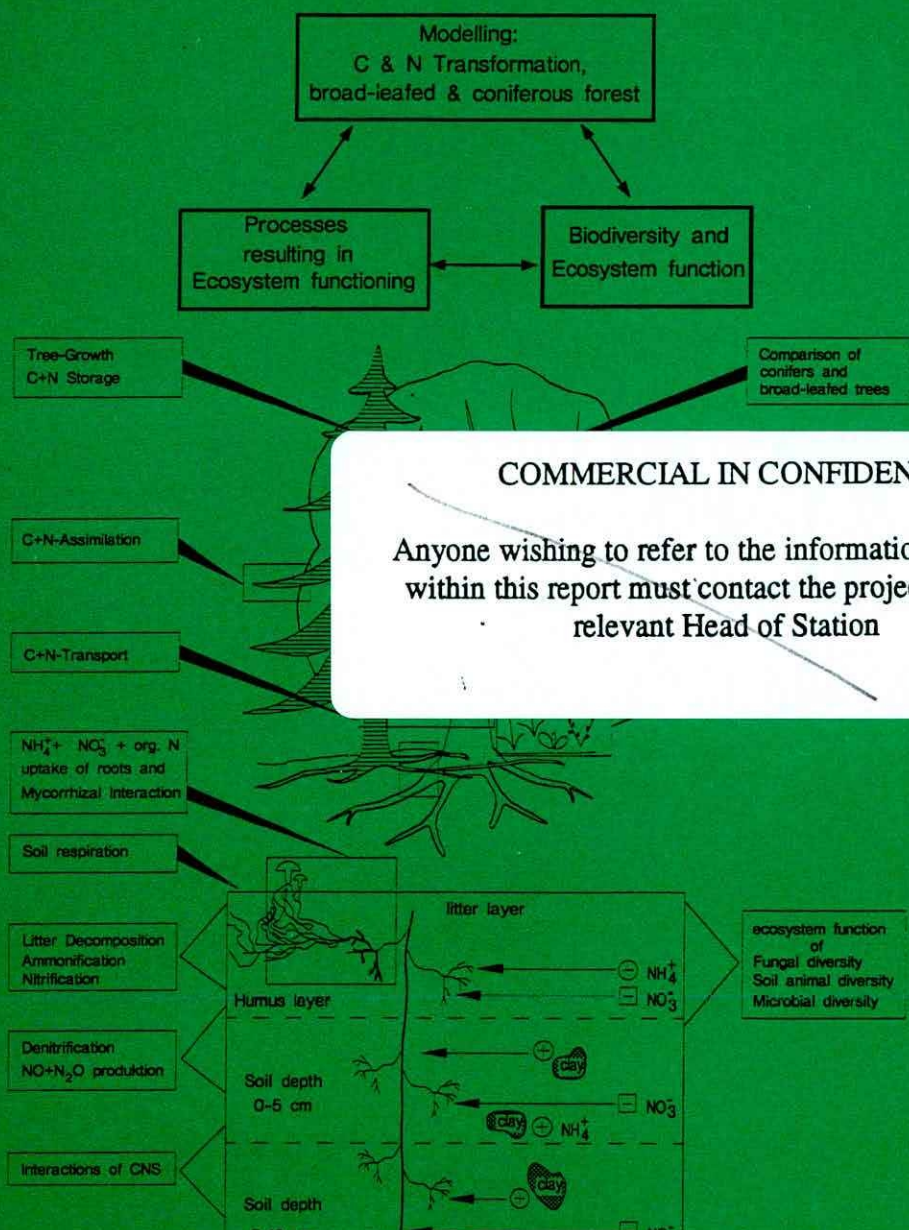
CANIF - CArbon and Nitrogen Cycling in Forest ecosystems

Annual Report
1.2. 1996 - 31.1.1997

EEC contract No ENV4-CT95-0053
and
subcontract No ERB IC20 CT960024

E.-D. Schulze (coordinator)



Bayreuth, Germany
February, 1997

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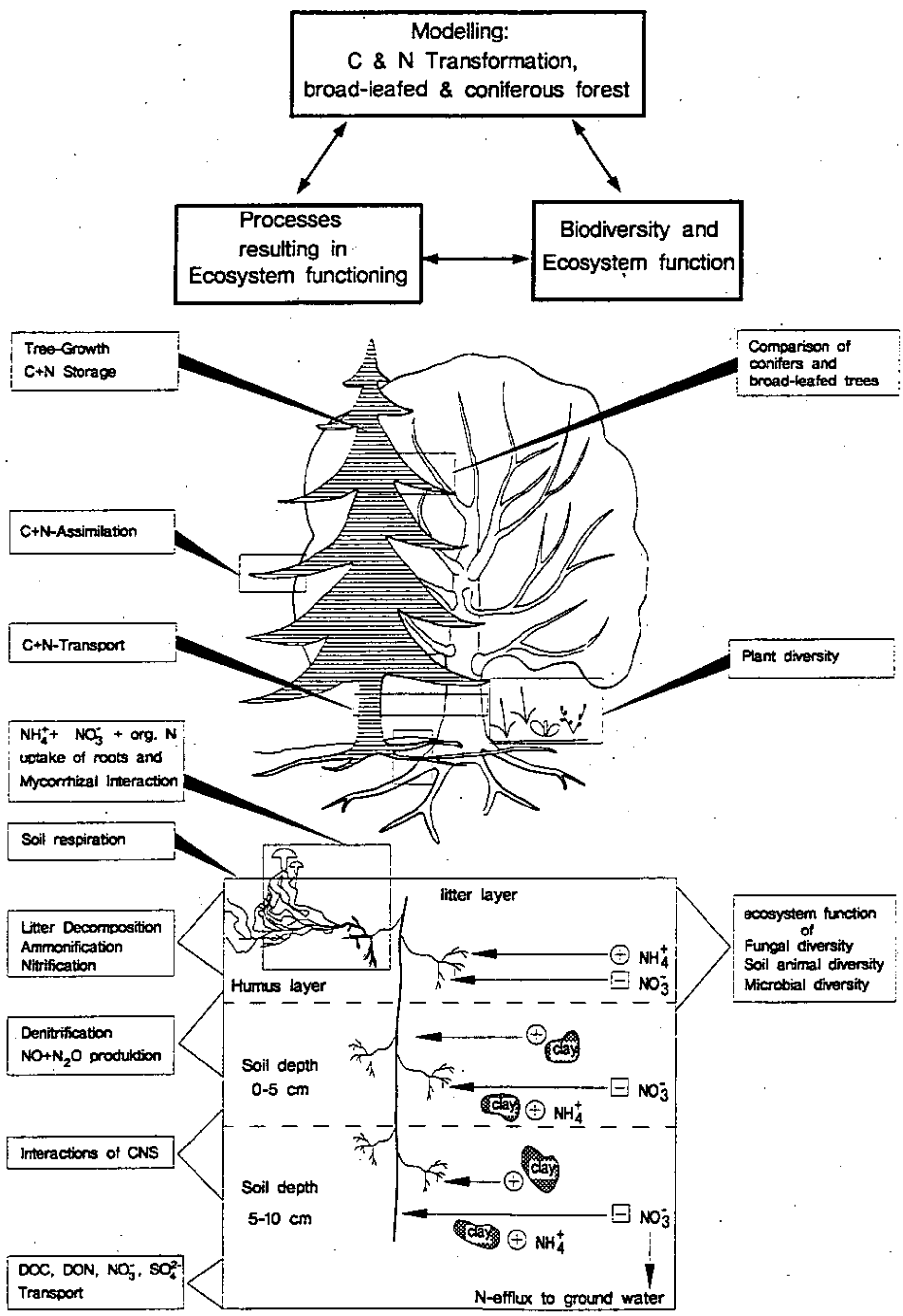

Bayreuth, Germany
February, 1997

PART A

ENVIRONMENT & CLIMATE RESEARCH PROGRAMME (1994-1998)
SUMMARY PROGRESS REPORT
(to be completed by coordinator)

1. Contract N°: ENV4-CT95-0053

2. Title: CANIF - Carbon and Nitrogen cycling in Forest ecosystems

3. Reporting period: 01.02.96 - 31.01.97

4. Scientific coordinator: Prof.Dr. E.-D. Schulze
   University of Bayreuth

5. Project participants:
   1. Prof.Dr. Peter Högberg
      Swedish University of Agrigultural Sciences
   2. Prof.Dr. Guiseppe Scarascia-Mugnozza
      University of Tuscia
   3. Dr. Eckart George
      University of Hohenheim
   4. Dr. Francis Martin
      INRA Nancy
   5. Prof.Dr. D.J. Read
      University of Sheffield
   6. Prof.Dr. Tryggve Persson
      Swedish University of Agricultural Sciences
   7. Dr. Sten Struwe
      University of Copenhagen
   8. Prof.Dr. Volkmar Wolters
      University of Giessen
   9. Dr. Antony F. Harrison
      Institute of Terrestrial Ecology
   10. Dr. Björn Andersen
       Danish Forest and landscape Research Institute
   11. Prof.Dr. Frank Berendse
       Wageningen Agricultural University
   12. Assoc. Prof. Dr. Tomas Paces
       Czech Geological Survey

PART A

SUMMARY PROGRESS REPORT OF THE PROJECT

I. GENERAL OBJECTIVES (from Technical Annex)

CANIF investigates effects of climate, and soil-borne and deposited nitrogen on C- and N-assimilation and turnover as well as on forest organism functions along a climatic transect through Europe extending from North Sweden to Central Italy.

(1) To contribute to the European and global research programmes envisaged by the EC Environment and Climate Work Programme (Framework IV, 1994-1998) and its Terrestrial Ecosystems Research Initiative (TERI) and by the IGBP-GCTE (Global Change and Terrestrial Ecosystems), which aim
- to better understand mechanisms driving pools and fluxes of carbon, water, nitrogen and other nutrients in forest ecosystems (TERI 3.2)
- to extrapolate this understanding to scenarios of land-use and climate change (TERI 3.2)
- to identify ways in which biological diversity regulates ecosystem function, structure and dynamics (TERI 4)

(2) To promote scientific co-operation, education, training and technology transfer within the EC by linking 12 European and 1 Eastern European research institution via a single major multidisciplinary project.

II. SPECIFIC OBJECTIVES FOR THE REPORTING PERIOD (from Technical Annex)

The project milestones will differ between tasks due to the specific requirements of the system being studied. Deliverables are specified for each subproject in part 6. Overall project.

year				1						2						3			
Month	1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
Management Meeting	X	X						X						X					X
Technical Workshops	X	X				X						X						X	
Establishing sites			X																
Core data acquisition				X	X	X	X	X	X	X		X	X	X	X	X	X	X	
Modelling			X	X	X	X	X	X	X	X		X	X	X	X	X	X		
Project reports							X						X						X

III. SPECIFIC OBJECTIVES FOR THE NEXT REPORTING PERIOD (from Technical Annex)

(1) 15N pulse labeling with ammonium and nitrate will be a major tool in order to quantify fluxes of N-compounds through the ecosystem. Standard analytical methods (HPLC, GC, MS) will be used by all participants based on joint protocols.
(2) Laboratory experiments under controlled conditions will support the interpretation of field observations.

IV. MAIN ACTIVITIES UNDERTAKEN

The participants of the CANIF project have organized two major assemblies
- a planning workshop at Thurnau
- a reporting and planning workshop at Viterbo

Besides this, a large number of coworkers have visited all sites along the transect, depending on the specific objectives. The sampling was most intense at the Viterbo site, because it is the most southern location, and it was not included in the former NIPHYS design.

CANIF is an ecosystem project. Thus, the transect ranging from N-Sweden to central Italy is the main tool. Each group, depending on the field of expertise, develops its own methodology of investigation, which is explained for each partner in Part B.

As joint result, CANIF will produce a CD-ROM database for modelling activities in TERI.

V. JOINT PUBLICATIONS

Database, University of Bayreuth

VI. CHANGES IN STATUS
None

VII. Is the project on schedule?
yes

VIII. SUMMARY OF PROGRESS ACHIEVED

CANIF achieved the following general results in its 1st year of operation:

Nitrate use of deciduous trees is higher by factor 10 than nitrate use of conifers. This results in lower export of nitrate to groundwater in deciduous forest stands.

Nitrogen-concentration is not a sensitive environmental indicator. However, nitrogen contents of leaves or needles determine growth.

The Nitrate to ammonium ratio determines nitrate uptake in forest trees.

In forest soils there is a rapid „futile cycle“ (see Schulze, Academic Press) of ammonium and nitrate turnover, which operates on a 24 hr basis even in acid soils. This futile cycle results in rapid and dynamic efflux of nitrate form forest soils. Thus, (i) nitrogen saturation is a dynamic process, and (ii) nitrogen saturation may occur even without nitrate efflux.

C/N pools were highest in the Mediterranean climate and not in the boreal forest.

N_2O production is not a significant problem in forest soils.

Diversity of mycorrhizae and of animals is important as insurance and buffer against uncertainties. There is a loss of diversity in coniferous forest in Central Europe.

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting Period: 01.02.1996 - 31.01.1997

Partner: 01

Principal Investigator: Prof.Dr. E.-D. Schulze

Scientific Staff: Dr. Gerhard Gebauer, Guntram Bauer

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I. OBJECTIVES FOR THE REPORTING PERIOD

1996: Quantification of storage amino-acids and starch as measure for carbon/nitrogen imbalance at all sites.

II. OBJECTIVES FOR THE NEXT PERIOD:

1997: Pulse labelling of spruce and beech stands with ^{15}N-ammonium and nitrate at the Bayreuth sites (coordinated experiment of Bayreuth, Umea, Nancy and Viterbo).

III: Are there any particular problems? Is your part of the project on schedule?

