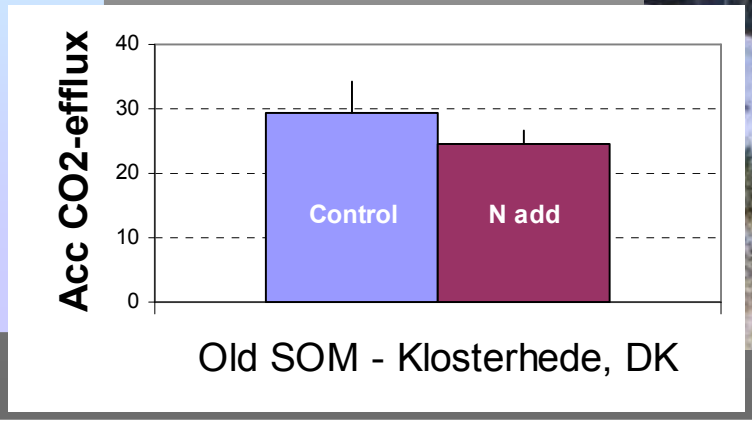
- Decreased consumption indicated empirically.
- In NEU - verification in long-term manipulations

CO_2:

- Some observations of decreased respiration
- In NEU - more documentations

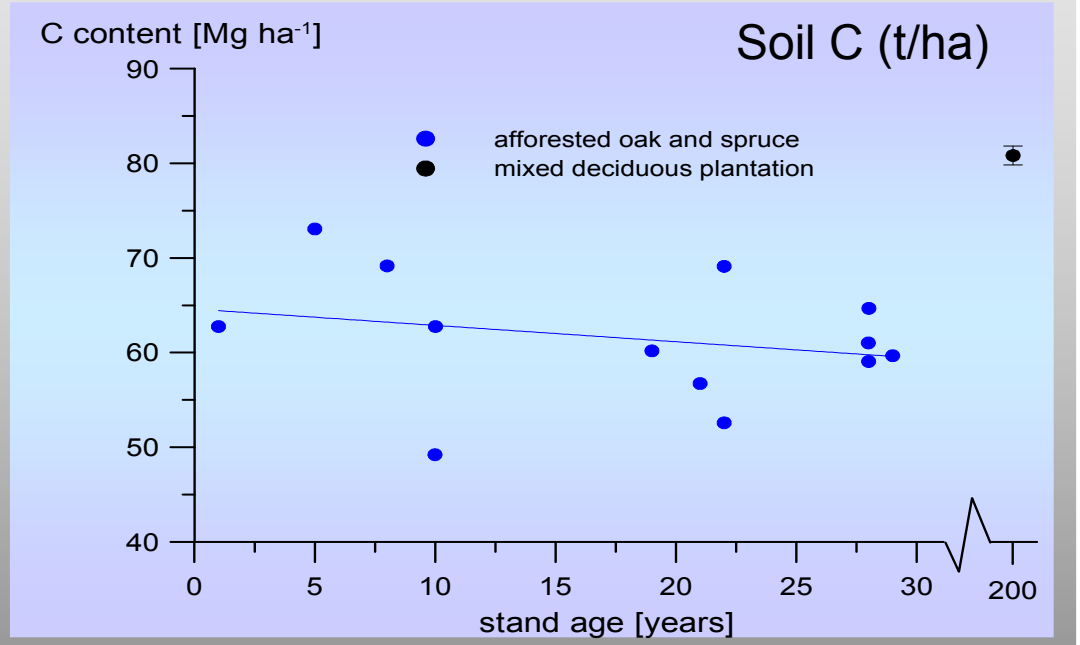


NOFRETETE
Ambus et al. 2005



Former arable land

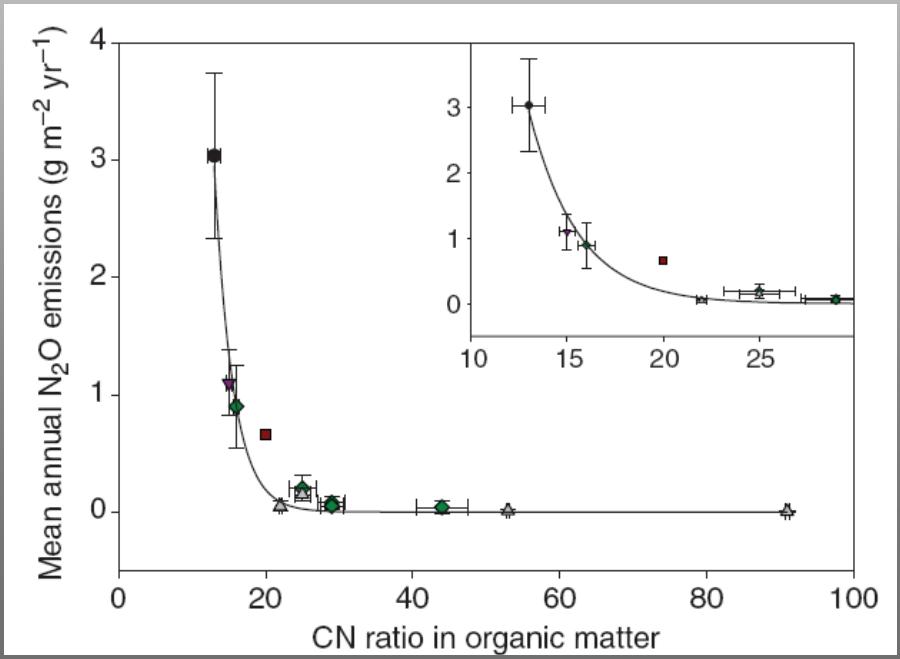
- C accumulation, but not always
- More N_2O emission indicated
- Less CH_4 consumption indicated



1, 5, 8, 10, 18, 23, 29 and 200 yr stands, oak or spruce

Wet forest soils

- The wet c. 10% may be as important for N_2O and CH_4 as the 90% dry
- N enrichment may increase N_2O loss



2.2 – arable ecosystems

Agriculture and GHG
- key problems and questions

- fluxes of N2O from agro-ecosystems across Europe
- management – tool to constrain emissions of GHGs
- spatial and temporal heterogeneity – timing, events and hot spots

Knowledge gaps arable

- Management systems that reduce net GHG emissions
- Better understanding of environmental controls to help with modelling
- Continuous measurements of N_2O - improved flux estimates
- Emission factors
- Indirect losses of N_2O (drainage)

C2 - Arable experiments

Site	Climate, ecosystem, soil	Treatments	Network
Turew, PL	Continental Arable land, gleysol	Grassland conversion	National
Belgium, BE	Atlantic Arable land, Loam	Conv. vs zero input	National
Foulum, DK	Atlantic Grass/arable, sandy	Conv., org. farm and tillage	National
Tulloch, UK	Atlantic, Grass/arable rotation, podzol	Organic rotation	National
Madrid, ES	Mediterranean, Arable/ horticulture, limestone	Water and N Inputs	National
Pianosa, IT	Mediterranean, Agriculture – Macchia, limestone	LUC, abandonment	National
Zimbabwe, ZI	Semi arid tropical, Chrono, sand	Regional transect	INCO
Danube, UKR	Cont. Arable land, gleysol	LUC	INCO
GEFOS, SE	Atlantic, Arable land on drained soil	Draining of peat	National

