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A Decomposition Submodel

H. Parnas

J. Radford

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Parnas, H., Radford, J. 1974. A Decomposition Submodel. U.S. International Biological Program, Desert Biome, Utah State University, Logan, Utah. Reports of 1973 Progress, Volume 1: Central Office/Modelling, RM 74-63.

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1973 PROGRESS REPORT

A DECOMPOSITION SUBMODEL

H. Parnas
Hebrew University, Israel
and
J. Radford
Utah State University

US/IBP DESERT BIOME
RESEARCH MEMORANDUM 74-63

in

REPORTS OF 1973 PROGRESS
Volume 1: Central Office, Modelling
Auxiliary Submodels Section, pp. 105-127

MAY, 1974

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Citation format: Author(s). 1974. Title.
US/IBP Desert Biome Res. Memo. 74-63.
Utah State Univ., Logan. 23 pp.

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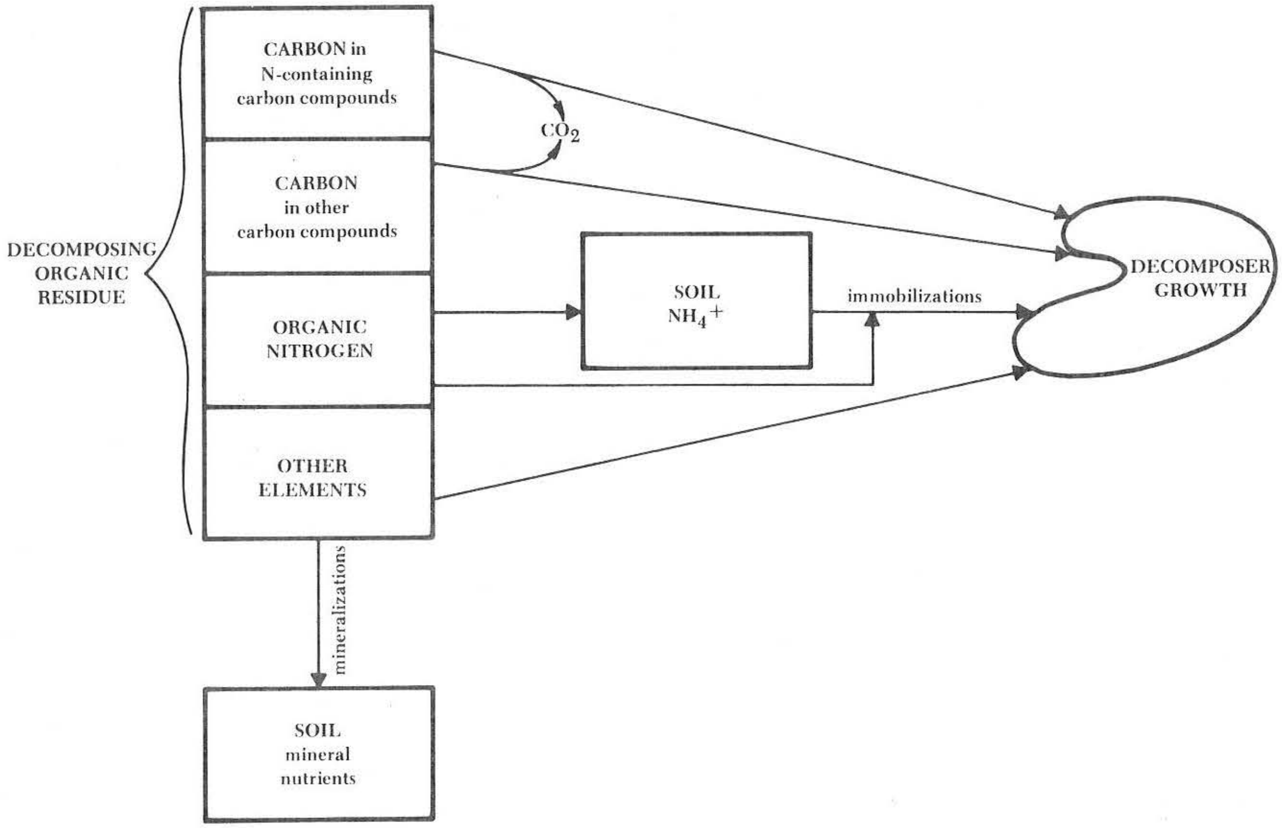

Figure 1. General flows of constituents.

microbial biomass are considered part of soil organic matter, for purposes of simplicity.

Breakdown of C-N-Compounds

The only representative of the C-N-compounds is protein. The rate of protein breakdown in any type of organic material depends on the C:N ratio of that organic material. If the ratio is above the critical ratio a/f_n (which represents the ratio between the required carbon to the required nitrogen), then the rate of protein breakdown will be governed by the requirement for nitrogen. If the ratio is below the critical ratio, then the requirement for carbon will determine the rate of protein breakdown. The proportion of protein in the mixture of the organic material can be explicitly calculated from the concentration of the organic material and its C:N ratio.

Breakdown of C-Compounds ("Other" Carbon)

The rate of breakdown of the C-compounds is always complementary to that of the protein. When the C:N ratio of the organic material being decomposed is higher than the critical ratio, the C-compounds will serve as the main source for carbon. On the other hand, when the ratio is below a/f_n, their contribution decreases and is exactly proportional to their relative concentration. Their relative concentration decreases as the C:N ratio decreases.

Organic Nitrogen Mineralization

No mineralization occurs when the C:N ratio of the substrate is greater than a/f_n because, under such conditions, nitrogen is the growth-limiting factor. When the ratio is below a/f_n, mineralization occurs together with the decomposition of the substrate. Mineralization occurs because, under such conditions, the breakdown of protein is determined by the requirement for carbon. Along with carbon that is being released, a proportional amount of nitrogen is being released. However, the amount of required carbon is 20-30 times higher than that of nitrogen, meaning that the excess nitrogen will be released to the environment as ammonium. Thus, the rate of mineralization is inversely proportional to the C:N ratio. The addition of extra nitrogen might increase the requirement for carbon but, on the other hand, it always decreases the relative requirement for the organic material nitrogen (because organic nitrogen and the extra nitrogen serve for growth according to their relative concentration). It follows that the rate of mineralization is increased by addition of extra nitrogen.

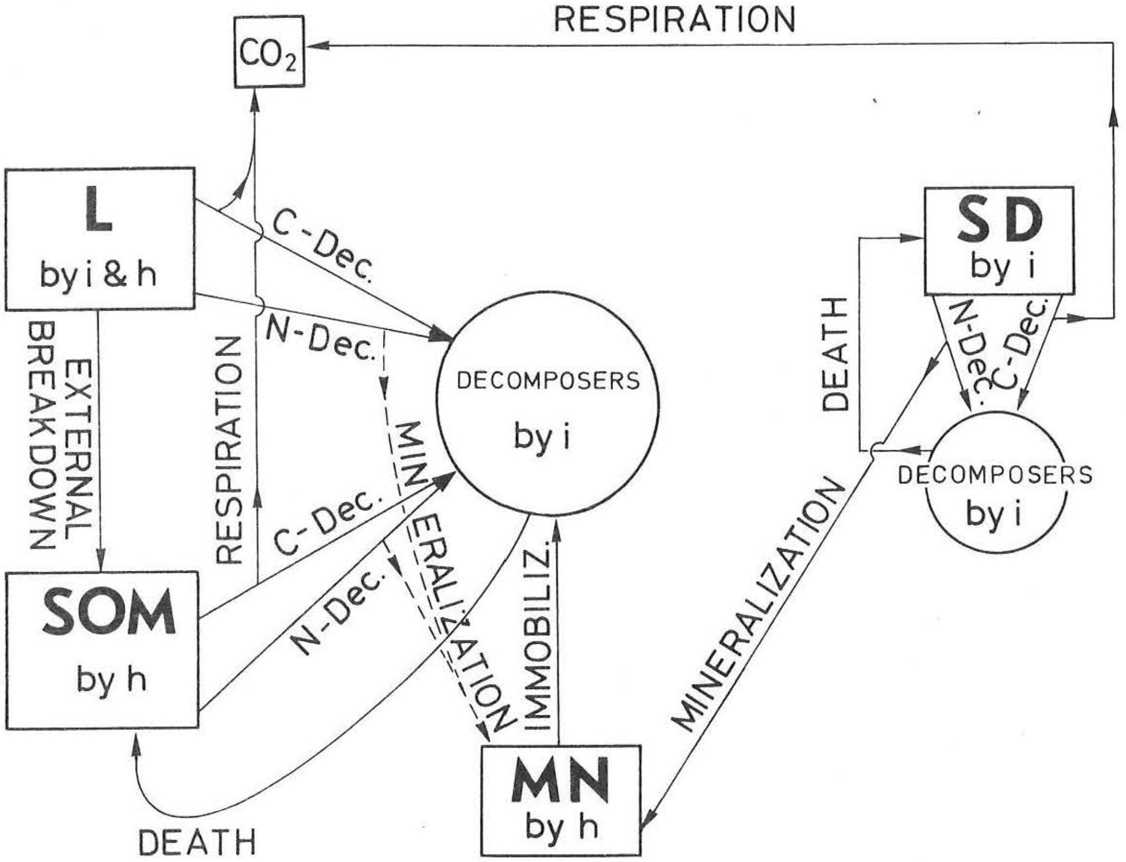

Figure 2. System diagram. Note that surface litter and/or standing dead with soil affect only horizon 1. Decomposers of the top horizon normally work on all types of surface litter; each standing dead type has a separate decomposer type *k*. The generally physical-mechanical transfer of standing dead to surface litter (as well as a number of other processes) is handled elsewhere.

Inorganic Nitrogen Immobilization

When inorganic nitrogen is available and when the growth rate of the decomposers is still dependent on nitrogen concentration, immobilization of inorganic nitrogen will occur. This will always be the case for organic materials which are poor in nitrogen, such as those whose C:N ratio is below a/f_n.

CO_2 *Evolution*

The process of microbial decomposition is accompanied by CO_2 evolution. The rate of CO_2 evolution by organic material being decomposed is proportional to the rate of carbon decomposition multiplied by (1-efficiency). The efficiency is defined as the ratio of carbon assimilated to carbon decomposed.

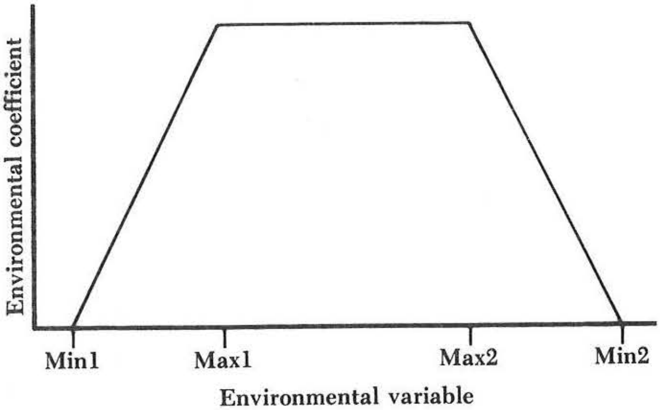

Figure 3. Dependency of maximal growth rate on environmental conditions (for explanations see text).

External Breakdown

The major route of organic material decomposition is via microbial breakdown. In addition to this, a relatively unimportant route is added in some artificial way to the subroutine. This last route is breakdown by the external enzymes which are available in the area. The purpose of that process is to have a direct input to soil organic matter from the various litter types, dead roots and the animal residues. The direct input should normally compensate for the loss from soil organic matter caused by microbial breakdown. More efficient ways of generating this input could and should be introduced.

Mineralization of Non-Carbon, Non-Nitrogen Elements

In order for other organic materials to be added eventually to soil mineral nutrients and so to complete decomposition, a constant ratio (amount of constituent mineralized to total carbon decomposed) is multiplied by total carbon decomposed. This ratio is specific to dead materials generally and to soil organic matter. Such an artificial means of calculating net mineralization (mineralization minus immobilization) should be replaced later by explicit calculations as is the case for nitrogen.

ASSUMPTIONS

1. The rate of decomposition of any type of organic material is proportional to the growth rate of its decomposers.
2. Both the carbon of the C-compounds and that of the C-N-compounds can serve as a carbon source for microbial growth. Their relative contribution depends on optimal considerations which will cause maximal long-term growth rate.
3. Both organic and inorganic nitrogen can serve as a nitrogen source for microbial growth. Their relative contribution is according to their relative concentration.
4. Each of the organic materials is being decomposed at a rate determined by its own concentration and its own C:N ratio.
5. In addition to microbial breakdown of litter, dead roots and animal residues, external breakdown takes place. This process is not accompanied by CO_2 evolution. It is more a mechanical breakdown. Its order of magnitude is very small compared to the microbial breakdown.
6. The nutrients in the first soil horizon are available to the decomposers which react on soil surface. The products of decomposition which happen on the soil surface move to the first soil horizon (or to the microbes, or to the atmosphere).
7. The decomposition of each type of organic material by horizon is made by the same mixed population of that horizon. This population can move from one substrate to the other.
8. The nutrients which are included in the living microbial biomass are made available to plants only after death and decomposition/mineralization of the microbes themselves.