No Yes

IV: MAIN RESULTS OBTAINED: METHODOLOGY; RESULTS; DISCUSSION; CONCLUSION

1. A constant Root/Shoot ration was quantified for a chronosequence of spruce at Bayreuth
2. Tree growth correlates with needle N-content rather than with N-concentration throughout the transect
3. Glutamine synthetase is higher in Fagus than in Picea. The bark is a major compartment for NH_4 assimilation.
4. CO_2 assimilation of the spruce canopy reached 9.5 $\mu mol\ m^{-2}s^{-1}$

PART B

V. List of Publications arising from the project:

Bauer G, Schulze E-D, Mund M (1996) Nutrient status of the evergreen conifer *Picea abies* and the deciduous heartwood *Fagus sylvatica* along an European transect. Tree Physiology submitted 22.5.96

Köstner B, Schupp R, Schulze E-D, Rennenberg H (1995) Sulfur transport in the xylem sap of spruce (Picea abies L. Karst.) and its significance for the trees sulfur budget. Tree Physiology submitted 22.5.96.

Gebauer G, Schulze E.-D. (1996) Nitrate nutrition by central European forest trees. In: H Rennenberg, W Eschrich, H Ziegler (eds.) Trees - Contributions to modern tree physiology. SPB Academic Publ. The Hague. (in press)

Signature of Partner: E.D. Schulze

Date: 26.7.97

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: February 1996 - January 1997

Partner: Dept. of Forest Ecology, SUAS, Umeå, Sweden

Principal Investigator: Prof. Peter Högberg

Scientific staff:

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Telephone: +46 90 165007

Fax: +46 90 167750 E-Mail: Peter.Högberg@sek.slu.se

I. OBJECTIVES FOR THE REPORTING PERIOD:

To conduct N-15/C-13 labelling experiments in boreal forests. To develop for field purposes the C4-sugar substrate-induced respiration method (Högberg & Ekblad 1996).

II. OBJECTIVES FOR THE NEXT PERIOD:

This year (1997) we will do an additional N-15 labelling study along the natural N-supply gradient at Betsele (Giesler et al. 1997). We will study the turnover of inorganic N pools and see how fast organic N sources are used by plants as compared to these pools. We will likely use glutamine, as this amino acid is much more abundant than glycine. We will also do some further development on the substrate-induced respiration method, before it will be employed at field sites abroad.

III. Are there any particular problems ? Is your part of the project on schedule ?

Our part of the project is running on schedule.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

See separate page

V. List of Publications arising from the project (include copies):

Högberg P, Högbom L, Schinkel H, Högberg M, Johannisson C, Wallmark H 1996 N-15 abundance of surface soils, roots and mycorrhizas in profiles of European forest soils. Oecologia 108: 207-214.
Högberg P 1997 N-15 natural abundance in soil-plant systems. Tansley Review. New Phytologist, accepted.
Giesler R, Högberg M, Högberg P 1997 Soil chemistry and plants in the Fenno-scandian boreal forest as exemplified by an extreme local gradient. Ecology, accepted.

Signature of Partner: Peter Högberg

Date: 1997-02-10

N-15/C-13 labelling experiment in the field

We undertook a major N-15/C-13 labelling experiment to assess the importance of organic N use in different species directly in the field. This work was done in collaboration with the plant physiologist Torgny Näsholm and his group. Briefly circular plots (24 cm in diam.) were treated by injections of N-15/C-13 labelled glycine, N-15 labelled ammonium or just water (control) into the morlayer. The N additions were 1 kg N/ha.The experiment was conducted in the end of June close to the Åheden site (the soil temperature was c. 7°C). The circular plots contained both *Deschampsia* grass and ericaceous *Vaccinium*; the mor was also ramified by tree roots. This means that there were arbuscular mycorrhizas, ericoid mycorrhizas and ectomycorrhizas, respectively.

Soil respiration rate and C-13 abundance of respired CO2 was measured after 2 hrs, 1 day and 7 days. Root samples and microbial N were extracted after 6 h, 1 d and 7 d. Samplings were also made of the soil solution and extractable inorganic N and amino acids, in addition to soil total N and C.

The major preliminary results are as follows:

1. Uptake of the two N sources by roots occurred at roughly the same rate in all three groups of plants, and was very fast. The increase in labelling of roots after the initial 6 h response was usually small.
2. In the glycine treatment there was a very rapid respiration of the glycine. The initial respiration of labelled compound was 5 times faster at 2 h than at 1 d, and more than 10 times faster than at 7 d. The amount of labelled C respired during the period 0-7 d was around 15% of that added.
3. Despite this rapid respiration of glycine there was a small increase in C-13 abundance in roots on plots treated with labelled glycine.
4. Changes in N-15 and C-13 were more clearly observed in amino acids extracted from roots than in total N and C, and showed that 50-70% of the C-13 taken up with the glycine still remained in the tissue after 7 d.
5. Microbial N was c. 12 kg N/ha; the amount of labelled N going into this pool remains to be determined.
6. Also, many other parameters mentioned above have not yet been measured.

Thus, it appears that a small amino acid is used as rapidly as ammonium by plants with different types of mycorrhizas in this ecosystem. The rapid initial respiration of C-13 from glycine indicates that it is rapidly used as C source, but we do not yet know who is responsible for this respiration.

Development work to separate microbial activity from root activity

A first contribution from this work has been published (Högberg & Ekblad 1996 Soil Biology and Biochemistry 28: 1131-1138). In subsequent studies we found that we could saturate the respiration response at a certain level of addition of C4-sugar. The residual C3 respiration after a few days after such an induction, likely reflects the root respiration, but further work is needed to confirm this hypothesis.

A reconnaissance tour to Italy

We undertook a tour to Italian sites, notably to Collelongo, to make a preliminary sampling and to get ideas how C-13 labelling of soil activity should be done. Such studies are planned for 1998.

Annual Report - CANIF

Period: 1.2.96 - 31.1.97
Partner: 03
Principle Investigators: Prof. Dr. Giuseppe Scarascia-Mugnozza (gscaras@unitus.it)
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Ms. Sabina Dore (gaia@unitus.it)
Mr. Alberto Masci
Mr. Giuseppe Napoli
Mr. Roberto Bimbi
Mr. Tullio Oro
Mr. Renato Zompanti
Dr. Francesca Cotrufo (University of Napoli II)
Dr. Guia Cecchini (University of Firenze)
Prof. Dr. Guido Sanesi (University of Firenze)

Sites: Collelongo, beech forest (41°52' N, 13°38' E, 1550 m a.s.l.)
Monte di Mezzo, spruce plantation (41°49' N, 14°12' E, 900 m a.s.l.)

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I. Objectives '96

- to study nitrogen uptake and biomass production and partitioning in montane-Mediterranean forest ecosystems by means of ^{15}N labelling experiments and biomass analysis at the Italian sites;
- to investigate the rooting depth of the different forest tree species and to evaluate competitive interactions in water utilisation among trees of each forest stand;
- to measure soil respiration in beech and spruce stands of the Central Appennines in relation to environmental conditions and silvicultural practice (this objective was specifical for 1996).

II. Objectives '97

1. Biomass production:
   - to study litter production above- (leaves and needles) and below-ground (fine root turnover) in beech and spruce sites of the Central Appennines;
   - to monitor tree growth by means of dendrometer at both sites, with larger sampling in the beech forest.
2. Plant nutrient budget and cycling:
   - to study nitrogen uptake and partitioning in montane-Mediterranean forest ecosystems (beech and spruce) by means of ^{15}N labelling experiments;

- to investigate nitrogen distribution in plant compartments by means of classical analytical techniques. Special emphasis will be addressed to study vertical profiles of leaf nutrients.

3. Soil respiration:
   - According to the general objective of the group for the project, monitoring of soil respiration will be continued at beech and spruce sites. Measurements will be performed every 15-30 days.
     Soil respiration will be also measured in different soil/litter conditions and, for the beech site, in areas where different silvicultural practice have been applied. At the beech site, in co-operation with the EC project EUROFLUX soil respiration will be estimated at a larger scale by means of eddy flux measurements (test and daily campaigns).
4. Soil processes:
   - Together with Prof. Guido Sanesi from Florence and Dr. Björn R. Andersen from DFLRI (Denmark) soil solution will be collected by means of gravity and suction-cup lysimeters. Microlysimeters will be also installed adjacent to suction lysimeters, in order to assess their performance and comparability. Soil water will be then analysed for the major chemicals and for DOC and DON. Due to their limited space requirement, microlysimeters will be installed at various location within the beech forest, in order to sample spatial variability of soil solution. Soil processes will be mainly investigated in the beech site.
5. Decomposition processes
   - Together with Dr. Francesca Cotrufo leaf and twig litter decomposition will be studied. Leaf and twig samples will be collected and analysed after 0.5 and 1 year from their incubation in mesh bags (leaf litter) and nylon lines (twigs). The experiment is running in 4 different beech forests (Denmark, France, Germany, Italy) and a first comparison will be possible.
6. Isotopes studies
   - Plant material will be analysed for carbon ($^{12}C/^{13}C$) and deuterium/ hydrogen abundances (D/H). D/H values of plant material (leaves, branches and roots) will be compared to those of rain and of water extracted from different soil depth to investigate the rooting depth of the different forest tree species and to evaluate competitive interactions in water utilisation among trees of each forest stand.
     Analysis of leaf carbon isotopic ratio ($^{12}C/^{13}C$) of different tree species (beech/spruce) and, within a species, of different leaf layers in the canopy will be utilised to infer intrinsic water use efficiency.

III. Problems and deviations from plans

Overall, within 1996, there were not major deviations from the stated workplan. In fact, the objectives stated in section I for the first year (1996) were those to be pursued along the whole project duration (96-98) and, as a consequence, the work has been particularly concentrated on two of the three listed objectives. Specifically, the major part of the work has been performed on studying biomass and its partitioning in montane-Mediterranean forest ecosystems and in measuring soil respiration in the same ecosystems (beech and spruce stands).

The rooting depth of the different forest tree species has been indirectly studied when assessing the biomass of the main root apparatus of beech and spruce, while isotopic analysis of water extracted from different soil depth to evaluate competitive interactions in water utilisation among trees will be performed in 1997. Scientific and technical information on ^{15}N labelling techniques have been gathered; experiments will be performed in 1997.

IV. Results

- The Italian forest stands of beech (Collelongo, natural forest) and spruce (plantation) have been characterised for meteorological, structural and biomass parameters.

In the beech stand the total LAI, the inter-annual variation of LAI of the last 5 years, the leaf area duration, and LAI vertical distribution have been recorded as well as stand density, tree biomass distribution above- and below-ground, stem analysis and biomass productivity. Biomass study involved the felling and careful analysis of 23 trees distributed over the diameter range of the forest trees. Belowground biomass was investigated on 6 of those 23 trees. It came out that 25% of a total woody biomass of 280.8 t ha^{-1} is made up from roots, while root/shoot ratio is 0.33. Mean annual increment of total biomass is 2.81 t ha^{-1} yr^{-1} and that of root is not negligible, reaching about 0.7 t ha^{-1} yr^{-1}.

A similar set of parameters has been collected in the spruce plantation, although this was the first year of studies. In the case of spruce, biomass analysis involved 21 trees, while root biomass was measured on 5 trees. The stand, planted 38 years ago at a high density, at the moment has 3010 tree ha^{-1} with a relevant mean height (21.3 m) and diameter at breast height (20.2 cm). For this reason, and taking advantage of the favourable climate condition (T_{mean}=8.5 °C, P=1006 mm), total biomass is particularly high (556.7 t ha^{-1}). Stem biomass is 328.5 t ha^{-1}. Root biomass contribution to total biomass and root/shoot ratio are similar to those of beech, arriving to 26% and 0.36, respectively. Mean annual increment of total biomass is 13.5 t ha^{-1} yr^{-1} and that of root is not negligible, around 3.8 t ha^{-1} yr^{-1}.

Stem analysis provided interesting information on height-age relationships.

At a mean age of 100 years, dominant beech trees are still growing in height and this is true also for dominated trees, although to a lesser extent. Nevertheless, in our stand, the height growth stimulation reported for beech trees growing in Germany seemed not evident.

On the contrary, in the spruce plantation, height growth saturation was reached both in dominant and dominated trees. This fact, together with the high standing biomass is indicating the need for this stand to be thinned.

- Within the CANIF project, our group plans to estimate the rooting depth of trees by the isotopic analysis (deuterium/ hydrogen abundances) of plant material (leaves, branches and roots), rain and of water extracted from different soil depth. During the first year, the rooting depth has been indirectly studied when assessing the biomass of the main root apparatus of beech and spruce. In fact, the main root apparatus of 6 beech and 5 spruce trees was extracted partly by hand and partly with a small excavator. These operations allowed allometric measurements of the apparatus (width, depth, diameter. etc.). At the same time, a careful study of the hole left by the root apparatus was performed, so to investigate roots depth and distribution.

  Beech roots were distributed as deep as 90 cm belowground. Nevertheless, along a profile from 0 to -90 cm, only 2% of the total number of roots was present in the last 15 cm (-75 ÷ - 90 cm); 35% was located in the first 15 cm, and, overall, more than 80% of the roots were within the first 45 cm.

  Soil at the spruce site was clayish and more compact in respect to that of the beech one and roots could be found not deeper than 60 cm.. Similarly to beech, 35% of the roots were in the first 10 cm. Overall, compared to the beech site, the distribution of the roots along the 60 cm-deep profile was more uniform and 7-8% of the roots were present in the last 10 cm (-50 ÷ - 60 cm).

  Overall, on a profile-surface basis, beech showed a higher density of roots, with 0.086 roots cm^{-2} compared to 0.036 roots cm^{-2} for spruce. The roots surrounding the hole left by main root apparatus extraction were mainly fine, with 80% (spruce) and 90% (beech) of the total number made up by roots with diameter < 1 mm.