NEU-C2 - Proposed arable experiments

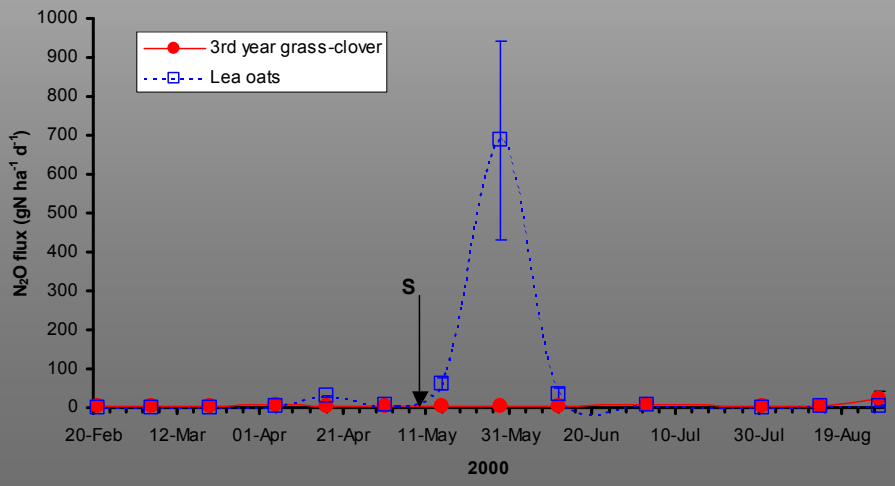
Arable	Site	System	Cntry	Exp.	Age	Climate	Soil	Partner
Cultivation	Turew	Arable land	PL	Conversion to grassland	1	*Continental*	Gleysol	AUP/Chojnicki (ZALF/Sommer)
	Belgium	Conventional vs zero	Be	Conventional vs. no input	??	*Atlantic*	??	GeU/Van Kleemput
	Foulum	Arable and grassland	DK	Conv. & org. farming - tillage practices	8	*Atlantic*	Loamy sand	DIAS/Olesen
Intensification	Tulloch	Grass/arable rotation	UK	Arable/grass rotation	13	*Atlantic*	Podzol (Sandy	SAC/Rees
	Madrid	Arable/ horticulture	ES	Irrigation and manure N Inputs		*Mediterranean*	??	Vallejo
	Pianosa	Agriculture – Macchia	IT	LU change / land abandonnem	10	*Mediterranean*	Limestone	SUN/Cotrufo
Drainage	GEFOS	Arable land on drained soil	SE	Draining of old peatland	1	*Atlantic*	Organic soil	GoU/Klemmetson

key manipulations

- Nitrogen/manure management
- Cultivation
- Crop sequences
- Drainage/irrigation
- Land use change/abandonment
- Chronosequences

Results from previous projects

- Management plays a major role in influencing the magnitude and timing of GHG emissions
- There is a major temporal and spatial (plot scale-continental scale & event-annual) variability
- C and N cycles interact with non-CO_2 GHGs
- Hot spots in time and space



Examples of manipulations

Land use change - Tillage

drainage/irrigation

- Italy (SUN)
- Scotland (SAC)
- Zimbabwe UoZim

Land management/N input

- Italy (SUN)
- Scotland (SAC)
- Zimbabwe UoZim

2.3 - Shrublands

Shrublands – knowledge gaps

- impact of climate changes (Temp., CO2, precipitation)
- long-term impact of N deposition and interactions with N status and other nutrients
- effects of LUC and draining
- effect of species composition on C, N and GHG exchange.

C2 - shrubland/wetland experiments

Site	Climate, ecosystem, soil	Treatments	Network
Whim, UK	Atlantic, Calluna heath bog, peat	N deposition (N forms; wet/dry NH_x/NO_y, PK)	National
Brandbjerg, DK	Atlantic, Grassland/shrubland, sandy podzol	Climate & CO_2	National
Stordalen, SE	Subarctic, mire, peat	CNP & N depos. vs CH_4	C-Europe, NECC
Fäjemyren, SE	N. temperate, mire, peat	CNP & N depos. vs CH_4	INSTIGATE, NECC
Mols, DK	Atlantic, calluna shrub & grass, sandy podzol	Climate	VULCAN, CLIMOOR
Männikjärve, EE	Atlantic, bog, peat	NP addition	National
Clocaenog, UK	Atlantic, Calluna heathland, Peaty podzol	Climate	VULCAN, CLIMOOR
Garraf, ES	Mediterranean shrubland, Calc. Cambisol	Climate	VULCAN, CLIMOOR
Oldebroek, NL	Atlantic, calluna shrubland, Podzol	Climate	VULCAN, CLIMOOR