MATHEMATICAL DESCRIPTION

CHANGES IN DETRITUS DUE TO DECOMPOSITION ($\dot{X}_{21df}$)

$$\dot{X}_{21df} = -{}_{D}Z_{1df} - {}_{D}Z_{2df} - Z_{3df} - {}_{D}Z_{4df} + P_{1kf} \cdot {}_{D}Z_{5kd} \qquad (1)$$

where:

${}_{D}Z_{1df}$ = Decomposition of detritus type d carbon type f as in (7)

${}_{D}Z_{2df}$ = Decomposition of detritus type d non-carbon, non-nitrogen constituent f as in (13)

Z_{3df} = External breakdown as in (14)

${}_{D}Z_{4df}$ = Decomposition to mineral form of nitrogen constituent f in detritus type d as in (16)

P_{1kf} = Units constituent f normally found per unit total carbon in biomass k

${}_{D}Z_{5kd}$ = Death of biomass type k due to subsistence on detritus type d as in (10)

k = The biomass type numbers of the decomposers which utilize dead material d

CHANGES IN SOIL ORGANIC MATTER DUE TO DECOMPOSITION ($\dot{X}_{22hf}$)

$$\dot{X}_{22hf} = -{}_{S}Z_{1hf} - {}_{S}Z_{2hf} - {}_{S}Z_{4hf} + \sum_{d \in S_h} Z_{3df} + P_{1kf} \cdot {}_{S}Z_{5kh} \qquad (2)$$

where:

${}_{S}Z_{1hf}$ = Carbon decomposition of SOM in horizon h as in (7)

${}_{S}Z_{2hf}$ = Non-C, non-N decomposition of SOM in horizon h as in (13)

${}_{S}Z_{4hf}$ = Nitrogen mineralization from SOM in horizon h as in (16)

$\sum_{d \in S_h} Z_{3df}$ = The sum of externally broken-down detritus constituents f for all detritus types d contributing to SOM in horizon h as in (14)

P_{1kf} = As in (1)

${}_{S}Z_{5kh}$ = Decomposer death due to subsistence on SOM in horizon h as in (10)

k = The decomposer population which utilizes SOM in horizon h

CHANGES IN MINERAL NITROGEN TYPE OR DUE TO DECOMPOSERS ($\dot{X}_{24_{hn}}$)

$$\dot{X}_{24_{hn}} = \sum_{d \in N_h} (-{}_{D}Z_{6_{dn}} + {}_{D}Z_{4_{dn}}) - {}_{S}Z_{6_{hn}} + {}_{S}Z_{4_{hn}} \qquad (3)$$

where:

$\sum_{d \in N_h}$ = Summation over all detritus types in the set of detritus types exchanging nitrogen with the horizon h pool

$Z_{6_{in}}$ = Immobilization of mineral N by decomposers in detritus types (D/d) or in SOM (S/h) as in (17)

$Z_{4_{in}}$ = Demineralization of organic N to the $X_{24_{hn}}$ pool from detritus (D/d) and SOM (S/h) as in (16)

n = Mineral N type ($n = 1$, organic N; $n = 2$, NH_4; $n = 3$, NO_2; $n = 4$, NO_3)

CHANGES IN ASH ELEMENTS (NON-N, NON-C) DUE TO DECOMPOSITION ($\dot{X}_{23_{hf}}$)

$$\begin{aligned} \dot{X}_{23_{hf}} &= \sum_{n} \dot{X}_{24_{hn}}, \text{ if } f = 1 \\ \text{and} &= \sum_{d \in M_h} {}_{D}Z_{2_{df}} + {}_{S}Z_{2_{hf}}, \text{ if } kf < 3 \\ \text{and} &= 0 \text{ , if } f > 3 \end{aligned} \qquad (4)$$

where:

$\dot{X}_{24_{hn}}$ = Mineral nitrogen type n increment or decrement as in (3)

$\sum_{d \in M_h}$ = Summation over all detritus types d which are in the set of types M_h contributing to horizon h minerals

${}_{D}Z_{2_{df}}$, ${}_{S}Z_{2_{hf}}$ = Demineralizations due to decomposer growth on detritus (D/d) and SOM (S/h) as in (13)

CHANGES IN DECOMPOSER BIOMASSES (STATE VARIABLE EQUIVALENT)($\dot{X}_{25_{kf}}$)

$$\begin{aligned} \dot{X}_{25_{kf}} &= \sum_{d \in D_k} ({}_{D}Z_{1_{df}} - {}_{D}Z_{7_{df}}) + \sum_{h \in S_k} ({}_{S}Z_{1_{hf}} - {}_{S}Z_{7_{hf}}), \text{ for } f > 1 \\ \text{and} &= \sum_{d \in D_k} \Big(\sum_{n} {}_{D}Z_{6_{dn}} - {}_{D}Z_{4_{d2}} \Big) + \sum_{h \in S_k} \Big(\sum_{n} {}_{S}Z_{6_{hn}} - {}_{S}Z_{4_{h2}} \Big), \text{ for } f = 1 \end{aligned} \qquad (5)$$

where:

$\sum_{d \in D_k}$ = Summation over all detritus types d that are utilized by biomass k

$\sum_{h \in S_k}$ = Summation over all SOM that is utilized by biomass k

${}_{D}Z_{1_{df}}$, ${}_{S}Z_{1_{hf}}$ = As in (7)

${}_{D}Z_{7_{df}}$, ${}_{D}Z_{7_{hf}}$ = As in (20)

$\sum_{n}$ = Summation over all mineral N types

${}_{D}Z_{6_{dn}}$, ${}_{S}Z_{6_{hn}}$ = N immobilizations as in (17)

${}_{D}Z_{4_{d2}}$, ${}_{S}Z_{4_{h2}}$ = NH_4^+ evolutions as in (16)

CO_2 RESPIRATION ($\dot{X}_{01_{13}}$)

$$\dot{X}_{01_{13}} = \sum_{f \in C} \Big(- \sum_{d} {}_{D}Z_{7_{df}} - \sum_{h} {}_{S}Z_{7_{hf}} \Big) \qquad (6)$$

where:

$\sum_{f \in C}$ = Summation over all C types

$\sum_{d}$ & $\sum_{h}$ = Summation over all detritus types and all SOM, respectively

${}_{D}Z_{7_{df}}$ & ${}_{S}Z_{7_{hf}}$ = Respiration from C types f in detritus (D/d) and SOM (S/h) as in (20)

NITROGEN AND CARBON DECOMPOSITION IN DETRITUS AND SOM ($Z_{1_{if}}$)

$$\begin{aligned} Z_{1_{if}} &= Z_{8_i}/P_2, \text{ if } f = 1 \\ \text{and} &= Z_{8_i}, \text{ if } f = 3 \\ \text{and} &= Z_{9_i} \cdot (Z_{10_i} - Z_{8_i}), \text{ if } f > 3 \end{aligned} \qquad (7)$$

where:

Z_{8_i} = Protein C decomposition of material type i as in (8)

P_2 = The ratio units C to units N normally found in biological N-containing compounds (i.e., protein)

Z_{9_i} = The ratio units carbon type f to units total C in material i

Z_{10_i} = Total carbon decomposition from material i as in (9)

PROTEIN CARBON DECOMPOSITION (Z_{8_i})

$$Z_{8_i} = P_2 \cdot P_3 \cdot Z_{11_{kd}} \cdot Z_{12_k} \cdot (X_{21_{d1}}/Z_{13_k}),$$

for detritus types d

$$\text{and} = P_2 \cdot P_3 \cdot Z_{11_{kh}} \cdot Z_{12_k} \cdot (X_{22_{h1}}/Z_{13_k}),$$

for SOM in horizon h

$$\text{and} = Z_{10_i} \cdot Z_{14_i}/Z_{15_i}, \text{ if material } i \text{ C:N ratio is less than } P_4 \qquad (8)$$

where:

P_2 = As in (7)

P_3 = Normal ratio units N to units total biomass of decomposers

$Z_{11_{kd}}$ & $Z_{11_{kh}}$ = Growth of decomposers k on detritus (d) or SOM (h) in units growth per unit biomass per unit time as in (10)

Z_{12_k} = Decomposer biomass k which utilizes material type i as in (12)

$X_{21_{df}}$ & $X_{22_{hf}}$ = As in (1), (2)

Z_{10_i} = Total carbon decomposition of material i as in (9)

Z_{14_i} = Total protein C in material i

Z_{15_i} = Total carbon of all types in i

P_4 = a/f_n (see Verbal Description) or carbon concentration in decomposer cells divided by the product of nitrogen concentration and decomposition assimilation efficiency

Z_{13_k} = Total N (organic + inorganic) available to biomass k, there being no inorganic N available to above-surface k

TOTAL C DECOMPOSITION (Z_{10_i})

$$Z_{10_i} = (Z_{11_{ki}}/P_5 + P_6) \cdot Z_{12_k} \qquad (9)$$

where:

$Z_{11_{ki}}$ = Growth of biomass k on dead material i as in (10)

P_5 = Efficiency of carbon assimilation, units assimilated per unit decomposed by k

P_6 = Maintenance requirement for carbon, units required per unit k

Z_{12_k} = Units biomass k as in (12)

GROWTH OF DECOMPOSERS k ON MATERIAL i ($Z_{11_{ki}}$)

$$Z_{11_{ki}} = Z_{16_j} \cdot Z_{15_i} \cdot Z_{13_k}/((P_7 + Z_{15_i}) \cdot (P_8 + Z_{13_k})) \qquad (10)$$

where:

Z_{16_j} = The environmentally adjusted growth rate of decomposers k in the set R_j of k which have the same growth rate on material type j as in (11)

Z_{15_i} = Total carbon as in (8)

Z_{13_k} = Total nitrogen available to k as in (8)

P_7, P_8 = Michaelis constants for carbon, nitrogen utilization

ENVIRONMENTALLY ADJUSTED GROWTH RATES (Z_{16_j})

$$Z_{16_j} = P_{9_j} \cdot Z_{17_z} \cdot Z_{18_z} \cdot Z_{19_z} \cdot Z_{20_z}, \text{ if type } j \text{ material is in environmental zone } z \qquad (11)$$

where:

P_{9_j} = Maximal growth rate for dead material class j

Z_{17_z}, Z_{18_z}, Z_{19_z},& Z_{20_z} = Environmental coefficients returned from OPT subroutine for environmental zone z

BIOMASS OF DECOMPOSERS ($Z_{12_{k_t}}$)

$$Z_{12_{k_t}} = Z_{12_{k_{t-1}}} \cdot \exp\left(\sum_{i \in G_k} Z_{11_{ki}} - Z_{21_{ki}}\right) \qquad (12)$$

where:

t, $t\text{-}1$ = The present and immediately preceding time step

$\sum_{i \in G_k} Z_{11_{ki}}$ = The sum of growth rate increments that affect biomass k in its utilization of the set of dead materials $i \in G_k$ as in (10)

$Z_{21_{ki}}$ = Death rate of k; $Z_{21_k} = P_{10}$ if all Z_{15_i}, $i \in G_k$, are $\leqslant 0$; $Z_{21_k} = P_{11}$ if any $Z_{15_i} > 0$.