- Soil respiration was measured at both sites using a portable IRGA (EGM PPSystem, Great Britain) equipped with a soil respiration chamber. Concurrently, soil temperature was measured with the EGM soil probe (PPSystem, Great Britain), while soil volumetric water content of the first 20 cm was measured with the TDR technique (Trime IMKO GmbH, Germany). Measurements were more frequent at the beech site with 10 dates, since mid

May (day 144) to mid November 1996 (day 318), than at the spruce site, where soil respiration was sampled three times, starting mid June (day 170) and ending at the end of October (day 296).
At both sites, soil CO_2 emission ranged between 2.0 and 4.0 μmol m^{-2} s^{-1}, peaking in August. Peak value was higher in the beech forest (3.8 μmol m^{-2} s^{-1}) than in the spruce plantation (3.1 μmol m^{-2} s^{-1}).
In the beech forest, soil respiration was not dependent solely on temperature, but a strong interaction with soil water content of the first 20 cm of soil was found. Infact, from May to July (days 144-219), soil respiration declined with declining soil humidity, while, on the same time, soil and air temperature were increasing. On the other hand, when temperature started to become limiting, to from the peak in August till November, respiration decreased, responding to decreasing temperature. Nevertheless, concurrently with a steeper increase in soil water, a sudden increase of soil CO_2 emission occurred in October (day 283). These findings point to the fact that, in certain environments, soil respiration can not be modelled only on the basis of respiration/temperature relationships and more complex models are needed.
On the contrary, at the spruce site, soil respiration appeared to follow the classical relation with soil temperature. Interestingly, at that site, the relation between soil CO_2 emission and soil humidity proved to be inverse, with the former increasing while the latter was decreasing. In this case, the clayish and compact soil of the site could play a role, creating, with its high water-holding capacity, unfavourable conditions for organic matter mineralisation and root respiration. Nevertheless, a larger number of measurements will be needed before drawing some definite conclusions.

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 1.2.1996 - 31.1.1997

Partner: University of Hohenheim, Institute of Plant Nutrition

Principal Investigator: Dr. Eckhard George

Scientific staff: Christoph Stober

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I. OBJECTIVES FOR THE REPORTING PERIOD:

1) To investigate the relations between nitrogen (N) uptake by, and transport of photosynthetic carbon (C) to different root zones.
2) To determine the contribution of ectomycorrhizal hyphae to the N uptake of trees and the corresponding carbon supply from the trees to the hyphae, and to measure respiration rates.
3) To estimate fine root turnover.

II. OBJECTIVES FOR THE NEXT PERIOD:

4) To analyse non-structural carbohydrates in different root parts in order to assess the current energy status of the root tissue as a measure of the corresponding carbon investment in the root system (together with other groups).
5) To quantify soil respiration rates and to estimate the proportion of root respiration (including mycorrhizal respiration).

III. Are there any particular problems ? Is your part of the project on schedule ?

No. Yes.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

Enclosed.

V. List of Publications arising from the project (include copies):

Signature of Partner: Universität Hohenheim
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70593 Stuttgart
Eckhard George

Date: 12-02-97

IV. Main results obtained:

N uptake of individual roots was tested by application of ^{15}N containing agar blocks to these roots. Ammonium and nitrate were supplied simultaneously in different ratios. Uptake and translocation to basal root zones was measured by mass spectrometry. In Fig. 1, as an example, results are shown for one application period (24 h) and for agar blocks containing 1 mM N.

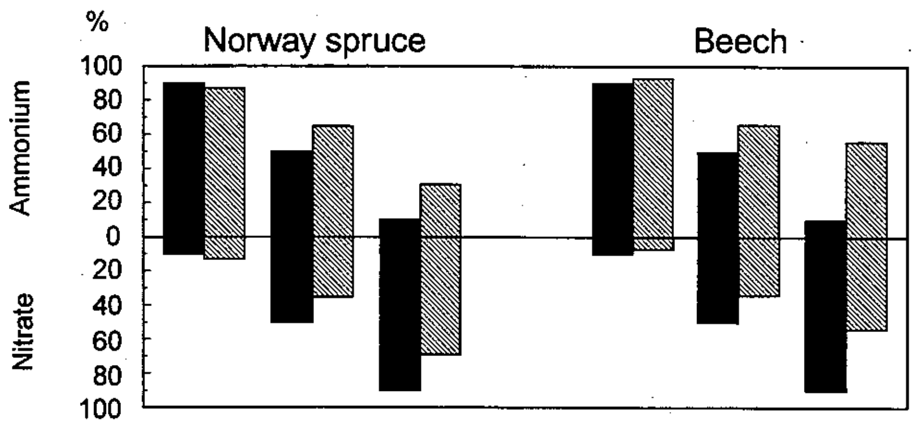

Fig 1: Ratio of ammonium and nitrate supply (dark bars) and ratio of ammonium and nitrate uptake (light bars) in roots of Norway spruce and beech (24h, 1 mM N)

When ammonium supply was 90% and nitrate 10% of total N supply, uptake of ammonium and nitrate showed a ratio similar to the ratio in supply. When supply was equal for both N forms, twice as much ammonium as nitrate was taken up. This was true for both tree species under investigation. When nitrate supply exceeded ammonium supply, uptake of nitrate was higher than that of ammonium (Norway spruce) or at least equal (beech). Thus, uptake of N is strongly influenced by ratios in availability of N forms. By analyzing the N depletion in the agar and balancing uptake N to residual N, we will confirm our findings.

The role of the mycorrhizal symbiosis on N uptake on the one hand and the corresponding allocation of photosynthetic carbon to the root and the fungus on the other hand was studied by double labelling experiments with ^{13}C and ^{15}N. Mesh bags of different mesh size penetrable to roots and hyphae, or to hyphae only, were installed next to five-year-old trees in April/May 1996 at three spruce (Aheden, Skogaby, Aubure) and two beech (Hilleroed, Aubure) sites. ^{15}N labelled ammonium, nirate and glutamic acid were supplied to the soil compartments in July. Six weeks later, the shoots of the trees were exposed to ^{13}C labelled CO_2 for eight hours. After six days, shoots, roots and mesh bags were harvested. Plants were separated into several components before drying, weighing and grinding. Analysis of ^{15}N and ^{13}C will be done in 1997. One day before harvest, respiration measurements were carried out by sampling soil-emitted CO_2 in a headspace placed on one of the mesh bags or on the soil. First analysis showed increasing $^{13}C/^{12}C$ ratios with increasing CO_2 concentration in all treatments (Fig. 2).

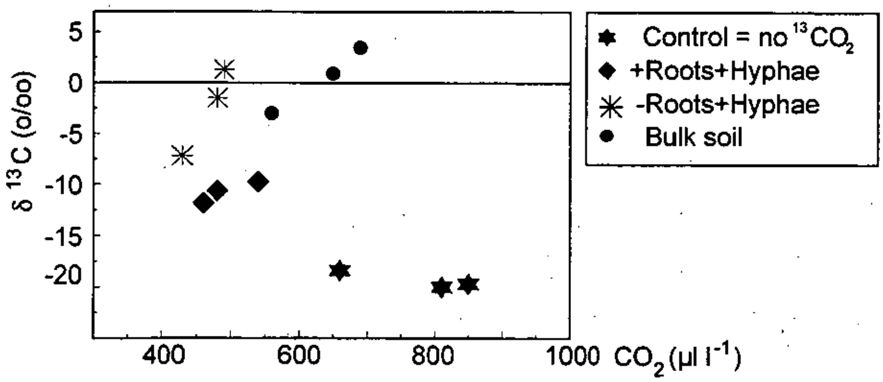

Fig. 2: Relationship between CO_2 concentration and $\delta^{13}C$ of samples from headspaces placed on soil or soil compartments next to young trees five days after aboveground $^{13}CO_2$ exposure to these trees

Root window observations were continued for a third vegetation period at most sites. Root growth was less in 1996 than in the years before. Analysis of the climate data of the sites will show whether this was due to different weather conditions in 1996. Differences between species and between sites followed, however, similar pattern to previous years. After the final recordings in spring 1997, root window data will be completed and turnover rates will be estimated.

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period:**February 1996 to December 1996**

Partner:**05 IN (FR)**

Principal Investigator:**Dr. Francis MARTIN**

Scientific staff: **Dr. M. COLIN-BELGRAND, B. ZELLER & Dr. F. MARTIN**

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I. OBJECTIVE FOR THE REPORTING PERIOD

All sites:

(1) Application of ^{15}N-labelled beech litter to study its decomposition and size and turnover of soil N fractions at selected CANIF sites.
(2) Assessment of the intraspecific biodiversity of major types of ectomycorrhizal fungi.

Aubure site:

(3) Study of the leaching, accumulation and release of N in decomposing ^{15}N-labelled beech litter deposited on the site in fall.
(4) Quantitation of total amounts of C and N immobilized in lignous biomass on the stand: biomass estimation, sampling for chemical analysis. C, N and major elements measurements.
(5) Identification of major types of beech ectomycorrhizas by molecular diagnostics.

II. OBJECTIVES FOR THE NEXT PERIOD

All sites:

(1) The release of ^{15}N from labelled decomposing litter in the main soil and plant compartments will be assessed after 18 months of litter decomposition (sampling in October 1997). Trees located in the ^{15}N-labelled area will be wrapped in the beginning of fall to avoid wind dispersal of possibly labelled crown leaves.

Aubure site:

(2) N acquisition capacity of the different genets of the ectomycorrhizal fungus *Laccaria amethystina* will be estimated.

(3) Seasonal variability of leaching, accumulation and release of ^{15}N from labelled decomposing litter in the main solid and liquid compartments of the beech ecosystem will be measured.

(4) Total amount of C & N immobilized in the lignous compartments and dynamics of N pools in different soil horizons will be used in a simulation model.

III. Are there any particular problems ? Is your part of the project on schedule ?

No problem to mention
Work schedule and milestones of the project for the year 96 have been achieved.

IV. MAIN RESULTS OBTAINED

All sites

(1) Application of ^{15}N-labelled beech litter to study its decomposition rate, and size and turnover of soil N fractions at selected CANIF sites

Major aims of the present study include 1) tracing a mechanism for the uptake and the release of N from litter and 2) identifying patterns of N dynamics taking place during litter decomposition in the main above- and below-ground compartments of the beech ecosystem. A detailed ^{15}N budget will be carried out 6, 18, 30 months after application of ^{15}N-labelled litter. Three sites (Steigerwald, Germany; Collelongo, Italy; Aubure, France) were selected amongst the CANIF sites. This choice was dictated by **(i)** the need for a well-known and well-studied species, such as *Fagus sylvatica*, common to selected sites along this transect and by **(ii)** technical constraints imposed by ^{15}N labelling field experiments (see below).

Methodology. In Spring 1996, nine young beech trees were selected in the Steigerwald forest and at the Collelongo site. Height of selected trees was about 3-4 m or 10 m in German and Italian sites, respectively. Root system of selected trees was isolated from the neighbouring soil with a plastic sheet sunk into the soil (30 cm depth). The 1995 litterfall was carefully removed and replaced by ^{15}N-labelled litter (250 g d.w./1 m^2 area/tree). The labelled area was covered by a plastic net to avoid ^{15}N pollution of the site by wind or animal dispersal.

In the Steigerwald site, the treated trees were wrapped with fine nets from the beginning of September until the first sampling (22 October 1996). Then, three trees were cut and all tree compartments were collected. Nine soil samples underneath the labelled area (0-10cm, 10-20cm and 20-30cm depth) were taken.

Results Total N and ^{15}N, and main nutrient elements will be determined on the following compartments:

- aerial tree part: leaves, buds 1996, bark and wood of annual growth unit of years 96 and 95)
- root tree part: mycorhiza, roots divided in 3 diameter classes (<1mm, 1-3mm, >3mm, taproot (sapwood and heartwood).
- sieved soil (4 mm): microbial biomass, soil KCl and K_2SO_4 extractions, solid fractions
- litter compartment.

Chemical analyses are currently underway.

(2) Assessment of the intraspecific biodiversity of major types of ectomycorrhizal fungi

Major species of ectomycorrhizal fungi have been collected during fall 1996 in Steigerwald (Germany), Collelongo (Italy) and Aubure (France). Unfortunately, production of fruiting bodies has been very low in Europe in 96 and the limited number of samples collected precluded a carefull assessment of the fungal diversity. However, the collected fruiting bodies have been typed and added to our current Web database of RFLP patterns.

Aubure site

(3) Study of the leaching, accumulation and release of N in decomposing ^{15}N-labelled beech litter deposited on the site in fall

Methodology. Results from a litter-bag experiment carried out using ^{15}N-labelled litter, identical to the litter used in the determination of litter decomposition rate [see (1)], were used in a simulation model to describe mass loss.

Results. During the first year of litter decomposition, accumulated mass loss reached 25 %. The N concentration of litter increased from 8.9 mg g^{-1} up to 14.3 mg g^{-1}. Increase in litter N concentration and mass loss were linearly correlated (r^2 = 0.97). Use of ^{15}N labelled litter allowed us to distinguish between N actually released from the litter and N actually taken up.

After one year of litter decomposition, a net absolute increase in N takes place. The release of ^{15}N, initially bound in the litter, (-14.4 %) was much lower than the uptake of N into the litter (+77.8 %). Highest amounts of N (^{15}N) released from decomposing beech litter were detected in the solid soil compartment (110 % of released N). The high ^{15}N amount in the soil was due to a pollution of the soil by litter fragments. About 15 % of the litter-derived N (^{15}N) was incorporated into the microbial biomass N; approximately 5 % was extracted from the soil as mineral N (^{15}N) (NO_3^-; NH_4^+) (fig. 1). Only a low amount of N (^{15}N) was taken up by roots and mycorrhizal tips and transferred to the leaves (fig 1).

(4) Quantitation of total amounts of C and N immobilized in lignous biomass

Methodology. A special method, developed in our laboratory (Ranger *et al.* 1992), was used to accurately evaluate the biomass and C & N content of beech stands. For the present study, this method can be summarised as follow:

(1) the inventory of the stand was carried out on a hectare area according the stand density and stand age

(2) Seventeen trees (distributed throughout all the girth classes defined from the inventory) were cut down at the end of winter and the major plant components were isolated and sampled: stemwood and stembark of each balk of the trunk cut every 2 meters along the total tree height, branches (wood + bark) divided in 5 classes of diameter (<1cm, 1-4 cm, 4-7 cm, >7 cm). The following parameters were measured: fresh weight of trunk, total weight of each classe of branches per tree. Stem circumference was measured at 0.50 , 1.30 m above-ground and every 2 meters along the stem, total length. Samples were taken on each extremity of balks and each classe of branches for water content, percentage of wood and bark and nutrient content.

Results. Stem and branches samples were analysed to estimate C and major nutrients (N, P, K, Ca and Mg) content. Biomass and nutrient content tables will be modelled from data of weight and dendrometric stem measurements and from nutrient concentration.