NEU-C2 - Proposed shrubland/wetland experiments

Shrubland and wetland

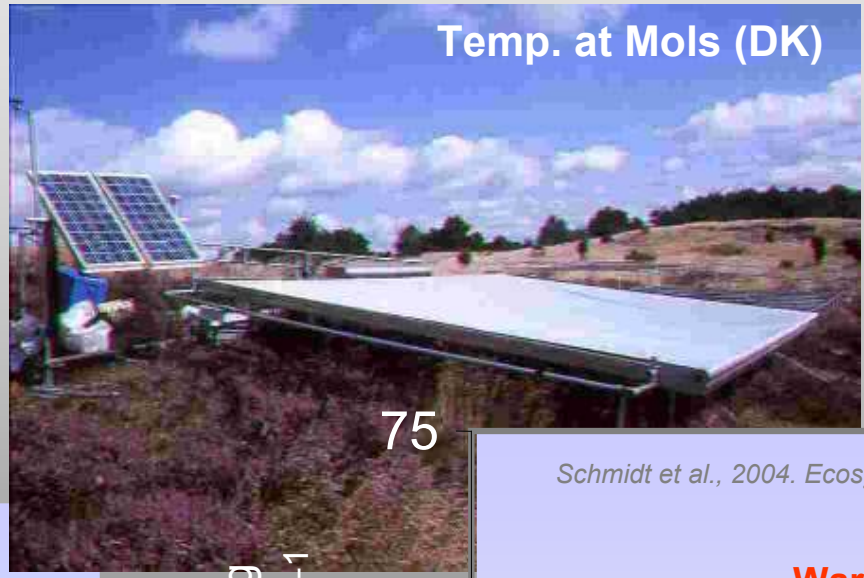
	Site	System	Cntry	Exp.	Age	Climate	Soil	Partner
N-deposition and	Whim	heath/acid bog	UK	N deposition	2	*Atlantic*	sandy podzol to	CEH/Shepard
	Brandbjerg	Grassland/ shrubland	DK	CO2+Temp. +H2O	1	*Atlantic*	Sandy podzol	RISOE/Beier
	Sweden	Temp. and subarc. mires	SE	N and P vs CH4	1	*Subarctic & Temperate*	Histosols	Lund&ANS/Christense n
Climate	Mols	Shrub/gras s	DK	Temp. & H2O	7	*Atlantic*	Sandy podzol	RISOE/Beier
	Clocaenog	Moorland	UK	Temp. & drought	7	*Atlantic*	peaty podzol	CEH/Emmett
	Garraf	Med. shrubland	ES	Temp. & drought	7	*Mediterranean*	Calcareao us	CREAF/Penuelas
	Oldebroek	Shrubland	NL	Temp. & H2O		*Atlantic*	Sandy podzol	UA/Tietema
Land use and management	Pianosa (Task 2.2)	Agriculture – Macchia	IT	Land use change / land	10	*Mediterranean*	Limestone	SUN/Cotrufo
	Rzecin/Demmin (Task 2.4)	grassland / moorland	PO	Draining/floo ding	1	*Continental*	Histosol	AUP/Chojnicki (ZALF/Sommer)
	Gottåsa (Task 2.2)	Conifer	SE	Drainage of peatland	1	*Atlantic*	Organic	GoU/Klemmetson

Manipulations

(established in former EU or national projects)

- N deposition (amount and N form) (UK, SE) – National
- N and P interaction (SE) - national
- Temp. and drought change (DK, NL, SP, UK (HU, IT)), VULCAN/CLIMOOR sites
- CO2, temp. and drought (individual and combined treatments (DK) – CLIMAITE
- *Land use change (IT) – with 4.2*
- *Draining of wetlands (SE, PO) – with 4.1 & 4.2)*