P_{10}, P_{11} = Starvation and non-starvation death rates, respectively

DEMINERALIZATION OF NON-N, NON-C CONSTITUENTS ($Z_{2_{if}}$)

$$Z_{2_{if}} = P_{12_f} \cdot P_{1_{kf}} \cdot Z_{10_i}, \text{ for } i \text{ being utilized by } k \qquad (13)$$

where:

P_{12_f} = Units f mineralized per unit f decomposed
$P_{1_{kf}}$ = f concentration as in (1)
Z_{10_i} = Total carbon decomposed by biomass k as in (9)

EXTERNAL BREAKDOWN OF DETRITUS CONSTITUENTS ($Z_{3_{df}}$)

$$Z_{3_{df}} = (X_{21_{df}}/X_{21_{d\bar{f}}}) \cdot Z_{22_d} \qquad (14)$$

where:

$X_{21_{d\bar{f}}}$ = As in (1), $\bar{f}$ signifying summation over all constituents
Z_{22_d} = Total external breakdown of detritus type d as in (15)

TOTAL EXTERNAL BREAKDOWN OF DETRITUS TYPE d (Z_{22_d})

$$\begin{aligned} Z_{22_d} &= 0\ , \text{for above-ground } d \\ \text{and } &= (P_{13_d} \cdot Z_{23_z} \cdot Z_{24_z} \cdot Z_{25_z}) \cdot P_{14} \cdot Z_{12_k} \\ &\cdot Z_{15_d}/(P_{15_d} + Z_{15_d}), \text{ for } d \text{ in environment } z \text{ and } k \\ &\text{utilizing } d \qquad (15) \end{aligned}$$

where:

P_{13_d} = A maximal breakdown rate, units broken down per unit external enzyme (= $P_{14} \cdot Z_{12_k}$)
Z_{23_z}, Z_{24_z} & Z_{25_z} = Temperature, pH and water (oxygen) coefficients derived for environmental zone z by OPT and RAMP subroutines
P_{14} = Units enzyme normally present per unit biomass present
Z_{12_k} = Biomass as in (12)
Z_{15_d} = Material d total carbon as in (8)
P_{15_d} = A Michaelis constant for detritus type d

NITROGEN DEMINERALIZATION FROM DEAD MATERIAL i ($Z_{4_{if}}$)

$$\begin{aligned} Z_{4_{if}} &= 0\ , \text{for } f \neq 1 \\ \text{and } &= Z_{1_{i1}} - P_3 \cdot Z_{11_{ki}} \cdot Z_{12_k} \cdot ((Z_{13_k} - Z_{26_k})/Z_{13_k}), \\ &\text{for } f = 1 \text{ and for proper } k \qquad (16) \end{aligned}$$

where:

$Z_{1_{i1}}$ = Organic nitrogen decomposition as in (7)
P_3 = The normal N concentration in decomposers, units N per unit biomass
$Z_{11_{ki}}$ = Growth of k on i as in (10)
Z_{12_k} = Biomass k as in (12)
Z_{26_k} = Total mineral N available to k; $Z_{26_k} = 0$ for above-surface k, $Z_{26_k} = \sum_n X_{24_{hn}}$ otherwise, for appropriate h
Z_{13_k} = Total N available to k as in (8)

NITROGEN IMMOBILIZATION BY BIOMASS k IN MATERIAL i ($Z_{6_{in}}$)

$$Z_{6_{in}} = Z_{27_i} \cdot P_{16_n} \cdot X_{24_{jn}}/Z_{26_k} \qquad (17)$$

where:

Z_{27_i} = Total N immobilized by biomass k in its activity on material i as in (18)
P_{16_n} = A preference factor, units n immobilized per unit total immobilization
$X_{24_{jn}}$ = Inorganic nitrogen type n that is available to k, j here corresponds to the location of i and k, as in (3)
Z_{26_k} = Total inorganic N available to biomass k as in (16)

TOTAL N IMMOBILIZATION BY DECOMPOSERS k ON MATERIAL i (Z_{27_i})

$$Z_{27_i} = P_3 \cdot Z_{11_{ki}} \cdot Z_{12_k} \cdot (Z_{26_k}/Z_{13_k}) \qquad (18)$$

where:

P_3 = N concentration in k as in (8)
$Z_{11_{ki}}$ = Decomposer growth as in (10)
Z_{12_k} = Decomposer biomass in in (12)
Z_{26_k} = Total inorganic N as in (16)
Z_{13_k} = Total N as in (8)

DECOMPOSER BIOMASS k DEATH WITH RESPECT TO MATERIAL i ($Z_{5_{ki}}$)

$$Z_{5_{ki}} = Z_{12_k} \cdot (1 - 1/\exp(Z_{21_{ki}})) \qquad (19)$$

where:

Z_{12_k} = Biomass as in (12)
$Z_{21_{ki}}$ = Death rate as in (12)

RESPIRATION OF CARBON TYPE f FROM MATERIAL i ($Z_{7_{if}}$)

$$\begin{aligned} Z_{7_{if}} &= (1 - P_5) \cdot Z_{2_{if}}, \text{ if } f \geqslant 3 \\ &= 0\ , \text{ if } f < 3 \qquad (20) \end{aligned}$$

where:

P_5 = Efficiency as in (9)
$Z_{1_{if}}$ = Decomposition of fraction f as in (7)

TABLE OF VARIABLE NAMES

SYMBOL	FORTRAN	EQUATION	UNITS	TYPICAL VALUES
$X_{01\,rf}$	AGAIN	6	g/ha	
$X_{21\,df}$	CLIT(D,F)	1	g/ha	
$X_{22\,hf}$	CORG(H,F)	2	g/ha	
$X_{23\,hf}$	CMIN(H,F)	4	g/ha	
$X_{24\,hn}$	SMIN(H,N)	3	g/ha	
$X_{25\,kf}$	DUMBIO(K,F)	5	g/ha	
$Z_{1\,if}$	DLOS	1	g/ha · time	
$Z_{2\,if}$	DMINRL	13	g/ha · time	
$Z_{3\,df}$	EXTLOS	14	g/ha · time	
$Z_{4\,if}$	DMINR	16	g/ha · time	
$Z_{5\,ki}$	VD	10	g/ha · time	
$X_{6\,in}$	DIM	17	g/ha · time	
$Z_{7\,if}$	R	20	g/ha · time	
$Z_{8\,i}$	DPROTC	8	g/ha · time	
$Z_{9\,i}$	—	7	dimensionless	
$Z_{10\,i}$	DORGC	9	g/ha · time	
$Z_{11\,ki}$	GRDEC	10	1/time	
$Z_{12\,k}$	CBIO(K)	12	g/ha	
$Z_{13\,k}$	RNITNC	8	g/ha	
$Z_{14\,i}$	PROTC	8	g/ha	
$Z_{15\,i}$	RCARB	8	g/ha	
Z_{16}	GRC	11	1/time	
$Z_{17\,z}$	TCC	11	dimensionless	
$Z_{18\,z}$	PHCC	11	dimensionless	
$Z_{19\,z}$	SCC	11	dimensionless	
$Z_{20\,z}$	WCC	11	dimensionless	
$Z_{21\,ki}$	D	12	1/time	
Z_{22}	VR	15	g/ha · time	
$Z_{23\,z}$	TRC	15	dimensionless	
$Z_{24\,z}$	PHRC	15	dimensionless	
$Z_{25\,z}$	WRC	15	dimensionless	
$Z_{26\,k}$	TNC(K)	16	g/ha	
$Z_{27\,i}$	DIMMO	18	g/ha · time	
$P_{1\,kf}$	CFEPCT(K,F)	1	dimensionless	.05
P_2	PC2PN	7	dimensionless	4.
P_3	BN	8	dimensionless	.10
P_4	BC2BNE	8	dimensionless	1.25
P_5	EFC	9	dimensionless	.40
P_6	MAINC	9	1/time	.0005

Table of Variable Names, continued

SYMBOL	FORTRAN	EQUATION	UNITS	TYPICAL VALUES
P_7	KMC	10	g/ha	10000.
P_8	KMN	10	g/ha	10000.
P_{9_j}	GC(J)	11	1/time	.005(SOM)
P_{10}	D1	12	1/time	.020
P_{11}	D2	12	1/time	.002
P_{12_f}	E2CPCT(F)	13	dimensionless	.5
P_{13_d}	KHC(D)	15	1/time	10.
P_{14}	BE	15	dimensionless	.0001
P_{15_d}	KMR(D)	15	g/ha	5.0
P_{16_n}	BNFAC(N)	17	dimensionless	1.2(WH_4)

COMPUTER IMPLEMENTATION

DATA REQUIREMENTS AND EXECUTION CHARACTERISTICS

The NITRO and SOILS subroutine write-ups should be referred to for notes on these related programs. For execution, one needs to make linkage with OPT and RAMP subroutines, also (Parnas, 1975; Lommen, 1974). NITRO is not essential, technically speaking.

Environmental zones must first be defined. There is one per horizon plus option for adding distinct zones for surface and standing dead (maximum NZONES = NHORIZ+2). If ISURF = NHORIZ, surface litter will be treated as part of horizon 1. Otherwise, ISURF should equal NHORIZ+1 (if surface and above-surface materials are considered at all).

CBIO biomass values should be one per horizon plus one value for surface (if considered at all and separate from horizon 1) and one value per standing dead type (if considered in addition to surface). GC growth rates are specific to the type of dead material with one value for soil detritus, one for SOM and one value for each separate other detritus type.

One should be doubly sure that CLITT has a non-zero value and that all common blocks (especially STAT and CHNG) are properly complete and aligned.

A flow chart of the decomposition submodel is provided in Figure 4.

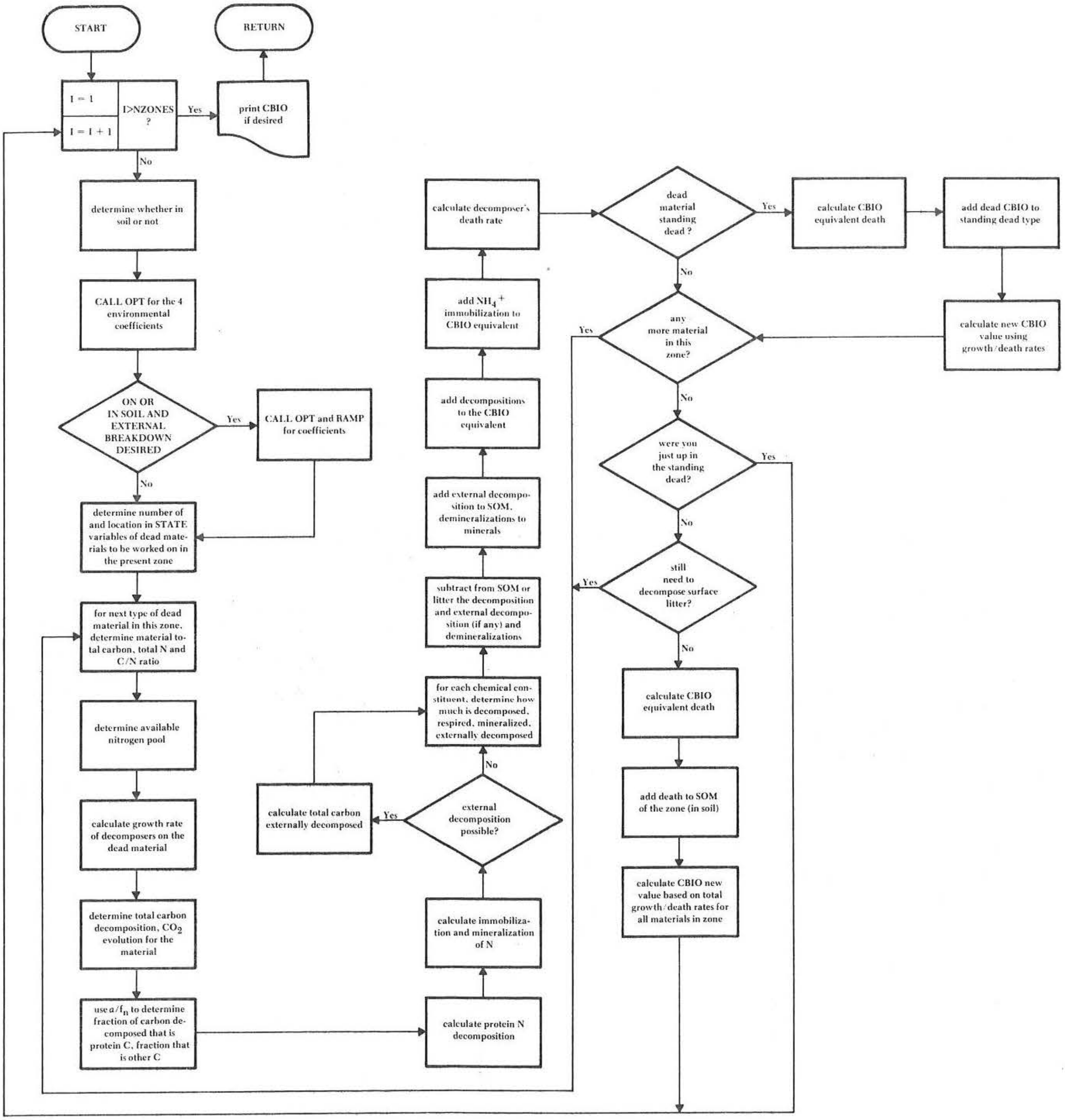

Figure 4. Flow chart of decomposition submodel.