(5) Identification of major types of beech ectomycorrhizas by molecular diagnostics

Major types of ectomycorrhizal fungi present in the beech stand in Aubure have been identified. *Laccaria amethystina*, *Lactarius subdulcis*, *Russula ochroleuca* et *Xerocomus chrysentheron* were some of the major types identified on this site. PCR/RFLP patterns have been generated for these different morphotypes.

Number of genets (i.e. mycelium sharing identical genotype) of *L. amethystina* and their spatial distribution have been assessed by DNA heteroduplex analysis and microsatellite-primed PCR DNA amplification on 600 fruiting bodies. A typical feature of this site is the large number (>10) of intricated genets with a limited spatial distribution (>dm^2).

V. List of publications arising from the project

None

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Champenoux, 29 January 1997

~~Dr. F~~rancis MARTIN

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 1 January - 31 December 1996

Partner: University of Sheffield

Principal Investigator: Professor D J Read

Scientific staff: Dr A F S Taylor

Address: Department of Animal & Plant Sciences
University of Sheffield
Sheffield
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UK

Telephone: +44 (0)114 222 4318

Fax: +44 (0)114 276 0159 E-Mail: D.J.Read@sheffield.ac.uk

I. OBJECTIVES FOR THE REPORTING PERIOD:

To identify the major types of ectomycorrhizal association found on beech and spruce at each location along the CANIF gradient so that elements of their taxonomic and functional biodiversity can be elucidated.

II. OBJECTIVES FOR THE NEXT PERIOD:

To evaluate the ability of each of the major mycorrhizal types, identified in (1) above, to assimilate the major amino-acids as nitrogen and carbon sources when supplied to detached roots in the laboratory, and intact systems in the field.

III. Are there any particular problems ? Is your part of the project on schedule ?

No particular problem. Dr Taylor was well qualified to achieve Objective 1 but his skills are less appropriate for Objective 2. He has, by prior agreement, left the project at this stage, and Dr Thomas Wallenda, who is a Plant Physiologist, has been appointed to work on Objective 2.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

Soil cores (12 per site) were taken from 4 of the major *Fagus* sites on the CANIF gradient viz. Gribskov (Denmark) Schacht (Germany) Aubure (France) Collelongo (Italy). At each site the total number of root tips, the proportion colonised by mycorrhizal fungi, the fungal species composition and diversity were determined. The dominant fungi at Gribskov were *Russula* spp, at Schacht *Lactarius*, and Aubure, again *Russula*. At Collelongo a large number of species, each with a low representation, were found. The results are summarised in Table 1. Total mycorrhizal colonisation at each site was extremely high, virtually all roots being mycorrhizal. Diversity indeces were highest at Schacht and Collelongo and lowest at Aubure. When comparing this data set with that obtained for spruce (Table 2) at sites where the two species occurred together in the same soil type, it is seen that where, as in Aubure, beech has a low mycorrhizal diversity, that of spruce is high. Conversely where beech diversity is high as at Schacht, spruce shows a lower diversity. The extent to which these differences reflect management histories or relative sensitivities of the host - symbiont combinations to pollutant inputs is currently being examined.

The first in a series of planned experiments investigating the pathways of assimilation of the carbon and nitrogen atoms of amino acids assimilated by mycorrhizal fungi, using double labelled (^{13}C & ^{15}N) amino acids, has been carried out in collaboration with Dr G Gebauer in Bayreuth. The tissues are currently being analysed.

V. List of Publications arising from the project (include copies):

Publications are in preparation.

Signature of Partner: DJRead

Date: 18/2/97

Table 1. Summary table of mycorrhizal data from CANIF sites

Site	No. of root tips examined	Colonisation (%)	No. of species	Diversity (Shannon-Weiner Index)
GRIBSKOV	2123	99.2	14	2.83
SCHACHT	2141	100	22	3.93
AUBURE	698	99.9	11	2.34
COLLELONGO	3209	99.8	19	3.14
	8171		34	

Table 2. Comparison between beech and spruce sites

	Gribskov		Schacht		Aubure	
	Beech	Spruce	Beech	Spruce	Beech	Spruce
No. of species	14	19	22	14	11	18
Colonisation (%)	99.2	90.7	100	98.6	99.6	99.1
Diversity	2.83	3.34	3.93	2.59	2.34	3.29

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period:	1 February 1996 - 31 January 1997
Partner:	Swedish University of Agricultural Sciences, Uppsala (part 7a)
Principal investigator:	Prof. T. Persson
Scientific staff:	A. Rudebeck, P. Karlsson, U Seyferth
Address:	Dept. of Ecology and Environmental Research, Swedish University of Agricultural Sciences, Box 7072, S-750 07 Uppsala, Sweden
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I. OBJECTIVES FOR THE REPORTING PERIOD (part 7a)

(1) To determine in situ C and N organic pools and C and N mineralisation rates for each soil horizon (to a depth of 50 cm) in samples taken to the laboratory at Collelongo and Monte di Mezzo.
(2) To determine field nitrification potentials based on laboratory studies at the Italian sites.
(3) To identify nitrifier types at Skogaby and Aubure.
(4) To determine CO_2, ammonium and nitrate formation rates in relation to soil temperature and soil moisture levels in the laboratory to obtain response functions at Skogaby.
(5) To compare ammonium and nitrate formation rates in undisturbed monoliths and in sifted soil horizons in the laboratory at Åheden, Gadevang/Gribskov and Klosterhede.
(6) To determine C and N organic pools and C and N mineralisation rates in organic and mineral soil horizons in long-term field N fertilisation experiments at Stråsan and Skogaby.
(7-9) See part 7b

II. OBJECTIVES FOR THE NEXT PERIOD

(1) To determine in situ C and N organic pools and C and N mineralisation rates for each soil horizon (to a depth of 50 cm) in samples taken to the laboratory at Sorø and the Czech sites.
(2) To determine field nitrification potentials based on laboratory studies at Sorø and the Czech sites.
(3) To go on with the identification of the nitrifier types at Skogaby and Aubure and also start with nitrifiers from Fichtelgebirge and Collelongo.
(4) To formulate resonse functions for temperature and moisture based on data from Skogaby.
(5) To evaluate the comparisons of soil processes in undisturbed and disturbed soil layers.
(6) To evaluate the studies made in N fertilisation experiments (see §6 above).
(7) To evaluate effects of soil faunal effects on C and N mineralisation.
(8) To start studies of net and gross N mineralisation using ^{15}N, primarily at Skogaby.

PART B

III. Are there any particular problems? Is your part of the project on schedule?

The subproject is on schedule.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages if necessary but preferably no more than 2)

(1) The C and N soil pools in the beech and spruce stands at Collelongo and Monte di Mezzo, respectively, were high compared with the the other sites in the Canif transect. The pools of organic N were particularly high, 18 and 19 tonnes per ha, respectively. These figures might be compared with about 8 tonnes per ha in Fichtelgebirge and 1.5-4.5 tonnes per ha at the other sites. On the other hand, the C and N mineralisation rates per g of soil were low. The soil C mineralisation (excluding roots and mycorrhizal fungi) was roughly calculated to be about 1900 per ha and year for Collelongo and 3500 for M. di Mezzo, whereas the corresponding figures for net N mineralisation was 145 and 160 kg N per ha and year.
(2) The net nitrification potential (the rate of nitrate produced in the absence of roots) was very high at Collelongo and Monte di Mezzo, and most of the ammonium formed was converted to nitrate. The nitrification potential calculated in that manner was about 125 and 160 kg N per ha and year for the sites.
(3) DNA has been extracted, and signals have been obtained with probes with specific ammonium oxidizers. The methods are refined based on the materials from Skogaby.
(4) Rates of C mineralisation, net N mineralisation, nitrification and N_2O production have been studied at 6 different temperatures and 4 soil moisture levels for two different soil layers at Skogaby. The data are in accordance with those presented for another site in the final report for NIPHYS (1996). Different models are tested to obtain response functions.
(5) A comparison between undisturbed and disturbed soil has been made for three soil materials. For some soil layers, there were differences. The results are under evaluation.
(6) C and N soil pools and C and N mineralisation rates have been studied for control plots and plots fertilised with inorganic N for the spruce sites at Stråsan and Skogaby. At Stråsan, where the fertilisation has went on for about 20 years (about 70 kg N per ha and year), the soil N pool has increased from about 2000 kg per ha in the control plots to 2900 kg N per ha in the fertilised plots. Net N mineralisation has also increased, from 6 to 60 kg N per ha and year. In this site, the trees have responded with a heavy N uptake. Most of the fertiliser N has been kept by the ecosystem. Only about 30% of the applied amount of fertiliser N (more than 1500 kg N per ha) could not be detected in the system. The same trend was found for Skogaby, but at that site ther was a significant leaching of N after N fertilisation. The study is under evaluation.

V. List of publications arising from the project (include copies):

Up till now nothing has been published of the data gathered in 1996.

Signature of the partner:

Date: 14 February 1997

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 1.2.96 - 31.1.97

Partner: Swedish University of Agricultural Sciences, Uppsala, (part 7b)

Principal Investigator: Dr. Hans Persson

Scientific Staff: Res. Ass. Kerstin Ahlström

Telephone: +46 - 18 67 24 26

Fax: + 46 - 18 67 34 30 E-Mail: Hans.Persson@eom.slu.se

I. OBJECTIVE FOR THE REPORTING PERIOD (part 7b):

(1) To initiate studies on root distribution (and rooting depth), in terms of dry weight, root length, carbon and nitrogen contents in stands of Norway spruce and European beech.

(2) To be able to relate the fine root distribution (see above) to fine-root dynamics obtained from "root windows (see project report of the Hoheinheim University Group). To carry out cross-site comparison on root distribution and growth dynamics in co-operation with other root and mycorrhizal scientists between all sites.

<u>Aubure sites:</u>
(3) To be able, within the framework of the project, to quantify the seasonal changes in the amount of fine roots (Norway spruce and European beech).

II: OBJECTIVE FOR THE NEXT PERIOD:

<u>Most sites:</u>

(1) To quantify root distribution (and rooting depth), in terms of dry weight, root length, carbon and nitrogen contents in stands of Norway spruce and European beech.

(2) To relate the fine root distribution (see above) to fine-root dynamics obtained from "root windows (see project report of the Hoheinheim University Group). To carry out cross-site comparison on root distribution and growth dynamics in co-operation with other root and mycorrhizal scientists between all sites.

<u>Aubure sites:</u>
(3) To quantify the seasonal changes in the amount of fine roots (Norway spruce and European beech).

German sites.

(4) Root sampling will be carried out at the German Bayreuth sites according to wishes from the Wageningen modelling group (Data for the carbon/nitrogen interaction model; F. Berendse and H. van Oene)

III. Are there any particular problems? Is your part of the project on schedule?

Root sampling has been on schedule. The most extensive root investigations according to our original plans have been made at Aubure. Root sampling was took place at Aubure on 4 occasions at and Skogaby and Gripskov on one occasion. Root sampling will furthermore be carried out at Aubure and Åheden next spring. Results are so far (see below) available from Aubure. Root sorting and preparing material for chemical analyses take place according to the original plans.

IV. MAIN RESULTS OBTAINED:

- The results indicate so far more fine roots (live + dead fine roots) at Aubure in the European beech stand than in the Norway spruce stand (see Fig. 1 below).

- Fine roots at both stands were distributed fairly independently of the distance to the nearest tree (root sampling were carried out 1.5, 2.5, 3.5 and 4.5 m from the nearest tree; see Fig. 2).

- The fine roots were more superficially distributed in the European beech stand that in the Norway spruce stand.

- The most vital fine roots were to be found in the top 0-2.5 cm soil horizon (more live fine roots).

Fine roots in the Norway spruce stand at Aubure were available at very low amounts (live, dead and totals) compared with other investigated European sites.

V. List of publications arising from the project:

Persson, H. & Ahlström, K. Manuscript. Effect of nitrogen deposition on tree roots.

Signature of Partner:

Hans Persson

Hans Persson

Date:

February 15th, 1997

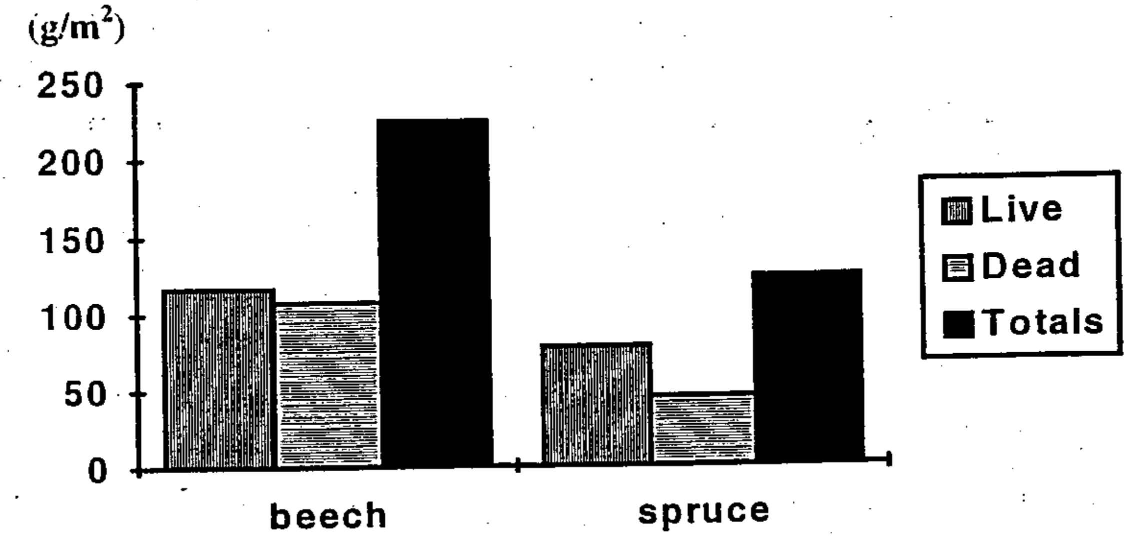

Fig. 1 Amount of fine roots (live, dead and totals) in a beech and Norway spruce stand at Aubure (Root sampling from August 1966)

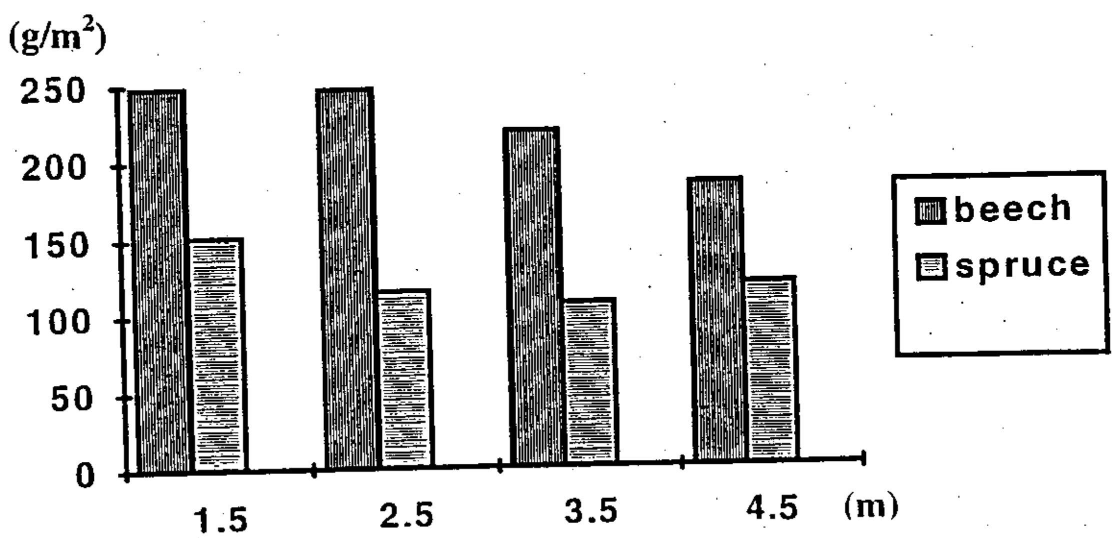

Fig. 2. Standing crop of fine roots (live + dead fine roots) at varying distance from the nearest tree (European beech and Norway spruce) at the Aubure sites.