Impact of T and drought on N leaching & GHG exchange

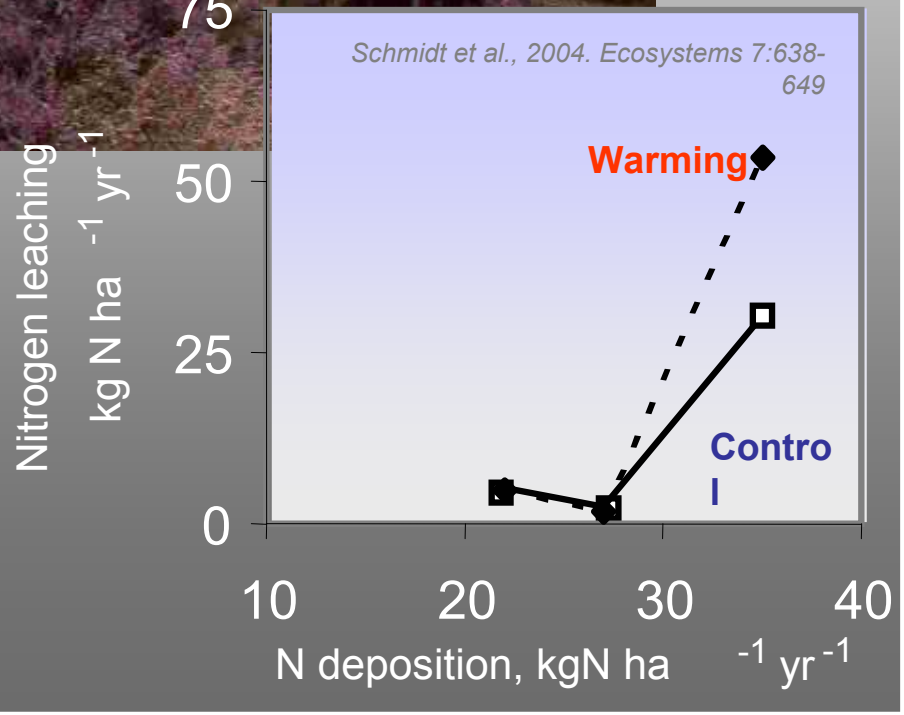


N_2O and CH4:

- No effect – few numbers
- Drought at wet sites may be important
- In NEU - annual budget

N leaching:

- N-status dependent
  - high N = increased risk



Climate change (CO2, T and H2O) and GHG exchange

N_2O:

- Nothing.
- In NEU - annual budgets

CH_4:

- Nothing
- In NEU - budgets

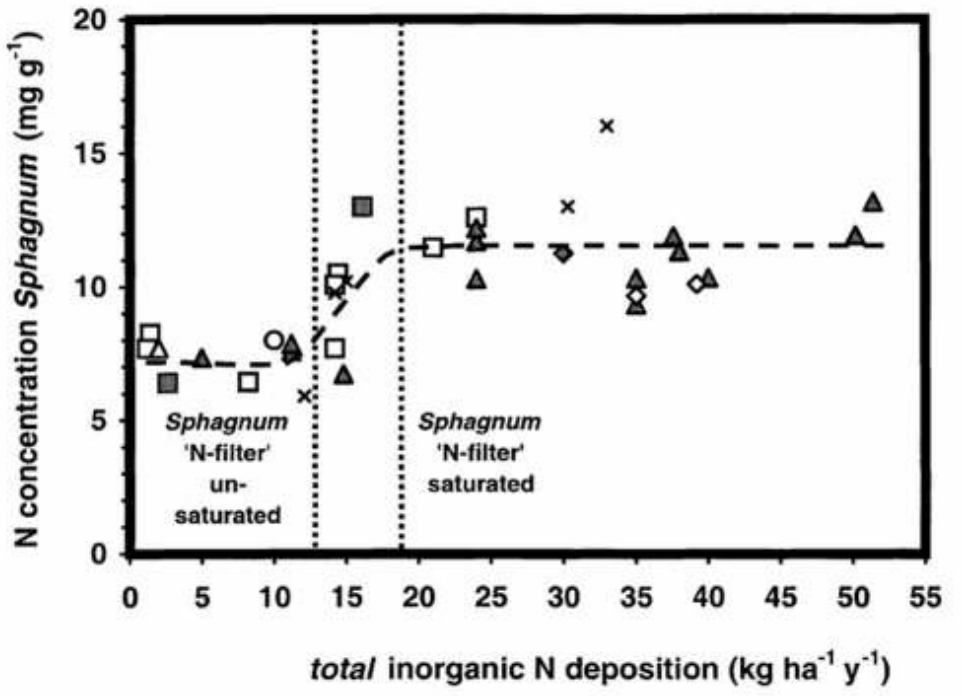
CO2, T and H2O, CLIMAITE (DK)

CO_2:

- *US numbers, no European*
- *In NEU – budgets*

N+P addition and N form

- Increased N = increased N status = growth, N loss, **species change**
- Effect on CH4 and N2O ????