PARAMETER EXPLANATIONS

BC2BNE	This is the expression a/f_n which equals the fraction of carbon in decomposer cells divided by the product of fraction of nitrogen and assimilation efficiency (units C assimilated per unit C decomposed).
BE	Ratio of units external enzyme present per unit decomposer biomass.
BN	Units of nitrogen normally found per unit decomposer biomass (CBIO) in general.
BNFAC(N)	Immobilization preference factor for inorganic type of nitrogen N.
CBIO(K)	Some measure of total biomass of decomposer biomass *k*.
CFEPCT(K,M)	Normal concentration of M in decomposer type *k*, units constituent in per unit total biomass.
DUMBIO-(K,M)	Dummy or equivalent biomass corresponding to CBIO(K). Any net assimilation of constituent M by CBIO(K) is added to DUMBIO(K,M); any loss of M from CBIO(K) by death of CBIO(K) is subtracted from DUMBIO(K,M) and added to soil organic matter or other appropriate compartment. Materials in DUMBIO are neither decomposed nor decomposer but may be used in other ways (by ANIMAL subroutine, for instance).
D1	Death rate under conditions of starvation.
D2	Normal non-starvation death rate.
EFC	Efficiency of carbon assimilation, units assimilated by CBIO per unit decomposed.
E2CPCT(M)	Unit *f* mineralized per unit *f* decomposed.
GC(J)	Maximal growth rate on dead material type J by decomposer biomass (part of an exponential expression).
IAGN	Pointer for the AGAIN array used to specify exchange of nitrogen with the atmosphere.
ICO2	Pointer for the AGAIN array used to specify exchange of carbon (CO_2) with the atmosphere.
INH4	Position in the SMIN (N,INH4) array occupied by ammonium.
INIT	The consitutent number of organic N (usually 1).
IPC	The constituent number of protein or N-containing carbon compounds.
ISOM	Dead material residue number of soil organic matter in general (usually 1); GC (ISOM) is growth rate of decomposers on soil organic matter.
ISURF	Surface litter zone number. If ISURF = NHORIZ, then surface litter is considered part of the top horizon. Otherwise, ISURF must equal NHORIZ + 1. Normally ISURF = NHORIZ.
KA	Exchange route of AGAIN corresponding to the atmosphere. Normally KA = 1.
KHC(IX)	Maximal external breakdown rate by enzymes, unit broken down of dead material IX per unit enzyme.
KMC	Michaelis constant for carbon for regular decomposition (calculation of GRDEC rate).
KMN	Michaelis constant for nitrogen for regular decomposition (calculation of GRDEC rate).
KMR(IX)	Michaelis constant for carbon for external breakdown of dead material type IX.
MAINC	Maintenance carbon requirement of a CBIO biomass in units decomposition required per unit CBIO.
NNAMLS	If .EQ. 1, PARNAS namelist is printed out.
NNIT	Number of inorganic nitrogen pools plus 1. Value should be 4.
NR1	Number of types of dead organic materials available to CBIO(K) when one is in the soil and attempting to utilize soil organic matter and dead roots. Value should usually be 2.
NZONES	Number of environmental zones. If only soil horizons are used, NZONES = NHORIZ. If standing dead is dealt with, add 1 to NHORIZ; if surface litter is ever separated from top horizon decomposition, add another 1 to NZONES.
PC2PN	Units of protein carbon normally found per unit protein nitrogen in protein (nitrogen-containing compounds) of dead organic matter in general.
PHC(JJ)	JJ = 1 gives the pH value below which growth is zero; JJ = 2, JJ = 3 give a range of pH's in which growth coefficient = 1; JJ = 4 gives pH value above which growth is zero.
PHCE(JJ)	Same as for PHC but for external breakdown.
SAC(JJ)	JJ = 1, JJ = 2 and 3 and JJ = 4 give the same type points as for pH, but this time for salinity.
TC(JJ)	JJ = 1, JJ = 2 and 3 and JJ = 4 give the same type points as for pH, but this time for temperature.
TCE(JJ)	Same as for TC but for external breakdown.
TNC(K)	Total inorganic nitrogen available to CBIO(K).
WC(JJ)	JJ = 1, JJ = 2 and 3, JJ = 4 give the same type points as for pH, but this time for water potential (an expression of oxygen content of soil).
WCE(JJ)	Same as for WC but for external breakdown.
WRTBIO	A logical switch which is set to "Time" if one desires print-out of CBIO values each simulation time unit.

LITERATURE CITED

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APPENDIX 1

Program Listing

Subroutine NITRO

```
      SUBROUTINE NITRO
      DIMENSION T(5,4),PHK(5,4),SA(5,4),W(5,4),G(5),GM(5),GR(5),CM(7),
     1 BIOM(4,5),V(5),D(5),D1(5),D2(5),CFEPCT(4,6)
      COMMON/ACCINC/ AGAINQ(3,4),DUMAC(6)
      COMMON/SPEC/ SPDUM1(52),NHORIZ,SPDUM2(51),NFRELM,NFRAC1,
     1 SPDUM3(106),ISTD,JSTD,ILIT,JLIT,ILH,SPDUM4(11)
      COMMON/TOTALS/ TDUM1(417),ALIT(15),AORG(5),TDUM2(1022)
      COMMON/STAT/ SDUM1(1470),CLIT(15,6),CORG(5,6),CMIN(5,6),
     1 SDUM2(8),TCOVER,SDUM3(61),SMIN(5,4),SD4(81),FIXN2(5),DUMMY(144)
      COMMON/CHANGE/CDUM1(1470),CLITQQ(15,6),CORGQQ(5,6),CMINQQ(5,6),
     1 CDUM2(70),SMINQQ(5,4),SD4QQ(81),FIXN2Q(5),DUMMYQ(144)
      COMMON/SOINIT/ CI(5),AUTGRO,AUTNIT,SYMNIT(5),B1(5)
      COMMON/SOIDEC/ EXTDEC,CBIO(11)
      COMMON/SOIENV/ TEMP(7),PH(7),SS(7),WATPOT(7),TNC(6)
      LOGICAL SYMFIX,HETFIX,VOLATL,WRTNIT
      REAL K3,KM3,K4,KM4,MAIN3,MAIN4
      DATA SYMFIX/.TRUE./,HETFIX/.TRUE./,VOLATL/.TRUE./,WRTNIT/.FALSE./
C---------------------------------------------------------------------
C..........NAMELIST OF PARAMETERS
C..........FOR DETAILS, SEE 1973 BIOME SEPARATES
      NAMELIST/HANNA/       A3     ,A4     ,A5     ,BIOM   ,
     * BN     ,BNH4   ,BNO2   ,BNO3   ,B3     ,B4     ,CBFAC  ,CFEPCT,
     * CION   ,CM     ,D1     ,D2     ,FVNH4  ,GM     ,HETFIX ,IAGN   ,
     * TCO2   ,INH4   ,INIT   ,INO2   ,INO3   ,IR     ,KA     ,KM3    ,KM4    ,
     * K3     ,K4     ,LDUM   ,MAIN3  ,MAIN4  ,NNAMLS ,PHK    ,PHMAX  ,PHMIN  ,
     * SA     ,SYMFIX ,T      ,TMAX   ,TMIN   ,VMAX   ,VOLATL ,W      ,WRTNIT -
      IL=ILH   .
C---------------------------------------------------------------------
C..........NITROGEN TRANSFORMATIONS FOR EACH SOIL HORIZON
      DO 17 N=1,NHORIZ
      DO 5 I=1,IR
C..........ENVIRONMENTAL COEFFICIENTS FOR EACH TRANSFORMATION TYPE I
      CALL OPT(T(I,1),T(I,2),T(I,3),T(I,4),TEMP(N),TC)
      CALL OPT(PHK(I,1),PHK(I,2),PHK(I,3),PHK(I,4),PH(N),PHC)
      CALL OPT(SA(I,1),SA(I,2),SA(I,3),SA(I,4),SS(N),SC)
      CALL OPT(W (I,1),W (I,2),W (I,3),W (I,4),WATPOT(N),WC)
C..........GROWTH RATE FOR BIOMASS INVOLVED IN TRANSFORMATION I
      G(I)=GM(I)*TC*PHC*SC*WC
      GR(I)=0.0
      V(I)=0.0
      D(I)=D1(I)
    5 CONTINUE
C---------------------------------------------------------------------
C..........TOTAL SOIL CARBON IN DEAD MATERIALS
      TOTOC =AORG(N)+ALIT(IL)
C..........SYMBIOTIC FIXATION
      IF (.NOT.SYMFIX) GO TO 15
      GR(1)=G(1)*CI(N)/(CM(1)+CI(N))
      IF(CI(N).GT.0.0)D(1)=D2(1)
C..........FREE HETEROTROPHIC FIXATION
   15 IF (.NOT.HETFIX) GO TO 20
      GR(2)=G(2)*TOTOC/(CM(2)+TOTOC)
      IF (TOTOC .GT.0.0) D(2)=D2(2)
      V(2)=BIOM(2,N)*(1.-1./EXP(D(2)))
C..........OXIDATION OF NH4 TO NO2
   20 GR(3)=G(3)*SMIN(N,INH4)/(CM(3)+SMIN(N,INH4))
      IF (SMIN(N,INH4).GT.0.0) D(3)=D2(3)
      V6=(A3*GR(3)+MAIN3+K3*B3*SMIN(N,INH4)/
     *        (SMIN(N,INH4)+KM3))*BIOM(3,N)
      V6TOB3=AMIN1(V6,GR(3)*BN*BIOM(3,N)/A3)
      DEATH3=BIOM(3,N)*(1.-1./EXP(D(3)))
C..........OXIDATION OF NO2 TO NO3
      GR(4)=G(4)*SMIN(N,INO2)/(CM(4)+SMIN(N,INO2))
      IF (SMIN(N,INO2).GT.0.0) D(4)=D2(4)
      V7=(A4*GR(4)+MAIN4+K4*B4*SMIN(N,INO2)/
     *        (SMIN(N,INO2)+KM4))*BIOM(4,N)
      V7TOB4=AMIN1(V7,GR(4)*BN*BIOM(4,N)/A4)
      DEATH4=BIOM(4,N)*(1.-1./EXP(D(4)))
C..........DENITRIFICATION BY PART OF DECOMPOSER BIOMASS CBIO
      GG=G(5)*(SMIN(N,INO2)+SMIN(N,INO3))*CION/((SMIN(N,INO2)+
     1 SMIN(N,INO3)+CM(5))*(CION+WATPOT(N)))
      GR(5)=GG*TOTOC/(CM(6)+TOTOC)
      IF (TOTOC .GT.0.0) D(5)=D2(5)
      V8=A5*GR(5)*CBIO(N)/CBFAC
C..........NH3 VOLATILIZATION
      IF (N.GT.1.OR.(.NOT.VOLATL)) GO TO 14
      CALL RAMP(TMIN,TMAX,TEMP(N),TC8)
      CALL RAMP(PHMIN,PHMAX,PH(N),PHC8)
      CALL DCLIN(VMAX,TCOVER,SOCOC)
      V10=SMIN(N,INH4)*TC8*PHC8*SOCOC*FVNH4
      GO TO 19
   14 V10=0.0
C..........IMMOBILIZATION OF MINERAL NITROGEN BY FIXERS
C..........V111 IS GROWTH REQUIREMENT, V11-- ARE UTILIZATIONS OF PARTI-
C..........CULAR TYPES OF N BASED ON PREFERENCES
   19 IF (N.GT.1) V111=(GR(1)*BIOM(1,N)+GR(2)*BIOM(2,N))*BN
      IF (N.LE.1) V111=(GR(1)*BIOM(1,N)+GR(2)*BIOM(2,N)+AUTGRO)*BN
      V11=V111*TNC(N)/(TNC(N)+CM(7))
C---------------------------------------------------------------------
C..........RESULTANT CHANGES IN NITROGEN POOLS
C..........AMMONIUM
      IF (SMIN(N,INH4).LE.0.0) GO TO 30
      V11NH4=V11*BNH4*SMIN(N,INH4)/TNC(N)
      SMINQQ(N,INH4)=SMINQQ(N,INH4)-V11NH4-V6-V10
      GO TO 35
   30 V10=0.0
      V11NH4=0.0
      V6=0.0
C..........NITRITE
   35 IF (SMIN(N,INO2).LE.0.0) GO TO 40
      V11NO2=V11*BNO2*SMIN(N,INO2)/TNC(N)
   38 SMINQQ(N,INO2)=SMINQQ(N,INO2)-V11NO2+V6-V6TOB3-V7-V8*SMIN(N,INO2)
     */(SMIN(N,INO3)+SMIN(N,INO2))
      GO TO 45
   40 V7=0.0
      V11NO2=0.0
C..........NITRATE
      SMINQQ(N,INO2)=SMINQQ(N,INO2)+V6-V6TOB3
   45 IF (SMIN(N,INO3).LE.0.0) GO TO 50
      V11NO3=V11*BNO3*SMIN(N,INO3)/TNC(N)
   48 SMINQQ(N,INO3)=SMINQQ(N,INO3)-V11NO3+V7-V7TOB4-V8*SMIN(N,INO3)/
     *   (SMIN(N,INO3)+SMIN(N,INO2))
      GO TO 55
   50 V11NO3=0.0
      SMINQQ(N,INO3)=SMINQQ(N,INO3)+V7-V7TOB4
C..........GAIN IN ORGANIC NITROGEN
   55 AUTNIT=0.0
      IF (N.EQ.1) AUTNIT=AUTGRO*BN
      SYMNIT(N)=GR(1)*BIOM(1,N)*BN
C..........DHUMNI IS CONTRIBUTION OF N TO SOIL ORGANIC MATTER VIA DEATH
      DHUMNI=(V(2)+DEATH3+DEATH4)*BN
      CORGQQ(N,INIT)=CORGQQ(N,INIT)+DHUMNI
C---------------------------------------------------------------------
C..........CHANGES IN BIOMASSES AND IN THE CLIT(LDUM,*) EQUIVALENT
      DO 65 I=1,4
      A=BIOM(I,N)
      BIOM(I,N)=BIOM(I,N)*EXP(GR(I)-D(I))
      IF (I.LT.2) GO TO 65
      CHANGE=BIOM(I,N)-A
      DO 62 K=2,NFRELM
      IF (CLIT(LDUM,K).LE.0.0) GO TO 62
      CLITQQ(LDUM,K)=CLITQQ(LDUM,K)+CFEPCT(I,K)*CHANGE
      CORGQQ(N,K)=CORGQQ(N,K)-CFEPCT(I,K)*CHANGE
   62 CONTINUE
   65 CONTINUE
C..........CHANGE IN DECOMPOSERS DUE TO DENITRIFICATION
      DCBIO=(EXP(GR(5)-D(5))-1.)*CBIO(N)/CBFAC
      CBIO(N)=CBIO(N)+DCBIO
C..........COMPUTATIONS NEEDED TO INTERFACE WITH SIMULATION SYSTEM
      CLITQQ(LDUM,INIT)=CLITQQ(LDUM,INIT)+V111-AUTNIT-SYMNIT(N)-DHUMNI+
     *  V6TOB3+V7TOB4
      AGAINQ(KA,IAGN)=AGAINQ(KA,IAGN)+V111-V11NH4-V11NO2-V11NO3-V8-V10
      B1(N)=BIOM(1,N)
      FIXN2Q(N)=FIXN2Q(N)+V111-V11NH4-V11NO2-V11NO3
      IL=IL+1
      IF (WRTNIT) WRITE(6,3)N,DHUMNI,V11,V111,V11NH4,V11NO2,V11NO3,V6,
     * V7,V8,V10
    3 FORMAT(I5,10E10.5)
   17 CONTINUE
      RETURN
C---------------------------------------------------------------------
C..........NAMELIST READ/WRITE
      ENTRY SNINH
      READ(5,HANNA)
      IF(NNAMLS.LE.0)RETURN
      WRITE(6,HANNA)
      RETURN
      END
```