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 1.2.1996 to 31. 1. 1997

Partner: no 8, University of Copenhagen

Principal Investigator: Sten Struwe

Scientific staff: Dr Xu Hui, Morten Miller, Annelise Kjøller, Sten Struwe

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DK-1307 Copenhagen K

Telephone: +45 35 32 20 50

Fax: +45 35 32 20 40 E-Mail: agm*mermaid.molbio.ku.dk

I. OBJECTIVES FOR THE REPORTING PERIOD:

Quantification of nitrogen gaseous losses from forest soils measured during campaigns in different seasons in the Danish beech forest site, Sorø.

II. OBJECTIVES FOR THE NEXT PERIOD:

The objectives for the second year of the CANIF project are to extend the gas measurements to a selection of the other CANIF sites in order to be able to provide figures for the overall modelling of the processes. It has so far been decided to work at three sites: Collelongo, Aubure and Schacht.

To determine the diversity of the saprophytic microfungal decomposer communities with respect to composition as well as functional role. Changes in the content of soil enzymes will be used as indication of changing growth conditions and substrate quality. It will be attempted to include a litterbag system to be able to test the decomposing litter better.

III. Are there any particular problems ? Is your part of the project on schedule ?

There is good progress in the subproject which also is ahead of the planned programme. The good cooperation in the project is a result of the previous experience from NIPHYS.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

see attachment

V. List of Publications arising from the project (include copies):

Xu Hui: N2O and CH4 fluxes from a beech forest in Denmark

M.Miller, J. Møller and A.Kjøller: Relative influence of fungi and bacteria on DOC formation and enzyme activity in beech leaves microcosms.

Signature of Partner: [signature]

Date: 24/2-97

Fluxes of N_2O and CH_4 in beech forest soil.

Materials and Methods

This study was conducted at the site located at a beech forest in Denmark, the Sorø site. The in situ fluxes of N_2O and CH_4 were measured simultaneously and monthly during April to November, 1996. The results of monthly gaseous fluxes (8 - 15 tubes of replicates for each month) were used to calculate the average of fluxes. The results of flux measurements from the last three months were used in statistical analysis.

Field measurements

The closed chamber technique was used for the measurements of in situ fluxes. PVC tubes, which were 23 cm in height, 13 cm in diameter and with a cover at the top, were inserted into soil about 10 cm depth (leaving the cover open) one month before the measurements. 8 - 15 tubes of replicates were distributed randomly within an area of $10m^2$.The gas samples were taken by plastic syringes through a stopper in the cover at 0, 1, 2, 3 and 4 hours after the tubes were covered. The gas samples were injected into vacuum tubes (3 ml Venoject, manufactured by TERUMO EUROPE N. V., Belgium) for storage and transferred to laboratory for measurements of N_2O and CH_4concentration within 48 hours after sampling..

The soil and air temperature were recorded during the measurement.

Gas fluxes were calculated from linear regression of the concentration versus time curves from the tubes.

The flux is equal to the linear change in gas concentration within the tube multiplied by the density of tube air and the ratio of tube volume to soil surface area . Positive fluxes indicate an emission of a gas from the soil to the atmosphere. Negative fluxes indicate a net consumption of gas from the atmosphere by the soil.

Available nitrogen analysis

Determination of available nitrogen concentrations (NH_4-N, NO_3-N and NO_2-N) were done on a flow injection photometer(Aquatec Analysis System(Tecator AB, Sweden).

Gas analysis

N_2O was measured with Hewlett-packard GC 5890. Porapak Q in column, oven temperature 70 C°,(Electron Capture Detector(63Ni)(ECD), detector temperature 265C°,(ultra-high purity N_2 as carrier, carrier flow was 20 ml N_2 min^{-1}. CH_4 was measured with Hewlett-packard GC 5890, oven temperature 60 C°,(Flame Ionization Detector(FID), detector temperature 150° C, (ultra-high purity H_2 as flame gas.

Statistic analysis

Multiple regression models were evaluated by STEPWISE MULTIPLE REGRESSION of SPSS(Version 6.0). The combination of data of 3 experiments on Sep. 11th, Oct. 10th, and Oct. 30th were used for statistic analysis. Total number of cases is 38.

Results

Monthly N_2O and CH_4 fluxes

In situ fluxes of nitrous oxide and methane were measured monthly during the period of April to October, 1996. The measurement period covered 164 days.

During the measurement period, N_2O was emitted from forest soil and atmospheric CH_4 was consumed by the forest soil in the mixed spruce and beech forest(Fig. 3 and 4). The range of monthly N_2O fluxes was 0.681 g N_2O-N m^{-2} h^{-1} to 6.910 (g N_2O-N m^{-2} h^{-1}. The range of CH_4 fluxes was 25.91 g CH_4-C m^{-2} h^{-1} to 62.40 g CH_4-Cm^{-2} h^{-1}. The weighted average of N2O flux during the measurement period was 0.931 g N_2O-N ha^{-1} d^{-1}, and weighted average of CH_4 flux was -7.597 g CH_4-C ha^{-1} d^{-1}. The total amount of N^2O emission and CH_4 consumption during the measurement period(164 days) are 0.1526 kg N_2O-N ha^{-1} and 1.246 kg CH_4-C ha^{-1} respectively.

Discussion

In situ N_2O fluxes and nitrification(N_2O)

No significant correlation between in situ N_2O emission rate and nitrification (NH_4) was found. However, there was a significant correlation between in situ N_2O emission rate and nitrification(N_2O).

Although N_2O production could be conducted both by nitrification and denitrification, the result of multiple regression indicated that the N_2O production in nitrification was the main process of N_2O production in this mixed spruce and beech forest.

Until twenty years ago denitrification was regarded as the supreme source of atmospheric N_2O, but later investigations have showen that nitrification could also be a significant source of N_2O. The relative importance of these processes varies with local circumstances. Nitrification is an aerobic process. The results implies that soil of the beech forest is suitable for N_2O nitrification because of its aerobic and available NH_4 condition. The average concentration of available NH_4 was 6.0 ug-N g^{-1} (dry soil) in this forest.

In situ N_2O fluxes and soil pH

The variability of N_2O flux in the mixed spruce and beech forest could be explained by the variability of soil pH because a significant correlation between N_2O flux and soil pH was found (Fig.5).

The influence of soil pH on N_2O is complex, both positive and negative effects on N_2O production are reported in papers. However, a significant negative correlation was found in this study. Because there is an evidence that N_2O production in nitrification is the main process of N_2O production in this forest soil, it is easy to explain the reverse correlation between N_2O flux and pH, with one of mechanisms for the responsible process of N_2O production in nitrification. The mechanism is that intermediates between NH_4 and NO_2, or NO_2 itself, can be transformed to N2O, especially under acidic conditions. This mechanism indicates that more intermediates of nitrification are converted to N_2O when pH is low.

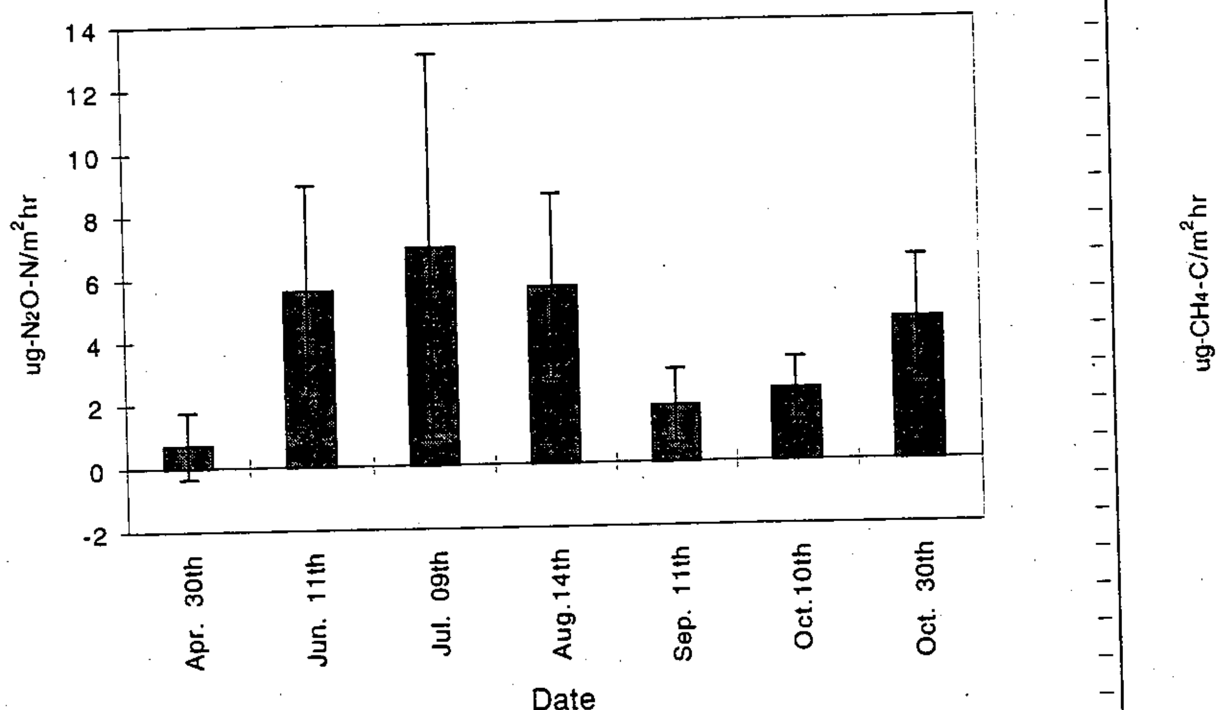

Fig. 3 N_2O Emission Rates in the mixed Spruce and Beech Forest (1996)

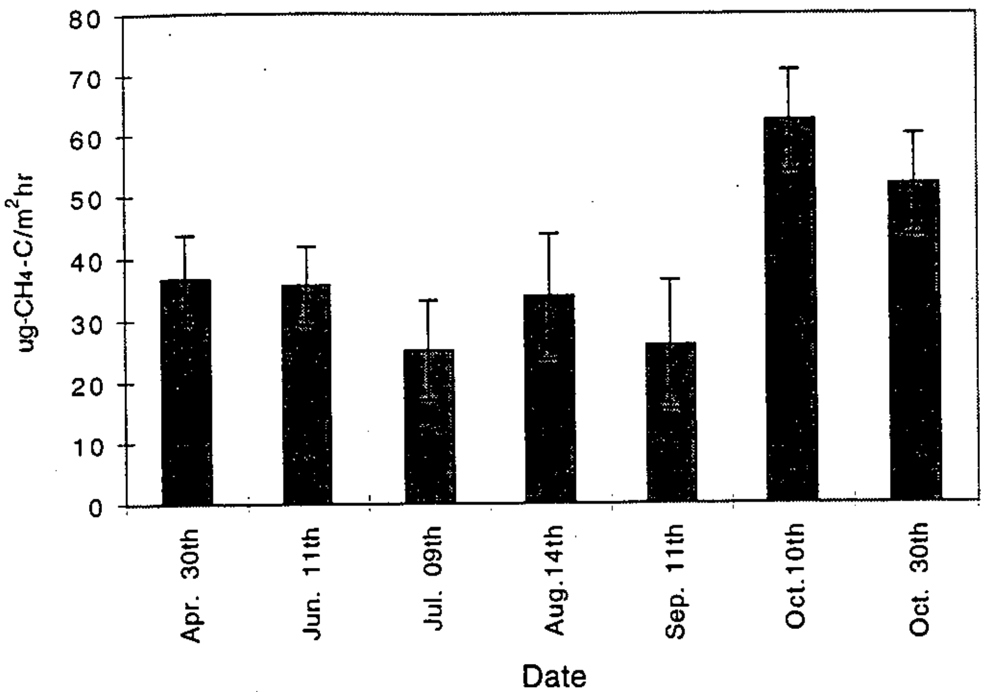

Fig. 4 CH_4 Consumption Rates in the mixed Spruce and Beech Forest (1996)