C2 -Manipulation Experiments Shrubland ecosystems

- *Experimental Networks and projects in shrubland ecosystems*
  - *–Vulcan & Climoor*
  - *–Graminae*
  - *–Climaite*

- *Key focus up til now*
  - *–Carbon storage*
  - *–Species change*
  - *–N leaching*

- *Key findings with respect to N and GHG*
  - *– N leaching depend on N status*
  - *– C and N respond in asynchrony*

- *Key questions today*
  - *–Carbon storage*
  - *–Species change*
  - *–Seasonality*

2.4 - Grasslands

Grasslands - knowledge gaps

- Elevated CO_2 and climate change impact
- Long term effect of N deposition on nutrient poor grasslands
- Effect of draining/flooding in wet grasslands
- Effect of abandonment or extensive use on previously managed grasslands
- When possible need to integrate methane emission from enteric fermentation by herbivores in the balance per unit land area

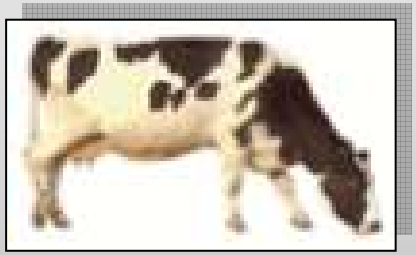
C2 - grassland experiments

Site	Climate, ecosystem, soil	Treatments	Network
Crichton, UK	Atlantic, grassland, clay loam	N input	National
Theix, FR	Medit., Grassland/Shrub, brown soil	Climate & CO_2	National
Gödöllő, HU	Continental, Grassland, Sandy	Management, CO_2 and N input	GREENGRASS
Plynlimon, UK	Atlantic, Acid grassland, peaty podzol	Temperature and N deposition	National
Rzecin/Demmin, PO	Atlantic, Acid grassland, peaty podzol	Draining/flooding	National
Stordalen & Fäjemyren, SE	Subarc. & temp., mire, peat	CNP & N depos.	C-EUROPE, NECC
Nafferton, UK (Chrono)	Atlantic, Grassland/riparean	Land use chronosequence	National