Subroutine DECOMP

```
      SUBROUTINE DECOMP

      DIMENSION GC(12),KHC(10),KMR(10),BNFAC(4),E2CPCT(6),CFEPCT(11,6)
      DIMENSION TC(4),PHC(4),SAC(4),WC(4),TCE(4),PHCE(4),WCE(4)
      LOGICAL INSOIL,SOM,EXTDEC,WRTBIO
      REAL KMN,KMC,KMR,MAINC,KHC

      COMMON/ACCINC/ AGAINQ(3,4),DUMAC(6)
      COMMON/SPEC/ SPDUM1(52),NHORIZ,SPDUM2(51),NFRELM,NFRAC1,
     1 SPDUM3(106),ISTD,JSTD,ILIT,JLIT,ILH,SPDUM4(11)
      COMMON/TOTALS/TDUM1(190),CLITT(15),TDUM2(212),ALIT(15),AORG(5),
     1  TDUM3(1022)
      COMMON/STAT/ SDUM1(1470),CLIT(15,6),CORG(5,6),CMIN(5,6),
     1 SDUM2(70),SMIN(5,4),DUMBIO(11,6),CO2(15),DUMMY(149)
      COMMON/CHANGE/CDUM1(1470),CLITQQ(15,6),CORGQQ(5,6),CMINQQ(5,6),
     1 CDUM2(70),SMINQQ(5,4),DUMBIQ(11,6),CO2QQ(15),DUMMYQ(149)

      COMMON/SOIENV/ TEMP(7),PH(7),SS(7),WATPCT(7),TNC(6)
      COMMON/SOIDEC/ EXTDEC,CBIO(11)

      DATA WRTBIO/.FALSE./

C---------------------------------------------------------------------
C.........NAMELIST OF PARAMETERS
C.........FOR EXPLANATIONS OF PARAMETER MEANINGS, SEE THE DESERT BIOME
C.........WRITE-UP(SEPARATE PUBLICATION FOR 1973) WHEREIN PARAMETERS
C.........ARE LISTED
      NAMELIST/PARNAS/ BC2BNE,BE    ,BN     ,BNFAC ,CBIO  ,CFEPCT,D1    ,
     * D2    ,DUMBIO,EFC   ,E2CPCT,GC     ,IAGN  ,TCO2  ,INH4  ,INIT  ,
     * IPC   ,ISOM  ,ISURF ,KA    ,KHC    ,KMC   ,KMN   ,KMR   ,MAINC ,
     * NNAMLS,NNIT  ,NR1   ,NZONES,PC2PN  ,PHC   ,PHCE  ,SAC   ,
     * TC    ,TCE   ,WC    ,WCE   ,WRTBIO
      IX=0
      IL=ILH
C---------------------------------------------------------------------
C.........DECOMPOSITION FOR EACH ENVIRONMENTAL ZONE IN SOIL AND ABOVE
      DO 2000 I=1,NZONES
      D=D1
      TGR=0.0
      INSOIL=.TRUE.
      IF (I.GT.NHORIZ) INSOIL=.FALSE.
C.........DETERMINE ENVIRONMENTAL COEFFICIENTS FOR PRESENT ZONE
      CALL OPT(TC(1),TC(2),TC(3),TC(4),TEMP(I),TCC)
      CALL OPT(PHC(1),PHC(2),PHC(3),PHC(4),PH(I),PHCC)
      CALL OPT(SAC(1),SAC(2),SAC(3),SAC(4),SS(I),SCC)
      CALL OPT(WC(1),WC(2),WC(3),WC(4),WATPCT(I),WCC)
      IF (I.GT. ISURF .OR..NOT.EXTDEC) GO TO 15
C.........ENVIRONMENTAL COEFFICIENTS FOR ENZYMES INVOLVED IN EXTERNAL
C.........BREAKDOWN OF LITTER AND DEAD ROOTS
      CALL OPT(TCE(1),TCE(2),TCE(3),TCE(4),TEMP(I),TRC)
      CALL OPT(PHCE(1),PHCE(2),PHCE(3),PHCE(4),PH(I),PHRC)
      CALL RAMP(WCE(1),WCE(2),WATPCT(I),WRC)
C---------------------------------------------------------------------
C.........DETERMINE THE NUMBER OF TYPES OF DEAD MATERIAL TO DECOMPOSE
C.........IN THE PRESENT ZONE.
   15 IR=0
      NR=NR1
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```
      IF (INSOIL) GO TO 1000
      IF (I.NE.ISURF) GO TO 18
C.........EXECUTION COMES TO THIS POINT IF SURFACE LITTER IS DEALT WITH
C.........AS A PART OF THE TOP SOIL HORIZON ZONE
   16 IR=ILIT-1
      NR=JLIT
      GO TO 1000
   18 IR=ISTD-1
      NR=JSTD
C-----------------------------------------------------------------------
 1000 IR=IR+1
      VR=0.0
      DMINR=0.0
      DIMMO=0.0
      SOM=.FALSE.
      L=IL
C.........FIND VALUES FOR TOTAL CARBON, TOTAL NITROGEN AND PROTEIN CAR-
C.........BON FOR THE APPROPRIATE TYPE OF DEAD MATERIAL OR SOIL ORGANIC
C.........MATTER
      IF((.NOT.INSOIL).OR.IR.NE.ISOM) GO TO 20
      SOM=.TRUE.
      RCARB=AORG(I)
      RNIT=CORG(I,INIT)
      PROTC=CORG(I,IPC)
      GO TO 30
   20 IF (.NOT.INSOIL) L=IR
      RCARB=ALIT(L)
      RNIT=CLIT(L,INIT)
      PROTC=CLIT(L,IPC)
   30 CONTINUE
      IF (RCARB.LE.0.0) GO TO 300
C.........CARBON/NITROGEN RATIO
      CN=0.0
      IF (RNIT.GT.0.0) CN=RCARB/RNIT
C-----------------------------------------------------------------------
C.........K IS THE BIOMASS NUMBER WITH WHICH ONE DECOMPOSES THE PRESENT
C.........DEAD MATERIAL BEING WORKED ON.  J DETERMINES THE GROWTH RATE
C.........OF BIOMASS K IN PART AND DEPENDS ON TYPE OF DEAD MATERIAL
      K=I
      IF (I.GT.ISURF) K=ISURF+IR-ISTD+1
      IF (INSOIL) J=JP
      IF (.NOT.INSOIL) J=J+1
C.........AVAILABLE NITROGEN POOL
      IF (I.LE.ISURF) RNITNC=RNIT+TNC(K)
      IF (I.GT.ISURF) RNITNC=RNIT
      GRC= GC(J)*TCC*PHCC*SCC*WCC
C.........GRDEC IS GROWTH RATE OF K ON PRESENT DEAD MATERIAL TYPE
      GRDEC=GRC*RCARB*RNITNC/((KMC+RCARB)*(KMN+RNITNC))
      TGR=TGR+GRDEC
C.........TOTAL CARBON DECOMPOSITION
      DORGC=(GRDEC/EFC+MAINC)*CBIO(K)
      DCO2=(1.-EFC)*DORGC
      CO2QQQ(L)=CO2QQQ(L)+DCO2
C.........PROTEIN CARBON DECOMPOSITION
      IF (CN.GE.PC2BNE) GO TO 103
      DPROTC=DORGC*PROTC/RCARB
      GO TO 105
  103 DPROTC=PC2PN*BN*GRDEC*CBIO(K)*RNIT/RNITNC
C.........OTHER CARBON DECOMPOSITION
  105 DOTHRC=DORGC-DPROTC
C.........PROTEIN NITROGEN DECOMPOSITION
      DORGN=DPROTC/PC2PN
C.........MINERALIZATION/IMMOBILIZATION
      DMINR=DORGN-BN*GRDEC*CBIO(K)*RNIT/RNITNC
      DIMMO=BN*GRDEC*CBIO(K)*(RNITNC-RNIT)/RNITNC
C.........EXTERNAL BREAKDOWN
      IF (SOM.OR.I.GT.ISURF.OR.(.NOT.EXTDEC)) GO TO 110
      IX=IX+1
      KEX=KHC(IX)*TRC*PHRC*WRC
      VR=KEX*BE*CBIO(K)*RCARB/(KMR(IX)+RCARB)
  110 CONTINUE
C-----------------------------------------------------------------------
C.........CHANGES IN CONCENTRATIONS OF DEAD MATERIAL CONSTITUENTS
      II=I
      IF (.NOT.INSOIL) II=1
      DO 200 M=1,NFRELM
      IF ((SOM.AND.CORG(II,M).LE.0.).OR.(.NOT.SOM.AND.CLIT(L,M).LE.0.))
     *          GO TO 200
      DLOS=0.0
      EXTLOS=0.0
      IF (.NOT.SOM) EXTLOS=(CLIT(L,M) /CLITT(L))*VR
      IF (M.EQ.INIT) DLOS=DLOS+DORGN
      DMINRL=0.0
C.........CFEPCT DETERMINES THE REQUIREMENT OF BIOMASS K FOR CONSTITUENT
C.........M RELATIVE TO TOTAL CARBON DECOMPOSITION. E2CPCT IS LIKE AN
C.........INEFFICIENCY OF UTILIZATION OF CONSTITUENT M--UNITS M MINERAL-
C.........IZED PER UNIT M ASSIMILATED
      IF (M.NE.INIT.AND.M.LT.NFRAC1) DMINRL=E2CPCT(M)*CFEPCT(K,M)*DORGC
      IF (M.EQ.IPC) DLOS=DLOS+DPROTC
      IF (M.EQ.IPC.OR.M.LT.NFRAC1) GO TO 140
      IF (SOM) DLOS=DLOS+(CORG(II,M)/(AORG(I)-PROTC))*DOTHRC
      IF (.NOT.SOM) DLOS=DLOS+(CLIT(L,M) /(ALIT(L)-PROTC))*DOTHRC
C.........ADD AND SUBTRACT CHANGES
  140 IF (SOM) CORGQQ(I,M)=CORGQQ(I,M)-DLOS-DMINRL
      IF (.NOT.SOM) CLITQQ(L,M)=CLITQQ(L,M)-DLOS-EXTLOS-DMINRL
      CORGQQ(II,M)=CORGQQ(II,M)+EXTLOS
      CMINQQ(II,M)=CMINQQ(II,M)+DMINRL
C.........RESPIRATION
      R=0.0
      IF (M.GE.NFRAC1) R=DCO2*(DLOS/DORGC)
C.........DUMBIO IS A STATE VARIABLE EQUIVALENT TO CBIO
      DUMBIO(K,M)=DUMBIO(K,M)+DLOS-R
      AGAINQ(KA,ICO2)=AGAINQ(KA,ICO2)-R
  145 IF (M.NE.INIT) GO TO 200
      IF (DIMMO.LE.0.0.OR.I.GT.ISURF) GO TO 160
      DO 150 N=2,NNIT
      IF (SMIN(II,N) .LE.0.0) GO TO 150
      DIM=DIMMO*BNFAC(N)*SMIN(II,N)/TNC(K)
      SMINQQ(II,N) =SMINQQ(II,N) -DIM
      DUMBIO(K,M)=DUMBIO(K,M)+DIM
  150 CONTINUE
  160 IF (SOM) CORGQQ(II,M)=CORGQQ(II,M)-DMINR
      IF (.NOT.SOM) CLITQQ(L,M)=CLITQQ(L,M)-DMINR
      SMINQQ(II,INH4)=SMINQQ(II,INH4)+DMINR
  200 CONTINUE
C.........DEATH RATE OF DECOMPOSERS
      IF (RCARB.GT.0.0) D=D2
  300 IF (I.LE.ISURF) GO TO 1500
C.........BIOMASS OF DECOMPOSERS IN STANDING DEAD
      VD=CBIO(K)*(1.-1./EXP(D))
      DO 1400 M=1,NFRELM
      IF (DUMBIO(K,M).LE.0.0) GO TO 1400
      DUMBIO(K,M)=DUMBIO(K,M)-CFEPCT(K,M)*VD
      CLITQQ(L,M)=CLITQQ(L,M)+CFEPCT(K,M)*VD
 1400 CONTINUE
      CBIO(K)=CBIO(K)*EXP(GRDEC-D)
      D=D1
C.........IF THERE ARE ANY MORE TYPES OF DEAD MATERIAL AVAILABLE FOR
C.........THIS ZONE, GO GET THE NEXT TYPE. ELSE, GO TO NEXT ZONE
 1500 IF (IR.LT.NR) GO TO 1000
C-----------------------------------------------------------------------
      IF (I.GT.ISURF) GO TO 2000
      IF (INSOIL.AND.ISURF.EQ.NHORIZ.AND.I.EQ.1) GO TO 1600
C.........BIOMASS OF SURFACE AND/OR SOIL DECOMPOSER POPULATIONS
      VD=CBIO(K)*(1.-1./EXP(D))
      DO 1550 M=1,NFRELM
      IF (DUMBIO(K,M).LE.0.0) GO TO 1550
      DUMBIO(K,M)=DUMBIO(K,M)-CFEPCT(K,M)*VD
      CORGQQ(II,M)=CORGQQ(II,M)+CFEPCT(K,M)*VD
 1550 CONTINUE
      CBIO(K)=CBIO(K)*EXP(TGR-D)
 1600 IF (.NOT.INSOIL) GO TO 2000
C.........DO THIS WHEN SURFACE LITTER IS BEING DECOMPOSED BY HORIZON 1
C.........POPULATION
      IL=IL+1
      IF (ISURF.NE.NHORIZ.OR.I.NE.1) GO TO 2000
      INSOIL=.FALSE.
      GO TO 16
 2000 CONTINUE
C-----------------------------------------------------------------------
      IF (WRTBIO) WRITE(6,222) (CBIO(K),K=1,10)
  222 FORMAT(2X,10E12.3)
      RETURN
C-----------------------------------------------------------------------
C.........NAMELIST INPUT/WRITE-OUT
      ENTRY SNIN
      READ(5,PARNAS)
      IF(NNAMLS.EQ.1)WRITE(6,PARNAS)
      RETURN
      END
```