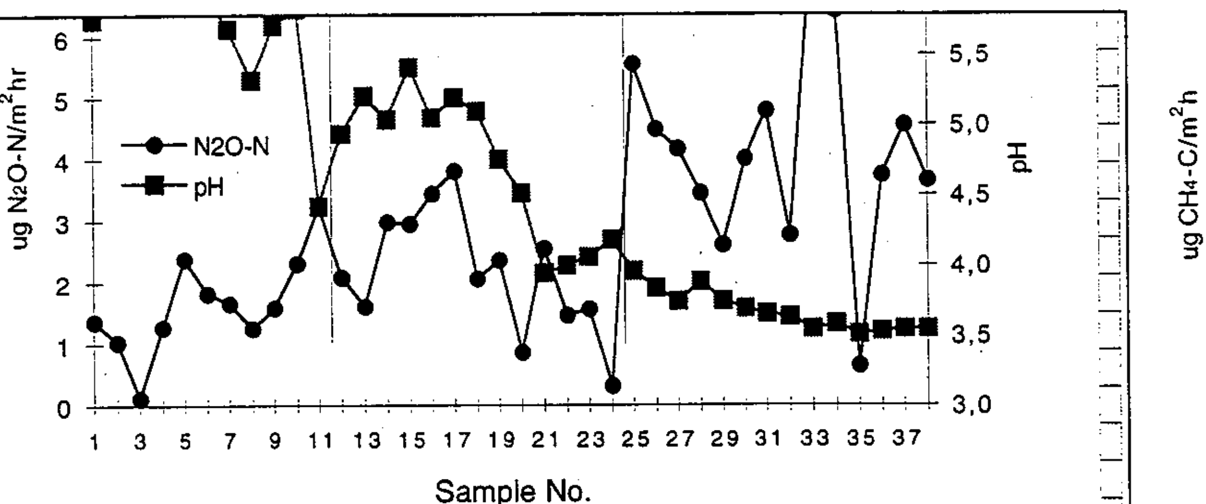

Fig. 5 N_2O emission rate and soil pH in the mixed spruce and beech forest soil

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 01.02.1996 - 31.01.1997

Partner: Justus-Liebig-University Giessen

Principal Investigator: Prof. Dr. Volkmar Wolters

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Dagmar.Schroeter@allzool.bio.uni-giessen.de

I. OBJECTIVES FOR THE REPORTING PERIOD:

(i) sampling of soil cores to determine the structure of the invertebrate communities; (ii) quantification of soil microbial biomass C and N and of functional diversity of soil bacteria; (iii) testing of laboratory facilities (microcosms, ^{15}N, Biolog)

II. OBJECTIVES FOR THE NEXT PERIOD:

(i) continuation of sampling; (ii) determination of invertebrate feeding activity, trophic connectivity and functional groups; (iii) experiments with laboratory microcosms (iv) evaluation of data; (v) ^{15}N analysis.

III. Are there any particular problems ? Is your part of the project on schedule ?

Due to a delayed start of the project and an early winter not all of the sites were sampled. On the other hand microcosm experiments and ^{15}N analysis were already started.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

To get a first information on the faunal inventory four coniferous sites (Aubure, Waldstein, Skogaby, Aheden) and the new danish deciduous site (Sorö) were sampled in late autumn.
On each coniferous site a total of 110 soil cores were taken and each core was separated into organic and mineral layer. The following parameters were measured: (i) abundance and species composition of microarthropods (acari and collembola; so far only examined on a low taxonomic level; further determination in progress); (ii) abundance of nematodes and enchytraeids; (iii) abundance and species composition of testate amoeba (counting and determination in progress); (iv) microbial carbon (C_{mic}); (v) microbial nitrogen (N_{mic}); (vi) respiration; (vii) functional diversity of soil bacteria; (viii) bulk density; (ix) water content; (x) thickness of soil layer; (xi) pH.

In a laboratory microcosm experiment the influence of water content and temperature on different soil mesofauna communities was tested.

In a field microcosm experiment ^{15}N labelled litter was used to study the effect of different soil fauna communtities on nitrogen dynamics. The variable complexity of the soil fauna communities significantly affected ^{15}N-content in leachate and litter residues.

results see next page!

V. List of Publications arising from the project (include copies):

Signature of Partner: [signature] Prof. Dr. V. Wolters

Date: 12. 2. 97

Multivariate analysis of the faunal data revealed significant differences between layers and sites, indicating site specific differences in the contribution of invertebrates to C and N turnover. The same applies for the microbial community as the microbial parameters biomass C and N, respiration and qCO_2 show.
Abundance of most invertebrate groups was inversely correlated with water content. This was confirmed in laboratory microcosm experiments.
The microflora was significantly affected by pH.
Functional diversity of soil bacteria according to Biolog-screening was generally high with extraordinarily high figures at the Northern Swedish site Aheden.

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period : 1 February 1996 - 31st January 1997

Partner : Partner 10 IT (GB)

Principal Investigator : Dr Anthony Harrison

Scientific staff : A P Rowland, J M Poskitt, J Garnett (ITE);
(Dr D D Harkness, NERC Radiocarbon Laboratory, East Kilbride, Scotland).

Address : Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-sands, Cumbria, LA11 6JU.

Telephone : 00-44-15395-32264

Fax : 00-44-15395-34705 EMAIL : T.Harrison@ITE.AC.UK

I. OBJECTIVES FOR THE REPORTING PERIOD :

Soil cores to be taken from all sites [Aheden (N.Sweden), Skogaby (S.Sweden), Hillerod (Denmark), Waldstein (Germany), Schacht (Germany), Aubure (France - 2 sites) and returned to the UK for processing and measurements. Soil cores to be subdivided into appropriate layers, weighing for mass and bulk density measurements, prepared (removal of roots and sieving) and drying, prior to submission for C and N analysis. Subsamples of each soil layer of a subset of cores from each site sent for ^{14}C radiocarbon analysis by accelerator mass-spectrometry; approx 60 in total will be submitted in this year. Produce the report.

II. OBJECTIVES FOR THE REPORTING PERIOD :

Revisit sites for resampling cores if necessary. Process soil cores and p.repare remaining soil samples for C and N analysis. Submit remaining samples for ^{14}C radiocarbon analysis by accelerator mass-spectrometry. Obtain data and calculate provisional estimates of soil carbon and nitrogen fluxes. Contact colleagues regarding data on primary productivity of forests and carbon flux measurements for each of the whole forest ecosystems. Produce report.

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period : 1 February 1996 - 31st January 1997

Partner : Partner 10 IT (GB)

Principal Investigator : Dr Anthony Harrison

Scientific staff : A P Rowland, J M Poskitt, J Garnett (ITE); (Dr D D Harkness, NERC Radiocarbon Laboratory, East Kilbride, Scotland).

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III. Are there any particular problems ? Is your part of the project on schedule ?

There are no practical or scientific problems with the research to date. The forest sites at the extremes of the European transect (Aheden, N Sweden, Collelongo and Monte di Mezzo, Italy) were not sampled in the first year for logistical reasons; these sites will be sampled May/June this second year (1997). However, we sampled two additional (to contract) forests (Nacetin and Jezeri) in the Czech Republic (See Partner 13, Principal Investigator Prof T. Paces) for inclusion in our study on soil carbon and nitrogen fluxes using identical methodology. The sampling of these sites was carried out with a detour from Bayreuth Germany, during the field sampling of the central European forest sites. The rescheduling of the sampling of the Ahenden, Collelongo and Monte di Mezzo sites will cause only a minor delay in the acquisition of results, but no effect on the project outputs as scheduled.

IV MAIN RESULTS OBTAINED: *METHODOLOGY, RESLTS, DISCUSSION, CONCLUSIONS.*

Soil layer dry weight and density measurements have been made on all soil cores sampled from Skogaby, Hillerod, Waldstein, Schacht and Aubure (2 sites), the pretreatments (removal of fine rootlets and sieving have been completed and subsamples (total of > 200 samples) of all layers have been submitted for the C and N analysis. 48 soil samples have been submitted for ^{14}C radiocarbon analysis by accelerator mass-spectrometry, but an additional 24 will be sent within 2-3 weeks. The processing of the additional soil cores taken from the Czech Republic forests is also well under way. The ^{14}C radiocarbon analyses will take some months, but the C and N analyses will be completed before receipt of the radiocarbon dates.

No results are yet available for discussion at this stage because of the necessary length of time need for sample analysis, which is the expected situation prior to the commencement of the project.

V. List of publications arising from the project :

None at this stage in the research project.

Signature of Partner : Anthony Harrison

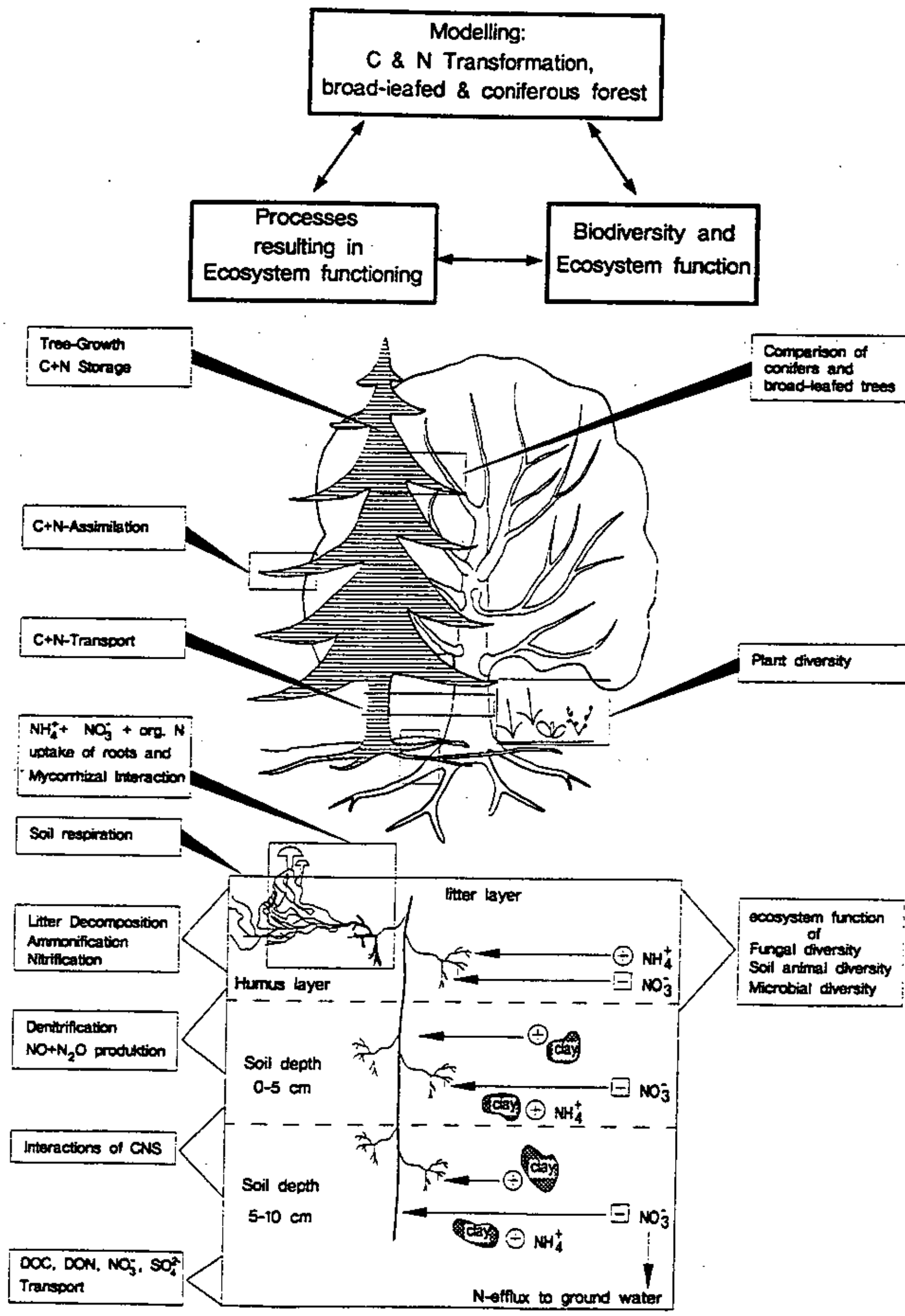
Date : 7th February 1997

CANIF - CArbon and Nitrogen Cycling in Forest ecosystems

Annual Report
1.2. 1996 - 31.1.1997

EEC contract No ENV4-CT95-0053
and
subcontract No ERB IC20 CT960024

E.-D. Schulze (coordinator)



Bayreuth, Germany
February, 1997

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period : 1 February 1996 - 31st January 1997

Partner : Partner 10 IT (GB)

Principal Investigator : Dr Anthony Harrison

Scientific staff : A P Rowland, J M Poskitt, J Garnett (ITE); (Dr D D Harkness, NERC Radiocarbon Laboratory, East Kilbride, Scotland).

Address : Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-sands, Cumbria, LA11 6JU.

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Soil layer dry weight and density measurements have been made on all soil cores sampled from Skogaby, Hillerod, Waldstein, Schacht and Aubure (2 sites), the pretreatments (removal of fine rootlets and sieving have been completed and subsamples (total of > 200 samples) of all layers have been submitted for the C and N analysis. 48 soil samples have been submitted for ^{14}C radiocarbon analysis by accelerator mass-spectrometry, but an additional 24 will be sent within 2-3 weeks. The processing of the additional soil cores taken from the Czech Republic forests is also well under way. The ^{14}C radiocarbon analyses will take some months, but the C and N analyses will be completed before receipt of the radiocarbon dates.

No results are yet available for discussion at this stage because of the necessary length of time need for sample analysis, which is the expected situation prior to the commencement of the project.

V. List of publications arising from the project :

None at this stage in the research project.