Greenhouse gas and organic matter fluxes in a grassland

NitroEurope IP

OM fluxes



Herbivore

CH_4

CO_2

Vegetation

CO_2

Hay / Silage

Soil

CH_4

CO_2

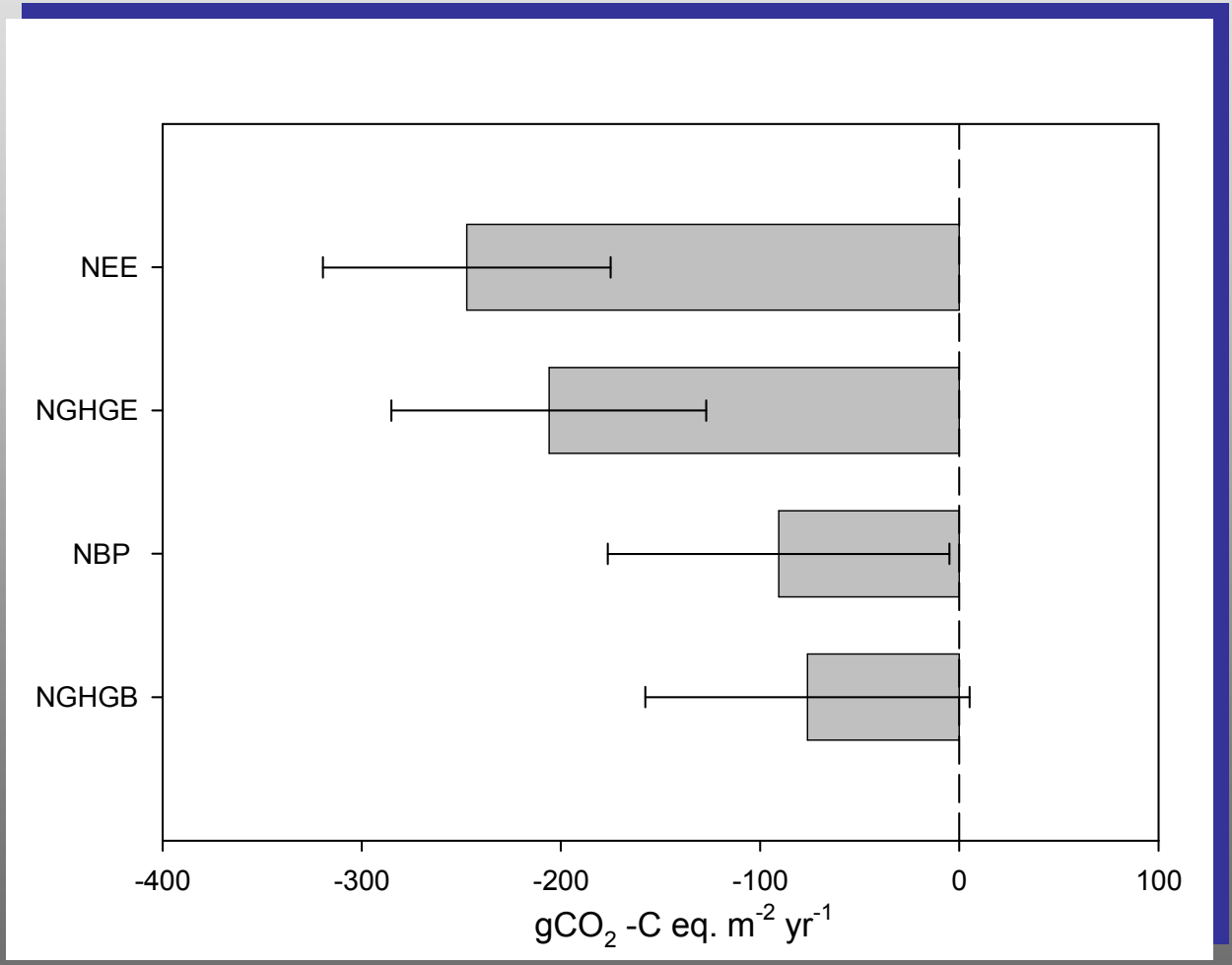
N_2O

Manure / Slurry

Dissolved organic C

Atmosphere

GHG balance of GreenGrass sites



Manipulation

- Climate change
  - CO_2, temperature, rainfall (Theix/Clermont)
  - CO_2, N supply (Gödöllö)
  - Temperature, N deposition (Plynlimon)
- N input/deposition
  - Crichton
  - Stordalen
- Draining/flooding (Rzeckin, Demmin)
- Land use change chronosequence (UK)

Methodological issues

- Spatial variability in grazed grasslands
- Annual balance
- Methane emission/oxidation from soils
- Need to determine key soil parameters (eg soil pore water filling…)
- Added value for modelling:
  - Detailed campaigns ?
  - Or rough annual balance?

C1 and C2 - Protocol

Common C1-C2 protocol

Remember – C2 look for relative change !!!!!

We should get as close as possible to a closed N budget

Spatial variation

– Spatial mapping

- Moving chambers

- Look for surrogates (e.g. moisture, vegetation)

- Concentrate on sites with obvious problems

- must be adressed in protocol

Sites

- Different sites may have different focusses or key points

- Site age may be important for response (how long into treatment)

- Split sites depending on modelling or metanalysis requirements

C1 and C2 - Protocol

……common protocol

Methodology

- Standard protocols may not work for all existing sites (we cannot chane design and installation)

- Intercalibration of different methods

- some measurements may need to be measured by experts touring all sites

- Task force to propose a protocol (C1, C2 and C3)

•TASK FORCE (Repr. C1, C2 and C3)

•1 – Set science questions (OK)

•2 – rough list of measurements (requirements relating to science questions and model requirements) (this meeting + task force)

•3 – specific protocol (task force) to be circulated and commented (by all)

Time – soon or after approval of 15 page ?

C2 – Knowledge gaps

Forest

- long-term impact of N deposition
- impact of climate changes
- effect of afforestation/abandonment on N rich arable land
- effect of draining/flooding in wet forest soils.

Arable

- Cont. meas. of N_2O - improved flux estimates
- Understand env. controls - modelling
- Management systems to reduce GHG
- Indirect losses of N_2O (drainage)
- Emission factors
- Recycling of NO_x by plants

Shrub

- Impact of climate changes
- Long-term impact of N deposition and interactions with N status and other nutrients
- Effects of LUC and draining
- Effect of species composition on C, N and GHG exchange.