Subroutine OPT

```
      SUBROUTINE OPT(AMIN1,AMAX1,AMAX2,AMIN2,RX,FR)
      IF(RX.LE.AMIN1.OR.RX.GE.AMIN2)GO TO 110
      IF(RX.GE.AMAX1.AND.RX.LE.AMAX2)GO TO 101
      IF(RX.GT.AMIN1.AND.RX.LT.AMAX1)GO TO 102
      IF(RX.GT.AMAX2.AND.RX.LT.AMIN2)GO TO 103
  110 FR=0.0
      GO TO 104
 101  FR=1.0
      GO TO 104
 102  FR=(RX-AMIN1)/(AMAX1-AMIN1)
      GO TO 104
 103  FR=(RX-AMAX2)/(AMIN2-AMAX2)
 104  RETURN
      END
```

Subroutine DCLIN

```
      SUBROUTINE DCLIN(AMAXX,RX,FRAC)
      MX=AMAXX
      IF(MX.EQ.0)GO TO 302
      IF(RX.GE.AMAXX)GO TO 300
      FRAC=1.0-RX/AMAXX
      GO TO 301
  300 FRAC=0.0
      GO TO 301
  302 FRAC=1.0
  301 RETURN
      END
```

Subroutine RAMP

```
      SUBROUTINE RAMP(AMINX,AMAXX,RX,FRAC)
      IF(RX.GE.AMAXX)GO TO 1
      IF(RX.LE.AMINX)GO TO 2
      FRAC=(RX-AMINX)/(AMAXX-AMINX)
      GO TO 3
 1    FRAC=1.0
      GO TO 3
 2    FRAC=0.0
 3    RETURN
      END
```

APPENDIX 2

Input/Output Example

Data Listing

```
    CHEERS TO GOLDA

  LICHEN HEATH WITH DATA FOR DECOMPOSITION RUN 1
    0    0    0    3    7   10    0    0    4    0    7    0    0    0
    1 1979   40    0    6    0
    0    0    1    0    0
NITROGEN     ANIONS         CATIONS      PROTEIN C    RESERVE C    STRUCTURAL C
DEAD LICHEN                 DEAD MOSS                 WOODY LITTER
HERBACEOUS LITTER           DEAD ROOTS 0-2CM          DEAD ROOTS 2-8CM
DEAD ROOTS 8-18 CM          DEAD ROOTS 18-35 CM       DUMMY MICROBES(N)
DUMMY MICROBES(D)
    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1
   1.00      1.00        1.00       1.85       2.5       2.5
   1.00      1.00        1.00       1.85       2.5       2.5
     0.        0.          0.         2.00       2.00      2.00
    0    0    1    4    5    8
   20.        80.        180.        350.
     2500.       750.       1500.       8595.     47400.    144000.   DEAD LICHEN
      358.        40.        224.       1232.      2710.     13978.   DEAD MOSS
      946.        52.        220.       3252.       188.     30960.   LITTER WOOD
    14320.       755.       3800.      49230.     84450.    314370.   LITTER HERBACEOUS
      217.        12.         44.        745.       783.      7440.   ROOTS-2
     1807.       100.        368.       6210.      3191.     61999.   ROOTS8
     1156.        63.        235.       7975.      2042.     39679.   ROOTS-18
      433.        24.         89.       1490.       766.     14880.   ROOTS-35
  1000.      1000.       10000.     10000.     10000.     10000.        DUMMY MICROBES
 1100000.  1100000.   1100000.   1100000.   1100000.   1100000.   DUMMY MICROBES(D)
   956377.     31140.     166080.    3287550.    864450.  16608000.   ORGA. MATTER 0-2
     1469.      3000.      77800.        5.5          .          .   MINERALS 0-2
   387928.     14040.      74880.    1333500.    257700.   7768800.   ORG.MATTER 2-8
       87.      3100.      28900.        11.          .          .   MINERALS 2-8
   797237.     28800.     153600.    2740500.    523500.  15936000.   ORG. MATTER 8-18
       66.     16000.      27200.        13.          .          .   MINERALS 8-1
   266467.     16320.      87040.     915980.    172020.   9792000.   ORG. MATTER 18-35
       36.     27200.      40800.         0.          .          .   MINERALS 18-35

10433
TOTAL SOM CARBON IN TOP 0-2CM
GRAMS PER HECTARE
10419104201042210425
TOTAL CARBON IN LITTER TYPES
GRAMS PER HECTARE
DEAD MOSS
WOODY LITTER
DEAD ROOTS 0-2CM
DEAD ROOTS 18-35CM
01696
AMMONIUM IN TOP 2CM
GM/HA
 1701 1706
NO2 AND NO3 IN TOP 2CM
GRAMS PER HECTARE
NO2 0-2CM
NO3 0-2CM
 1781 1782 1783 1784
CO2 EVOLUTION — CUMULATIVE CARBON
GRAMS PER HECTARE
0-2 CM
2-8 CM
8-18 CM
18-35 CM
 1792 1793 1794 1795
NITROGEN EXCHANGE WITH ATMOSPHERE  (+INPUT,-OUTPUT)
GM/HA
0-2 CM
2-8 CM
8-18 CM
18-35 CM
 $IN
  I=1,
  MDUM=10,
  SMIN=5*000000.,1428.,77.,41.,21.,0.,  5*0.,  41.,10.,25.,15.,0.,
  TCOVER=.50,
  P=20*  4.0, 20*  4.3, 20*  4.8, 20*  5.2,
  S=140*6.0,
  T=20* 11.0, 20*  9.9, 20*  9.5, 20*  9.2,
  W=20*-10.0, 20* -8.0, 20* -8.0, 20* -8.0,
  $END
 $HANNA
  A3=16., A4=16., A5=.50,
  CFEPCT=4*0., 4*.10, 4*.15, 4*.10, 4*.30, 4*.05,
  BIOM= 70.,  44.,  44.,  77.,  0.0,
        70.,  44.,  44.,  77.,  0.0,
        70.,  44.,  44.,  77.,  0.0,
    150.,  50.,  50.,  150.,  0.,
  BN=.10,  BNH4=1.0,  BNO2=.10,  BNO3=.30,  B3=.0005,  B4=.0005,
  CBFAC=2.0,  CION=-.00001,
  CM= 10., 10000., 100., 1000., 1000., 10000., 1000.,
  D1=5*.02, D2=5*.002, FVNH4=.01,
  GM=1.4,  1.4,  .70,  7.0,  .0001,
  HETFIX=.TRUE.,  IACN=1,  ICO2=3,  INH4=2,  INIT=1,  INO2=3,  INO3=4,
  IR=5,  KA=1,  KM3=1.0,  KM4=1.0,  K3=1.0,  K4=1.0,
  LDUM=9,
  MAIN3=.00005,  MAIN4=.00005,
  NNAMLS=1,
  PHK= 5*0.0,  5*7.0,  5*9.0,  5*11.0,
  PHMAX= 9.0,  PHMIN=7.0,
  SA= 5*0.0,  5*0.0,  5*4.0,  5*10.,
  SYMFIX=.TRUE.,
  T=5*0.0,  5*25.,  5*35.,  5*45.,
  TMAX=50.,  TMIN=10.,  VMAX=.85,  VOLATL=.TRUE.,
  W=5*-15.,  5*-2.0,  5*-.10,  5*0.0,
  WRTNIT=.TRUE.,
  $END
 $PARNAS
  BC2BNE=12.5,BE=.0001, BN=.10, BNFAC=0., 1.0,.10,.30,
  CBIO=90000.,90000.,11.,5.,
  CEEPCT=11*0., 11*.10, 11*.15, 11*.10, 11*.30, 11*.05,
```

```
DUMBIO=66*100000.,
D1=.02, D2=.002,
EFC=0.4,
E2CPCT=0., 5*.10,
GC=.050, .050, .01, .05, .05, .03,
IAGN=1, ICO2=4, INH4=2, INIT=1, IPC=4, ISOM=1, ISURF=4,
KA=1, KHC=4*5., 20.,10.,2.0,5.0,     KMC=10000., KMN=10000.,
KMR=10*5.0,  MAINC=.0005, NNAMLS=1, NNIT=4, NR1=2,
NZONES=4, PC2PN=4.,
PHC=0.0,6.0,8.0,10.0,
PHCE=0.0,7.0,8.0,9.5,
RESPRT=3*0.,.30,.50,.20,
SAC=0.0,0.0,4.0,10.0,
TC=0.0,25.,35.,50.,
TCE=0.0,30.,35.,45.,
WC=-15.0,-4.0,-2.0,-.00,
WCE=-15.,-0.0,
WRTBIO=.TRUE.,
 $END
```