Signature of Partner : Anthony Harrison

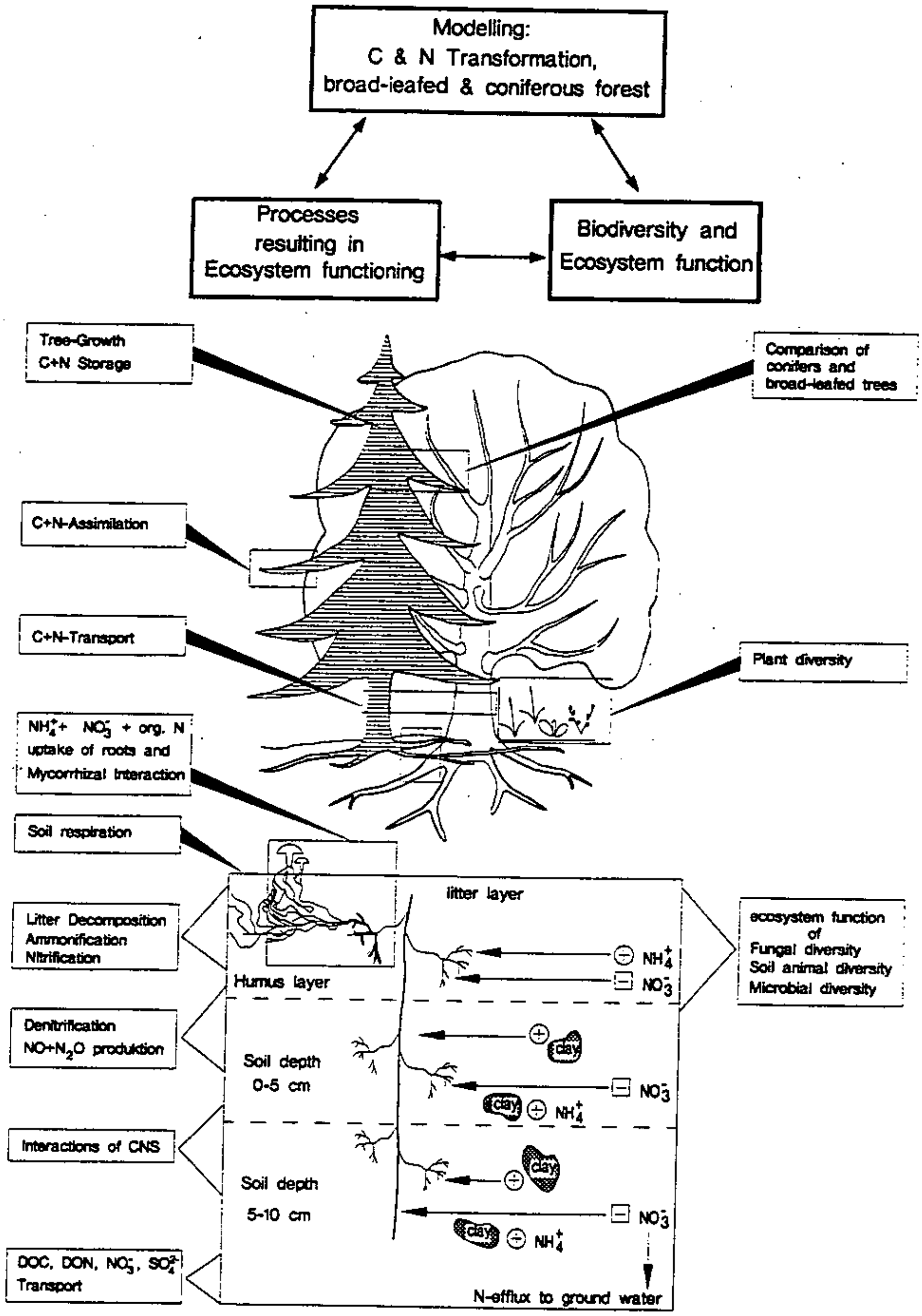
Date : 7th February 1997

CANIF - CArbon and Nitrogen Cycling in Forest ecosystems

Annual Report
1.2. 1996 - 31.1.1997

EEC contract No ENV4-CT95-0053
and
subcontract No ERB IC20 CT960024

E.-D. Schulze (coordinator)



Bayreuth, Germany
February, 1997

III. Are there any particular problems ? Is your part of the project on schedule ?

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No results are yet available for discussion at this stage because of the necessary length of time need for sample analysis, which is the expected situation prior to the commencement of the project.

V. List of publications arising from the project :

None at this stage in the research project.

Signature of Partner : Anthony Harrison

Date : 7th February 1997

PART B

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 1. February 1996 to 31. January 1997

Partner: Danish Forest and Landscape Research Institute, DFLRI

Principal Investigator: Dr. Bjørn R. Andersen

Scientific staff: Dr. Bjørn R. Andersen

Address: Danish Forest and Landscape Research Institute
Hoersholm Kongevej 11
DK-2970 Hoersholm
Denmark

Telephone: (+45) 4576 3200

Fax: (+45) 4576 3233 E-Mail: bra@fsl.dk

I. OBJECTIVES FOR THE REPORTING PERIOD:
Continuous sampling and analysis (N compounds, DOC, base cations) of soil water samples from the stands along the CANIF gradient.
Co-operation with Czech and French partners to obtain subsets of soil water samples collected as part of other ongoing projects (originally planned to be performed using our own equipment). Installation of sampler equipment at the Italian sites.

II. OBJECTIVES FOR THE NEXT PERIOD:
Continuation of sampling and analysis programme. Installation of sampler equipment at the Italian sites.
Completion of data base containing meteorological and stand data for the CANIF sites followed by hydrological modelling for all sites in co-operation with Dutch partner.
Emphasis on hydrology in Danish beech stand (dependent on our success in obtaining supplementary national funding)

III. Are there any particular problems ? Is your part of the project on schedule ?

The hydrological conditions in Denmark have been unusual in 1995-1996 (dry summers, early soil freezing) especially in the western parts, making it difficult to obtain soil water samples.

We experienced a period with malfunction of our previously (within project NIPHYS) developed analytical method for the determination of total nitrogen content of aqueous samples. Specifically , we were unable to obtain a complete and reproducible decomposition of nitrogen compounds. Thorough testing traced the problem to a pronounced effect of the position of the sample stream within the micro-wave oven room in which the oxidative conversion of nitrogen compounds into nitrate takes place. Solving the problem led to a better over-all performance of the analytical method.

The installation of sampler equipment at the Italian sites planned for 1996 was postponed to 1997 due to difficulties in delivery of our equipment followed by hospitalisation of the principal investigator.

Our French partner in Nancy has stopped soil water sampling at Aubure. Thus, we were not able to obtain subsamples from existing projects in 1996. We now consider to change back to our original installation plan.

IV. MAIN RESULTS OBTAINED:

METHODOLOGY. No changes in the methodologies used. Subsamples from Czech investigations come from zero tension soil water samplers.

RESULTS. We still observe that organically bound N is a significant part of total N in soil solutions from the investigated stands. Our measurements can not demonstrate that there is a direct relationship between concentrations of DON (dissolved organic N) and DOC (dissolved organic C), except at the Danish spruce stand.

DISCUSSION. It is probably because many other processes than those associated with N cycling influence the concentrations of DOC that we can not demonstrate a direct link between measured C and N concentrations.

CONCLUSIONS. Our original hypothesis on the significance of DON compared to inorganic N compounds is still supported by the measurements. Consequently, we continue to emphasise the need to include DON data when assessing N cycling and leaching to systems outside forest ecosystems.

V. List of Publications arising from the project (include copies):

Two manuscripts are in preparation. Their completion were postponed due to the analytical problem mentioned above (section III) which endangered the validity of our nitrogen compound concentration data from all sites.

Signature of Partner: 12/2 '97

Bjørn R. Andersen

Date: 12. February 1997

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: February 1. 1996 - January 31. 1997

Partner: Wageningen Agricultural University
Department of Terrestrial Ecology and Nature Conservation

Principal Investigator: Professor Dr. F. Berendse

Scientific staff: Dr. H. van Oene

Address: Department of Terrestrial Ecology and Nature Conservation
Wageningen Agricultural University
Bornsesteeg 69
NL-6708 PD Wageningen, The Netherlands

Telephone: +31 317 484973

Fax: +31 317 484845 E-Mail: Frank.Berendse@STAF.TON.WAU.NL

I. OBJECTIVES FOR THE REPORTING PERIOD:

- to extend the model with a soil chemistry module describing soil chemical equilibria and cation exchange reactions for calculation of soil solution concentrations and pH
- to visit other partners to gather data and visit the field sites
- to parameterise the processes included in the model

II. OBJECTIVES FOR THE NEXT PERIOD:

- to adapt and to test the model further (soil and water module)
- to finalize parameter estimation
- to construct a data bank with data needed for the model for all sites
- to perform a sensitivity analysis to determine the relative impacts of the different processes and parameters
- to validate the model using data on carbon and nitrogen pools, N productivity and N mineralisation
- to validate the model using data from a ^{15}N pulse labelling experiment in a 15-year old spruce stand

III. Are there any particular problems ? Is your part of the project on schedule ?

The gathering of data for parameter estimation and model validation lays behind schedule but will be completed in the first half of 1997.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

The current ecosystem model is developed and extended from an existing model within the Department. The model is a dynamic proces-oriented model, running with a timestep of one day (can be varied between 1 day and 1 month). The model now describes plant growth, soil organic matter dynamics, hydrology and soil chemistry. The model includes processes like light interception and C-assimilation, decomposition, mineralisation, N uptake, water uptake, evapotranspiration, and leaching. It keeps track of the C and N pools and fluxes in the vegetation, in the soil organic matter and in the soil. The soil chemistry module is added during 1996 and describes soil chemical reactions like cation exchange reactions, aluminum chemistry and leaching for different soil layers.
To gather site-specific data needed to run the model (i.e. initial C and N pools, climate data) visits were paid to the partners in Bayreuth and Copenhagen.
A first rough estimation for parameters related to plant characteristics and soil organic matter dynamics is done, and will be refined during 1997.
Preliminary results from model runs for the beech and spruce site in Germany show that the model is adequate to be used to simulate the fluxes of C and N. Comparison between two types of climate (oceanic and continental) showed the importance to obtain good climate data from the sites to be able to relate differences in relative importance of processes to climatic gradient.

V. List of Publications arising from the project (include copies):

Signature of Partner:

Date: 17 - 2 - 1997

DETAILED REPORT OF THE INDIVIDUAL PARTNERS

Reporting period: 1st January 1996 - 31st December 1996

Partner: Tomas PACES

Principal Investigator: E.-D. SCHULZE

Scientific staff: F. Buzek, M. Novak, J. Cerny

Address: Czech Geological Survey
Klarov 3
CZ-118 21 PRAGUE
Czech Republic
Telephone: +42-2-5816945

Fax: +42-2-5816748 E-Mail: paces@cgu.cz

I. OBJECTIVES FOR THE REPORTING PERIOD:

Evaluation of carbon isotope fractionation in soil organic carbon.
Isotope study of the relationship between atmospheric sulfur and sulfur intercepted by forest floor moss.
Determination of the effect of altitide on isotopic composition of sulfur in strem water sulfate ions.

II. OBJECTIVES FOR THE NEXT PERIOD:

Sampling of soil profiles in four CANIF sites: Ahden, Skogaby, Aubure and Viterbo. Seasonal collection of water at the sites. Water samples will include: lysimeter soil solutions, throughfall and bulk deposition. Separation of the following forms of sulfur in soil: total, sulphate, ester-sulphate, carbon bonded and sulfur in moss. Measurement of d34S in all forms of separated sulfur.
Sampling at three Czech sites: Cervena Jama (spruce), Jezeri (beech) and Salacova Lhota (spruce). Relationship between dissolved organic carbon and mineralization of organic S. Seasonal variation of DON and NH4. Measurement of d15N.

III. Are there any particular problems ? Is your part of the project on schedule ?

Project is on schedule. A problem to be solved is the sampling at foreign sites - how much help can be offered by local coordinators and teams. Uncertain is whether all samples will contain enough sulfur for isotopic measurement. This will be tested during the program.

IV. MAIN RESULTS OBTAINED: *METHODOLOGY, RESULTS, DISCUSSION, CONCLUSIONS* (use other pages as necessary but preferably no more than 2)

Leaching of soil DOC results in an isotopic shift in 13C - with increasing depth to more positive values of delta. The relationship between d13Ctotal and the ratio C/N is d13C=-0.05 * (C/N) - 25.05. Close linear correlation was found between d13C and lnCtotal. Different correlation coefficients at different sites may indicate differences in the process of carbon mobilization. Linear correlation was determined between deposition of SO2 from atmosphere and the isotopic composition of sulfur in SO2 and isotopic composition of sulfur in moss. Sulfur in moss is isotopically hevier than sulfur in atmospheric SO2.

We determined a seasonal variation in d34S across all altitudes from 480 to 824 m a.s.l. The summer season is characterized by a higher mean value (+4.3 per mil), the winter season by a lower mean value (+3.7 per mil). This reflects the pollution of atmosphere by SO2 during a heating season. The value of d34S in runoff increases (sulfur becomes isotopically heavier) with increasing altitudes. Details of the results are summarized in the Appendix.

V. List of Publications arising from the project (include copies):

No publication prepared yet.

Signature of Partner:

Date: 16.1.1997

APPENDIX (Partner 13)

Progress Report for 1996

Monitored sites: for C and N isotopes spruce forested catchments Salacova Lhota and Jezeri-Cervena Jama and research plot Nacetin and beech forested catchment Jezeri. For atmospheric SO_2 impact we combine isotope and concentration data (15 sites) on atmospheric SO_2 with data on S in mosses (22 sites); the altitude effect was studied at one site.
To evaluate relations between C,N and S pools in acidified forest soils, we have monitored following variables : $\delta^{13}C_{tot}$ in soil profile, $\delta^{34}S$ in air-borne SO_2 and mosses, $\delta^{34}S$ in streamwater.