Grassland

- CO_2 and climate change impact
- N deposition on nutrient poor grasslands
- Draining/flooding in wet grasslands
- Abandonment or extensive use on previously managed grasslands

C2 -Manipulation Experiments

Challenges

- Coverage of European conditions
(ecosystem types and drivers)

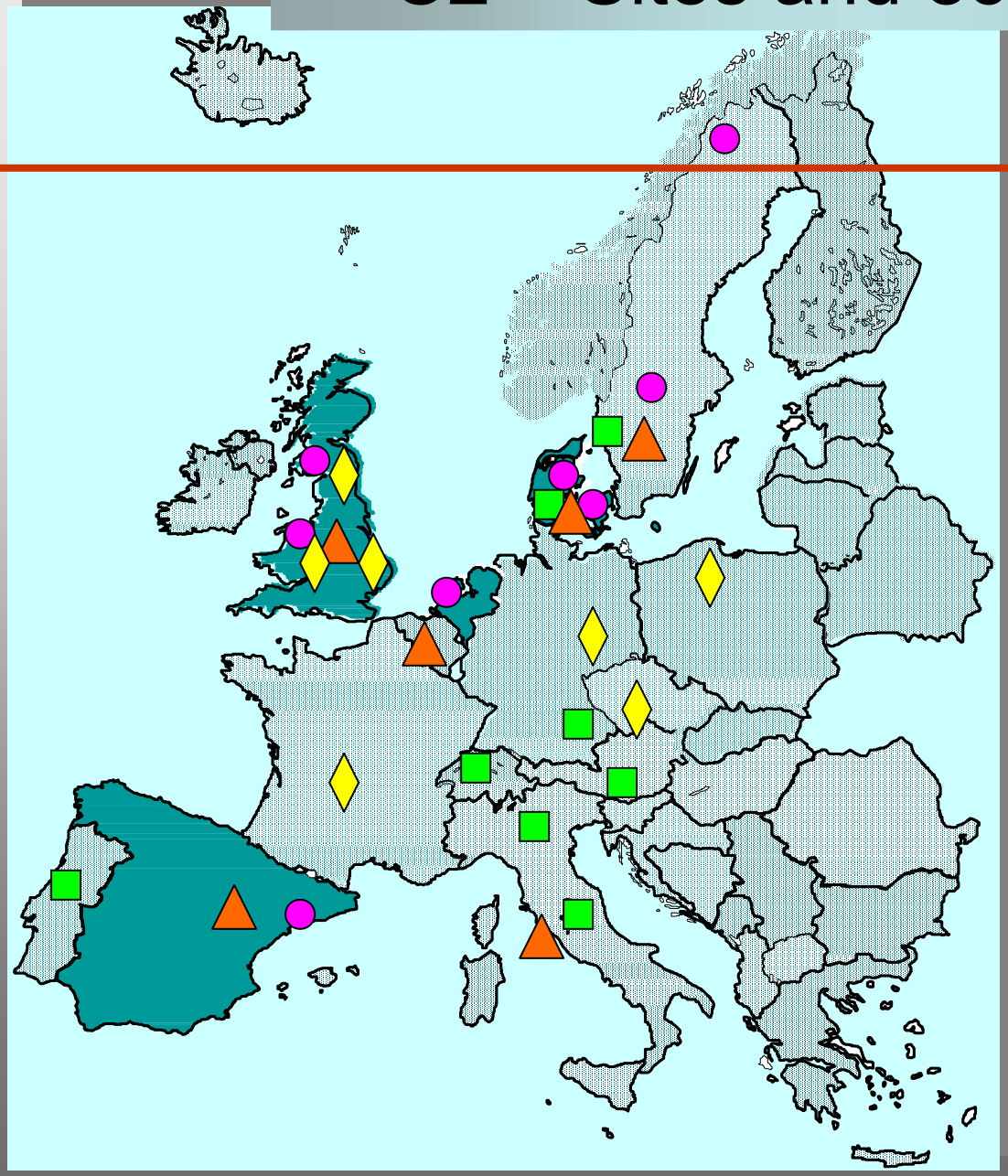
- Manipulations are different
(methods, replicates, focus etc.)

- Many groups
(Economy, logitstics and coordination)

C2 - Next step

- Agree common workplan and protocol
- "Harmonize" methodologies (e.g. intercalibration – also with C1)
- Collect existing data
- Start measurements and modelling (C3)

C2 – Sites and ecosystems



Sites and ecosystems

- Arable
- Forest
- Shrub/wet
- Grass