Simulation Run

```
  LICHEN HEATH WITH DATA FOR DECOMPOSITION RUN 1

INITIAL REPORT ON JAN   1 1978                                                                                1.092 SECONDS ELAPSED

CONSTITUENTS OF DEAD ORGANIC MATERIAL, G. OR KCAL. PER HECTARE
    TYPE OF MATERIAL          NITROGEN    ANIONS      CATIONS      PROTEIN C    RESERVE C    STRUCTURAL C  TOTAL C      DRY MATTER
DEAD LICHEN                    2500.00      250.00     1500.00      8595.00     47405.00     144000.00    200000.00    498663.25
DEAD MOSS                       358.00       40.00      224.00      1232.00      2710.00      13979.00     17920.00     44621.20
WOODY LITTER                    946.00       52.00      220.00      3252.00       188.00      30960.00     34400.00     85104.20
HERBACEOUS LITTER             14320.00      755.00     3800.00     49230.00     84450.00     314320.00    448000.00   1106875.48
DEAD ROOTS 0-2CM                217.00       12.00       44.00       745.00       383.00       7440.00      8568.00     21208.75
DEAD ROOTS 2-8CM               1807.00      100.00      368.00      6210.00      3191.00      61999.00     71400.00    176738.50
DEAD ROOTS 8-18 CM             1156.00       63.00      235.00      3975.00      2042.00      39679.00     45696.00    113110.25
DEAD ROOTS 18-35 CM             433.00       24.00       89.00      1490.00       766.00      14880.00     17136.00     42417.50
DUMMY MICROBES(N)              1000.00     1000.00    10000.00     10000.00     10000.00      10000.00     30000.00     80500.00
DUMMY MICROBES(D)           1100000.00  1100000.00  1100000.00   1100000.00   1100000.00    1100000.00   3300000.00  10834999.87
       TOTAL                1122737.00  1102296.00  1116480.00   1184729.00   1251135.00    1737256.00   4173120.00  13004238.87

SOIL VARIABLES
                              NITROGEN     ANIONS      CATIONS      PROTEIN C    RESERVE C    STRUCTURAL CTOTAL C      ORG.O.M.
ORGANIC MATTER CONSTITUENTS
   FROM   0. TO   20. MM.      956377.00    31140.00    166080.00   3287550.00    864450.00 16608000.00 20760000.00 41520000.00
   FROM  20. TO   80. MM.      387928.00    14040.00     74880.00   1333500.00    257700.00  7768800.00  9360000.00 18720000.00
   FROM  80. TO  180. MM.      797237.00    28800.00    153600.00   2740500.00    523500.00 15936000.00 19200000.00 38400000.00
   FROM 180. TO  350. MM.      266467.00    16320.00     87040.00    915980.00    172020.00  9792000.00 10880000.00 21760000.00
       TOTAL                  2408009.00    90300.00    481600.00   8277530.00   1817670.00 50104800.00 60200000.0012040000.00
IN MINERAL FRACTION
   FROM   0. TO   20. MM.        1469.00     3000.00     77800.00
   FROM  20. TO   80. MM.          87.00     3100.00     28900.00
   FROM  80. TO  180. MM.          66.00    16000.00     27200.00
   FROM 180. TO  350. MM.          36.00    27200.00     40800.00
       TOTAL                     1658.00    49300.00    174700.00

TOTAL, SOIL AND DEAD
    ORGANIC MATERIAL          3532404.00   1241896.00  1772780.00   9462259.00   3068805.00 51842056.00 64373120.00133404238.00

TOTAL IN ECOSYSTEM            3532404.00   1241896.00  1772780.00   9462259.00   3068805.00 51842056.00 64373120.00133404238.00

SOIL WATER POTENTIAL, ATM.
   FROM   0. TO   20. MM.           .00
   FROM  20. TO   80. MM.           .00
   FROM  80. TO  180. MM.           .00
   FROM 180. TO  350. MM.           .00                                                                     .232 SECONDS ELAPSED
      .902+05     .901+05     .110+02     .501+01     .000        .000        .000        .000         .000          .000
   1 .17005+00 .11808+00 .19847+00 .11479+00 .00000     .98873-03 .14870+02 .00000     .28603-08 .00000
   2 .10990+00 .34210-01 .42743+00 .30278-01 .00000     .11797-02 .93842+01 .00000     .12162-08 .00000
   3 .10111+00 .00000    .00000    .00000    .00000     .00000    .10700+02 .00000     .39249-12 .00000
   4 .31240+00 .18363-01 .52845+00 .10712-01 .00000     .22954-02 .00000    .00000     .11335-12 .00000
      .902+05     .902+05     .110+02     .501+01     .000        .000        .000        .000         .000          .000
   1 .33219-01 .12309+00 .20721+00 .11840+00 .12503-03 .10334-02 .15142+02 .40300+01 .38424-08 .00000
   2 .32345-01 .36215-01 .45343+00 .28132-01 .39137-03 .12507-02 .87877+01 .19816+01 .23353-08 .00000
   3 .22709-01 .00000    .00000    .00000    .00000    .00000    .86287+01 .24126+01 .55488-12 .00000
   4 .30758+00 .19622-01 .56486+00 .11444-01 .00000    .24532-02 .00000    .00000    .11337-12 .00000
      .903+05     .902+05     .110+02     .501+01     .000        .000        .000        .000         .000          .000
   1 .33816-01 .12831+00 .21634+00 .12207+00 .22855-03 .11865-02 .15418+02 .69449+01 .48157-08 .00000
   2 .33347-01 .38344-01 .48102+00 .25884-01 .71629-03 .15891-02 .81367+01 .33836+01 .33651-08 .00000
   3 .22801-01 .00000    .00000    .00000    .00000    .00800    .66548+01 .37844+01 .68358-12 .00000
   4 .30295+00 .20966-01 .60378+00 .12226-01 .00000    .26218-02 .00000    .00000    .11339-12 .00000
      .904+05     .902+05     .110+02     .501+01     .000        .000        .000        .000         .000          .000
   1 .34469-01 .13376+00 .22587+00 .12581+00 .31706-03 .14320-02 .15698+02 .91533+01 .57800-08 .00000
   2 .34413-01 .40606-01 .51029+00 .23572-01 .98289-03 .21614-02 .74401+01 .43619+01 .43033-08 .00000
   3 .22885-01 .00000    .00000    .00000    .00000    .00000    .49062+01 .44254+01 .78155-12 .00000
   4 .29851+00 .22401-01 .64538+00 .13061-01 .00000    .28020-02 .00000    .00000    .11342-12 .00000
      .905+05     .902+05     .110+02     .501+01     .000        .000        .000        .000         .000          .000
   1 .35173-01 .13943+00 .23582+00 .12962+00 .39466-03 .17612-02 .15983+02 .10873+02 .67352-08 .00000
   2 .35541-01 .43008-01 .54133+00 .21239-01 .11958-02 .29433-02 .67109+01 .50050+01 .51485-08 .00000
   3 .22955-01 .00000    .00000    .00000    .00000    .00000    .34683+01 .45497+01 .85315-12 .00000
   4 .29427+00 .23935-01 .68985+00 .13953-01 .00000    .29946-02 .00000    .00000    .11343-12 .00000
      .905+05     .903+05     .110+02     .502+01     .000        .000        .000        .000         .000          .000
   1 .35920-01 .14535+00 .24620+00 .13348+00 .46427-03 .21695-02 .16271+02 .12243+02 .76810-08 .00000
   2 .36729-01 .45559-01 .57427+00 .18928-01 .13585-02 .39139-02 .59653+01 .53762+01 .59007-08 .00000
   3 .23009-01 .00000    .00000    .00000    .00000    .00000    .23652+01 .43316+01 .90352-12 .00000
   4 .29022+00 .25572-01 .73738+00 .14904-01 .00000    .32003-02 .00000    .00000    .11345-12 .00000
      .906+05     .903+05     .110+02     .502+01     .000        .000        .000        .000         .000          .000
   1 .36708-01 .15152+00 .25705+00 .13739+00 .52803-03 .26548-02 .16564+02 .13360+02 .86175-08 .00000
   2 .37978-01 .48267-01 .60921+00 .16683-01 .14738-02 .50536-02 .52219+01 .55252+01 .65612-08 .00000
   3 .23046-01 .00000    .00000    .00000    .00000    .00000    .15673+01 .39131+01 .93785-12 .00000
   4 .28638+00 .27321-01 .78819+00 .15920-01 .00000    .34202-02 .00000    .00000    .11347-12 .00000
      .907+05     .903+05     .111+02     .502+01     .000        .000        .000        .000         .000          .000
   1 .37534-01 .15796+00 .26837+00 .14136+00 .58758-03 .37168-02 .16861+02 .14287+02 .95445-08 .00000
   2 .39288-01 .51141-01 .64627+00 .14546-01 .15451-02 .63435-02 .44999+01 .54933+01 .71331-08 .00000
   3 .23067-01 .00000    .00000    .00000    .00000    .00000    .10162+01 .34022+01 .96068-12 .00000
   4 .28274+00 .29188-01 .84249+00 .17004-01 .00000    .36551-02 .00000    .00000    .11348-12 .00000
      .907+05     .904+05     .111+02     .502+01     .000        .000        .000        .000         .000          .000
   1 .38397-01 .16467+00 .28019+00 .14537+00 .64420-03 .38568-02 .17161+02 .15074+02 .10462-07 .00000
   2 .40663-01 .54192-01 .68559+00 .12550-01 .15759-02 .77648-02 .38177+01 .53177+01 .76211-08 .00000
   3 .23076-01 .00000    .00000    .00000    .00000    .00000    .64804+00 .28739+01 .97561-12 .00000
   4 .27932+00 .31182-01 .90054+00 .18162-01 .00000    .39060-02 .00000    .00000    .11350-12 .00000
      .908+05     .904+05     .111+02     .502+01     .000        .000        .000        .000         .000          .000
   1 .39296-01 .17166+00 .29254+00 .14942+00 .69889-03 .45768-02 .17466+02 .15754+02 .11370-07 .00000
   2 .42105-01 .57429-01 .72730+00 .10721-01 .15709-02 .92995-02 .31903+01 .50324+01 .80316-08 .00000
   3 .23073-01 .00000    .00000    .00000    .00000    .00000    .40770+00 .23746+01 .98529-12 .00000
   4 .27612+00 .33310-01 .96259+00 .19396-01 .00000    .41741-02 .00000    .00000    .11351-12 .00000
      .909+05     .904+05     .111+02     .502+01     .000        .000        .000        .000         .000          .000
   1 .40231-01 .17896+00 .30542+00 .15350+00 .75249-03 .63803-02 .17774+02 .16353+02 .12268-07 .00000
   2 .43619-01 .60863-01 .77155+00 .90760-02 .15352-02 .10931-01 .26285+01 .46689+01 .83719-08 .00000
```

```
3 .23061-01 .00000    .00000    .00000    .00000    .00000    .25341+00 .19289+01 .99155-12 .00000
4 .27313+00 .35583-01 .10289+01 .20714-01 .00000    .44606-02 .00000    .00000    .11352-12 .00000
   .910+05   .905+05   .111+02   .503+01   .000      .000      .000      .000              .000          .000
1 .41201-01 .18656+00 .31888+00 .15760+00 .80566-03 .62712-02 .18036+02 .16892+02 .13157-07 .00000
2 .45208-01 .64505-01 .81849+00 .76203-02 .14744-02 .12642-01 .21378+01 .42559+01 .86502-08 .00000
3 .23042-01 .00000    .00000    .00000    .00000    .00000    .15576+00 .15460+01 .99562-12 .00000
4 .27038+00 .38009-01 .10998+01 .22120-01 .00000    .47666-02 .00000    .00000    .11352-12 .00000
   .910+05   .905+05   .111+02   .503+01   .000      .000      .000      .000              .000          .000
1 .42208-01 .19450+00 .33292+00 .16173+00 .85899-03 .72543-02 .18402+02 .17384+02 .14036-07 .00000
2 .46890-01 .68368-01 .86829+00 .67515-02 .13942-02 .14422-01 .17189+01 .38186+01 .88748-08 .00000
3 .23016-01 .00000    .00000    .00000    .00000    .00000    .34792-01 .12262+01 .99830-12 .00000
4 .26787+00 .40598-01 .11756+01 .23613-01 .00000    .50936-02 .00000    .00000    .11353-12 .00000
   .911+05   .905+05   .111+02   .503+01   .000      .000      .000      .000              .000          .000