(i) $\delta^{13}C_{tot}$ in soil profile
To evaluate carbon isotope fractionation of soil organic carbon we have determined $\delta^{13}C_{tot}$ in soil profiles. Soil organics is mobilized and leached from soil as DOC. It results in a shift of $\delta^{13}C_{tot}$ with increasing depth to more positive values. The $\delta^{13}C_{tot}$ was correlated with C/N ratio (Fig.1) or depth (Fig.2). The $\delta^{13}C$ of the organic horizon is close to $\delta^{13}C$ of organic input and varies from -26.6 to -26.2‰ (for needles) to about -24.5‰ in mineral horizon. Regression equations were calculated from 30 samples at 4 sites (Nacetin, Salacova Lhota and Jezeri - C.Jama) :

$$\delta^{13}C_{tot} = -0.05*(C/N) - 25.05 \qquad (r^2 = 0.19) \qquad (1)$$

$$\delta^{13}C_{tot} = -0.015*(\text{depth in cm}) - 26.55 \qquad (r^2 = 0.32) \qquad (2)$$

Linear type of equation may be useful in regional modelling but correlation coefficients are low. Another type of correlation was derived from the kinetic isotope fractionation in an open system which is expressed as:

$$\delta - \delta_0 = \varepsilon * \ln f \qquad (3)$$

Correlation equations expresed in the form $\delta^{13}C_{tot}$ + const. = coefficient * ln (Ctot/55) were formulated for all samples (Fig.3):

$$\delta^{13}C_{tot} + 26.7 = (-0.307) * \ln(Ctot/55) \qquad (r^2 = 0.55) \qquad (4)$$

and separately for Nacetin and Salacova Lhota (Fig.4):

$$\delta^{13}C_{tot} + 26.9 = (-0.443) * \ln(Ctot/55) \qquad \text{Nacetin } (r^2 = 0.87) \qquad (5)$$

$$\delta^{13}C_{tot} + 27 = (-0.363) * \ln(Ctot/55) \qquad \text{S.Lhota } (r^2 = 0.48) \qquad (6)$$

As correlation coefficient in such type of equation is related to overall fractionation of soil organic carbon, different values calculated for catchments with different deposition and acidification may reflect the process of carbon mobilization.

(ii) $\delta^{34}S$ in atmospheric SO_2 and mosses

Mosses were reported to be useful as an average record of atmospheric SO_2 (their sulphur content and $\delta^{34}S$ should correspond to average deposition on the site). To verify this relation we compared seasonal records of SO_2 concentrations and $\delta^{34}S$ in SO_2 with $\delta^{34}S$ and sulphur content in mosses. As SO_2 plots vary from site to site and seasonally we evaluate a linear relation of average deposition to its $\delta^{34}S$. This was compared with a similar equation expressed for mosses (samples taken in open air environment were most useful). Calculated correlation equations are:

$$\delta^{34}S\text{-}SO_2 = (-0.0408) * c_{SO2} (\text{in } \mu g/m^3) + 3.71 \qquad (r^2 = 0.32) \qquad (6)$$

$$\delta^{34}S\text{-moss} = (-11.43) * c_S (w\%) + 6.6 \qquad (r^2 = 0.10) \qquad (7)$$

Average atmospheric deposition of SO_2 in the range from 10 to 60 $\mu g/m^3$ corresponds to moss sulphur content from 0.05 to 0.3 %. Although standard error of both correlations is high - about 1.4‰, an overlap of both regressions is limited (Fig.5). Generally $\delta^{34}S$ in moss sulphur is more positive than in SO_2. This may result from uneven sulphur uptake during the year or some additional effect of wet deposition on total sulphur.

(iii) The effect of altitude on $\delta^{34}S$ of streamwater sulphate

The effect of altitude on the isotope composition of streamwater sulphate was studied in the steep sloping catchment Jezeri (elevation span of 344 meters). Between March 1995 and January 1996 a total of 53 water samples for sulphur isotope analysis were collected at 7 different altitudes between 480 and 824 meters above sea level (Table 1). The lowermost profile sampled (X-16) contained an approximately 5 % contribution of more concentrated runoff from a forested tributary with higher evapotranspiration which is not part of the catchment. $\delta^{34}S$ values within the catchment (J1 to J23) range between +2.7 to +5.6 per mil (CDT) and average +4.0 per mil. In May, June, December and January there was a clear-cut trend to higher $\delta^{34}S$ with increasing altitude. Such trend was previously observed in atmospheric deposition (open area precipitation and spruce canopy throughfall; winter 1992). Year-round average $\delta^{34}S$ value at the base of the slope (J1) was +4.3, and that in the uppermost segment of the catchment (J23) was +4.4 per mil. Generally, stream water in the central part of the slope (J9 to J19) had the lowest $\delta^{34}S$ values. The most striking feature of the runoff data (Table 1) is a seasonality in $\delta^{34}S$ when measured across all altitudes. The "summer" season (June-October) is characterized by a higher mean $\delta^{34}S$ value (+4.3 per mil), the "winter" season by a lower mean $\delta^{34}S$ value (+3.7 per mil). These data reflect a 1-to-2 month delay in streamwater response to a seasonal change in isotope signature of air-borne sulphur (end of heating season in mid-April brings an annual reduction in low- $\delta^{34}S$ emissions in the region).

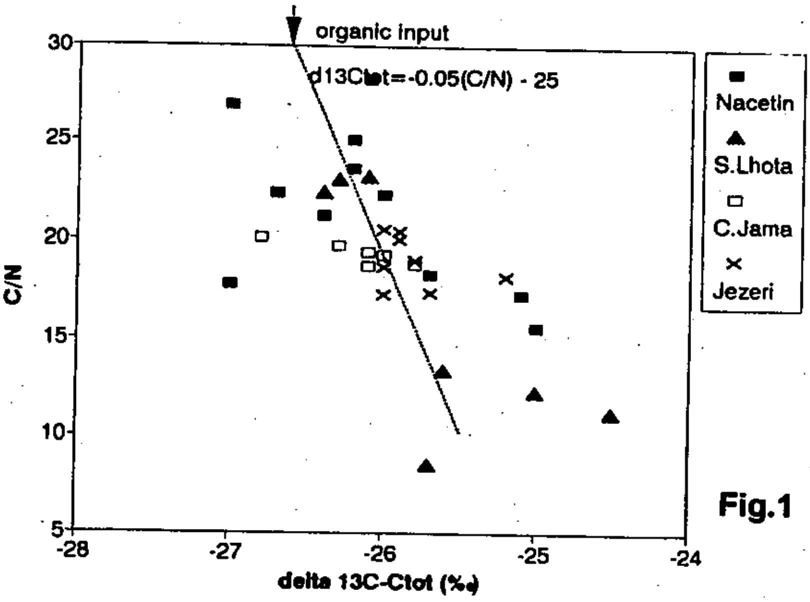

organic input
d13Ctot=-0.05(C/N) - 25
Nacetin
S.Lhota
C.Jama
Jezeri
C/N
delta 13C-Ctot (‰)

Fig.1

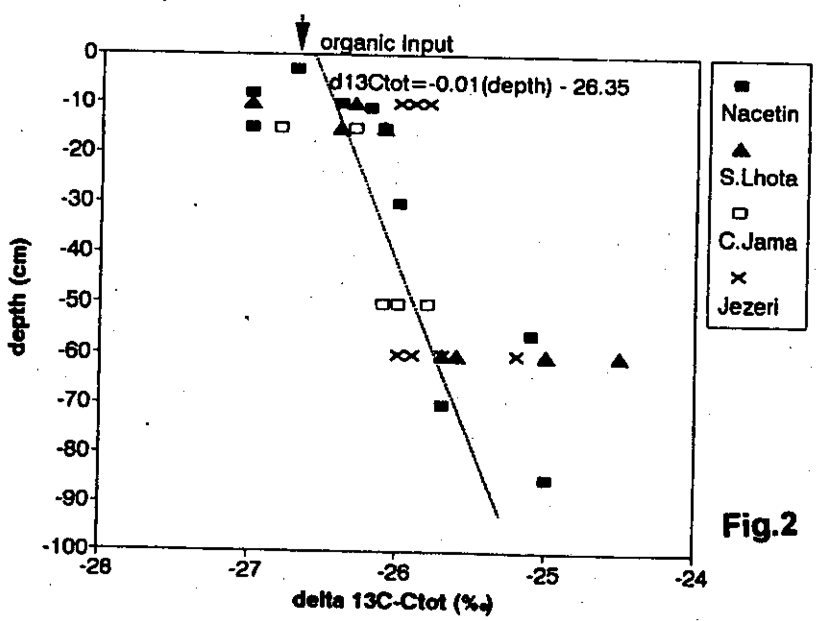
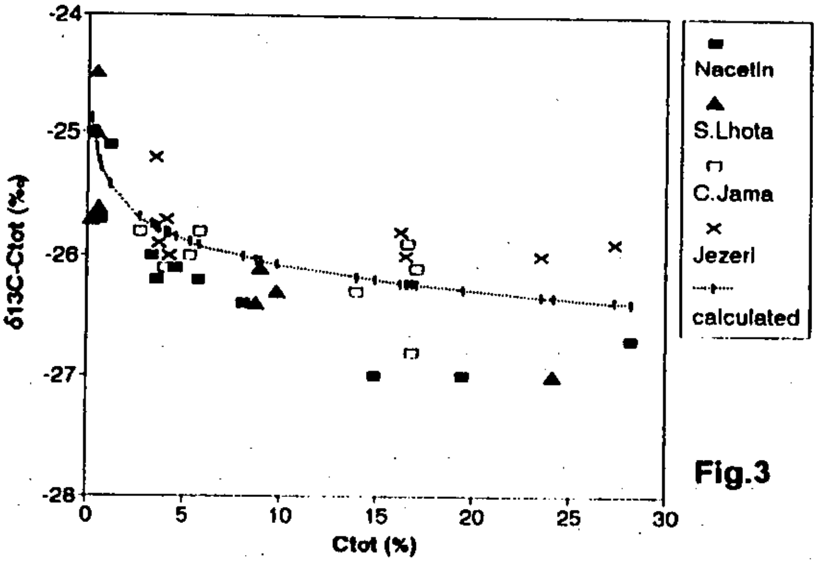
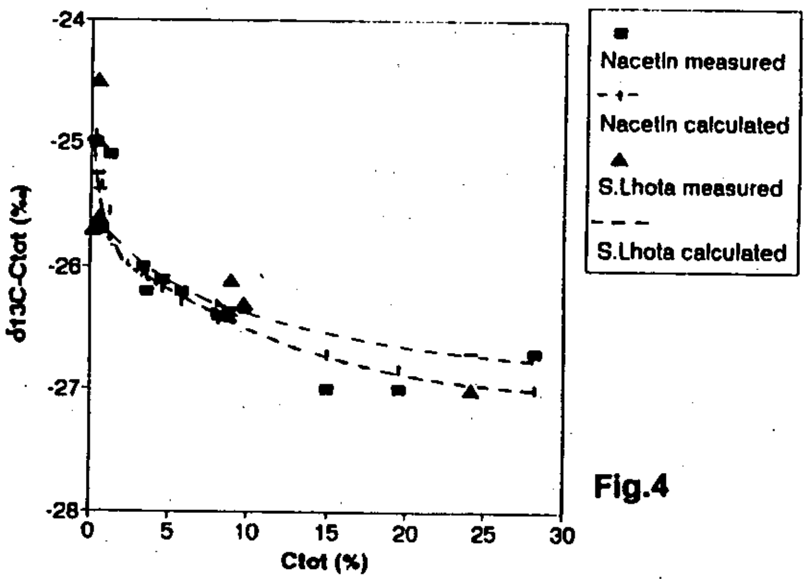

organic input
d13Ctot=-0.01(depth) - 26.35
Nacetin
S.Lhota
C.Jama
Jezeri
depth (cm)
delta 13C-Ctot (‰)

Fig.2



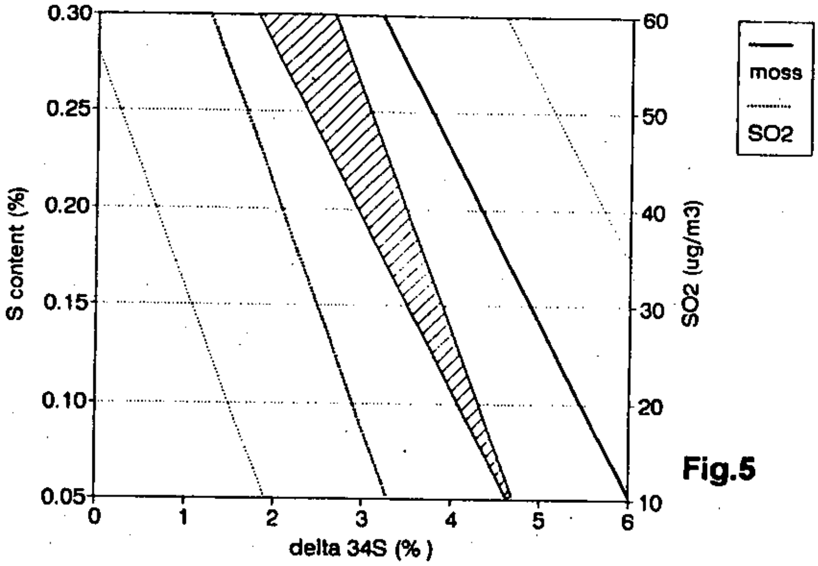
-24
-25
-26
-27
-28
δ13C-Ctot (‰)
0
5
10
15
20
25
30
Ctot (%)
Nacetin
S.Lhota
C.Jama
Jezeri
calculated

Fig.3



-24
-25
-26
-27
-28
δ13C-Ctot (‰)
0
5
10
15
20
25
30
Ctot (%)
Nacetin measured
Nacetin calculated
S.Lhota measured
S.Lhota calculated

Fig.4



0.30
0.25
0.20
0.15
0.10
0.05
S content (%)
0
1
2
3
4
5
6
delta 34S (%)
60
50
40
30
20
10
SO2 (ug/m3)
moss
SO2

Fig.5

Table 1

CHANGES IN $\delta^{34}S$ OF STREAMWATER SULPHATE WITH ALTITUDE AND TIME

A 10-month record from the Jezeri catchment (1995-1996)

sample ID	altitude	month*										
	(m a.s.l.)	3	4	5	6	7	8	9	10	11	12	1
X-16	480	3.4	3.0	3.4	3.9	-	-	5.3	4.5	-	3.5	4.2
J1	482	-	4.6	-	4.2	4.4	5.2	3.8	4.3	-	2.8	-
J9	652	-	3.0	3.6	4.2	-	-	-	-	-	2.8	-
J14	720	3.8	3.6	4.0	4.2	3.5	4.5	4.2	4.7	-	3.3	4.4
J18	768	-	3.3	-	4.0	-	4.5	-	-	-	3.4	-
J19	777	2.7	3.4	4.2	4.7	4.5	3.7	3.5	4.5	-	3.4	-
J23	824	3.6	3.8	4.1	4.8	5.2	4.7	4.1	4.2	-	5.6	4.7

* $\delta^{34}S$ values are in per mil (CDT).