1 .43252-01 .20277+00 .34759+00 .16586+00 .91223-03 .83352-02 .18721+02 .17842+02 .14905-07 .00000
2 .48641-01 .72464-01 .92112+00 .57604-02 .13005-02 .16259-01 .13683+01 .33779+01 .90539-08 .00000
3 .22997-01 .00000    .00000    .00000    .00000    .00000    .57233-01 .96458+00 .10001-11 .00000
4 .26560+00 .43762-01 .12566+01 .25219-01 .00000    .54428-02 .00000    .00000    .11353-12 .00000
   .912+05   .906+05   .111+02   .503+01   .000      .000      .000      .000              .000          .000
1 .44377-01 .21145+00 .36290+00 .16993+00 .96790-03 .95201-02 .19044+02 .18273+02 .15764-07 .00000
2 .50496-01 .76906-01 .97716+00 .47725-02 .11983-02 .18147-01 .10801+01 .29502+01 .91952-08 .00000
3 .22953-01 .00000    .00000    .00000    .00000    .00000    .34362-01 .75381+00 .10014-11 .00000
4 .26359+00 .46711-01 .13472+01 .26925-01 .00000    .58159-02 .00000    .00000    .11353-12 .00000
   .912+05   .906+05   .111+02   .503+01   .000      .000      .000      .000              .000          .000
1 .45453-01 .22039+00 .37880+00 .17413+00 .10242-02 .10916-01 .19370+02 .18685+02 .16614-07 .00000
2 .52454-01 .81408-01 .10266+01 .35510-02 .10923-02 .20080-01 .84663+00 .25476+01 .93056-08 .00000
3 .22917-01 .00000    .00000    .00000    .00000    .00000    .20558-01 .58601+00 .10024-11 .00000
4 .26193+00 .49458-01 .14357+01 .28747-01 .00000    .62144-02 .00000    .00000    .11352-12 .00000
STATE( 1490) PERMITS ONLY  .6163614247 OF THE PROPOSED UNIT CHANGE AT  17 +  .000 DAYS
   .913+05   .906+05   .111+02   .504+01   .000      .000      .000      .000              .000          .000
1 .46612-01 .22990+00 .39557+00 .17955+00 .10773-02 .11870-01 .19713+02 .19015+02 .17140-07 .00000
2 .54523-01 .86315-01 .10997+01 .32314-02 .10527-02 .21768-01 .73152+00 .23212+01 .93594-08 .00000
3 .22878-01 .00000    .00000    .00000    .00000    .00000    .15441-01 .50420+00 .10030-11 .00000
4 .26036+00 .52935-01 .15346+01 .30698-01 .00000    .66410-02 .00000    .00000    .11354-12 .00000
   .914+05   .907+05   .111+02   .504+01   .000      .000      .000      .000              .000          .000
1 .47811-01 .23992+00 .41300+00 .18601+00 .11300-02 .12775-01 .20069+02 .19311+02 .17473-07 .00000
2 .56712-01 .91536-01 .11666+01 .31223-02 .10507-02 .23372-01 .66875+00 .21897+01 .93893-08 .00000
3 .22839-01 .00000    .00000    .00000    .00000    .00000    .13039-01 .45987+00 .10036-11 .00000
4 .25917+00 .56453-01 .16404+01 .32795-01 .00000    .70974-02 .00000    .00000    .11356-12 .00000
   .915+05   .907+05   .111+02   .504+01   .000      .000      .000      .000              .000          .000
1 .49052-01 .25011+00 .43119+00 .19017+00 .11352-02 .14396-01 .20407+02 .19744+02 .18319-07 .00000
2 .59073-01 .97019-01 .12276+01 .25392-02 .94084-03 .25521-01 .51873+00 .18559+01 .94553-08 .00000
3 .22799-01 .00000    .00000    .00000    .00000    .00000    .77929-02 .35497+00 .10042-11 .00000
4 .25827+00 .60277-01 .17534+01 .35000-01 .00000    .75831-02 .00000    .00000    .11354-12 .00000
   .916+05   .907+05   .111+02   .502+01   .000      .000      .000      .000              .000          .000
1 .50338-01 .35320+00 .60377+00 .26313+00 .17096-02 .21892-01 .28089+02 .27289+02 .32474-07 .00000
2 .61488-01 .11015+00 .14063+01 .22041-02 .89552-03 .29697-01 .42790+00 .16700+01 .10184-07 .00000
3 .22757-01 .00000    .00000    .00000    .00000    .00000    .47101-02 .28581+00 .10543-11 .00000
4 .25768+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
STATE( 1690) PERMITS ONLY  .6173847988 OF THE PROPOSED UNIT CHANGE AT  20 +  .000 DAYS
   .918+05   .908+05   .111+02   .501+01   .000      .000      .000      .000              .000          .000
1 .52188-01 .37427+00 .64689+00 .27397+00 .18292-02 .24616-01 .28772+02 .27940+02 .33696-07 .00000
2 .64289-01 .11729+00 .14983+01 .19786-02 .84805-03 .32049-01 .36262+00 .14879+01 .10214-07 .00000
3 .14683+00 .00000    .00000    .00000    .00000    .00000    .00000    .24257+00 .10551-11 .00000
4 .25355+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .920+05   .908+05   .111+02   .499+01   .000      .000      .000      .000              .000          .000
1 .54128-01 .39678+00 .68628+00 .28709+00 .19512-02 .27052-01 .29488+02 .28544+02 .34484-07 .00000
2 .67271-01 .12492+00 .15964+01 .19011-02 .84011-03 .34785-01 .32793+00 .13853+01 .10232-07 .00000
3 .14409+00 .00000    .00000    .00000    .00000    .00000    .00000    .21925+00 .10557-11 .00000
4 .24950+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .922+05   .909+05   .111+02   .498+01   .000      .000      .000      .000              .000          .000
1 .56162-01 .42015+00 .72805+00 .29459+00 .21028-02 .31360-01 .30157+02 .29403+02 .36429-07 .00000
2 .70447-01 .13296+00 .17009+01 .15040-02 .72903-03 .37249-01 .24611+00 .11326+01 .10265-07 .00000
3 .14138+00 .00000    .00000    .00000    .00000    .00000    .00000    .16457+00 .10564-11 .00000
4 .24553+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .924+05   .909+05   .111+02   .496+01   .000      .000      .000      .000              .000          .000
1 .58297-01 .44491+00 .77238+00 .30170+00 .22594-02 .36184-01 .30829+02 .30212+02 .38344-07 .00000
2 .73878-01 .14151+00 .18123+01 .11853-02 .62840-03 .40213-01 .18399+00 .91984+00 .10288-07 .00000
3 .13874+00 .00000    .00000    .00000    .00000    .00000    .00000    .12326+00 .10571-11 .00000
4 .24163+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .926+05   .910+05   .112+02   .495+01   .000      .000      .000      .000              .000          .000
1 .60537-01 .47115+00 .81940+00 .30834+00 .24226-02 .41573-01 .31503+02 .30988+02 .40229-07 .00000
2 .77429-01 .15062+00 .19309+01 .93055-03 .53832-03 .43291-01 .13703+00 .74258+00 .10304-07 .00000
3 .13615+00 .00000    .00000    .00000    .00000    .00000    .00000    .92130-01 .10578-11 .00000
4 .23781+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .928+05   .910+05   .112+02   .493+01   .000      .000      .000      .000              .000          .000
1 .62898-01 .49894+00 .86928+00 .31441+00 .25935-02 .47577-01 .32175+02 .31743+02 .42084-07 .00000
2 .81264-01 .16030+00 .20573+01 .72762-03 .45850-03 .46496-01 .10171+00 .59620+00 .10314-07 .00000
3 .13361+00 .00000    .00000    .00000    .00000    .00000    .00000    .68721-01 .10584-11 .00000
4 .23406+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .930+05   .911+05   .112+02   .482+01   .000      .000      .000      .000              .000          .000
1 .65354-01 .52839+00 .92220+00 .31981+00 .27728-02 .54257-01 .32844+02 .32484+02 .43908-07 .00000
2 .85349-01 .17060+00 .21920+01 .56652-03 .38839-03 .49844-01 .75251-01 .47627+00 .10320-07 .00000
3 .13112+00 .00000    .00000    .00000    .00000    .00000    .00000    .51170-01 .10591-11 .00000
4 .23039+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .932+05   .912+05   .112+02   .490+01   .000      .000      .000      .000              .000          .000
1 .67943-01 .55960+00 .97834+00 .32440+00 .29613-02 .61675-01 .33506+02 .33212+02 .45700-07 .00000
2 .89702-01 .18155+00 .23355+01 .43901-03 .32730-03 .53352-01 .55524-01 .37866+00 .10322-07 .00000
3 .12868+00 .00000    .00000    .00000    .00000    .00000    .00000    .38046-01 .10598-11 .00000
4 .22678+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .934+05   .912+05   .112+02   .489+01   .000      .000      .000      .000              .000          .000
1 .70659-01 .59266+00 .10379+01 .32807+00 .31594-02 .69900-01 .34156+02 .33929+02 .47462-07 .00000
2 .94341-01 .19320+00 .24884+01 .33830-03 .27444-03 .57036-01 .40875-01 .29969+00 .10322-07 .00000
3 .12629+00 .00000    .00000    .00000    .00000    .00000    .00000    .28256-01 .10605-11 .00000
4 .22325+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .936+05   .913+05   .112+02   .488+01   .000      .000      .000      .000              .000          .000
1 .73509-01 .62770+00 .11011+01 .33066+00 .33673-02 .79009-01 .34790+02 .34633+02 .49191-07 .00000
2 .99284-01 .20559+00 .26512+01 .25888-03 .22900-03 .60913-01 .30037-01 .23616+00 .10319-07 .00000
3 .12394+00 .00000    .00000    .00000    .00000    .00000    .00000    .20968-01 .10612-11 .00000
4 .21979+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .937+05   .913+05   .112+02   .486+01   .000      .000      .000      .000              .000          .000
1 .76500-01 .66484+00 .11681+01 .33204+00 .35851-02 .89083-01 .35401+02 .35320+02 .50889-07 .00000
2 .10455+00 .21877+00 .28243+01 .19629-03 .19019-03 .65001-01 .22044-01 .18531+00 .10315-07 .00000
3 .12164+00 .00000    .00000    .00000    .00000    .00000    .00000    .15553-01 .10618-11 .00000
4 .21633+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .939+05   .914+05   .112+02   .485+01   .000      .000      .000      .000              .000          .000
1 .79640-01 .70420+00 .12392+01 .33204+00 .38128-02 .10021+00 .35982+02 .35985+02 .52553-07 .00000
2 .11017+00 .23278+00 .30097+01 .14693-03 .15722-03 .69317-01 .16165-01 .14481+00 .10310-07 .00000
3 .11939+00 .00000    .00000    .00000    .00000    .00000    .00000    .11533-01 .10625-11 .00000
4 .21305+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .941+05   .914+05   .112+02   .483+01   .000      .000      .000      .000              .000          .000
1 .82935-01 .74591+00 .13147+01 .33048+00 .40498-02 .11248+00 .36523+02 .36623+02 .54184-07 .00000
2 .11615+00 .24767+00 .32067+01 .10795-03 .12938-03 .73880-01 .11848-01 .11273+00 .10303-07 .00000
3 .11718+00 .00000    .00000    .00000    .00000    .00000    .00000    .85517-02 .10632-11 .00000
4 .20978+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .943+05   .915+05   .112+02   .482+01   .000      .000      .000      .000              .000          .000
1 .86393-01 .79013+00 .13947+01 .32718+00 .42954-02 .12600+00 .37013+02 .37224+02 .55780-07 .00000
2 .12253+00 .26350+00 .34166+01 .77071-04 .10599-03 .78709-01 .86843-02 .87428-01 .10296-07 .00000
3 .11501+00 .00000    .00000    .00000    .00000    .00000    .00000    .63421-02 .10639-11 .00000
4 .20657+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
   .945+05   .915+05   .112+02   .480+01   .000      .000      .000      .000              .000          .000
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1 .90023-01 .83700+00 .14796+01 .32196+00 .45485-02 .14086+00 .37437+02 .37778+02 .57340-07 .00000
2 .12932+00 .28033+00 .36403+01 .52504-04 .86421-04 .83824-01 .63672-02 .67579-01 .10287-07 .00000
3 .11288+00 .00000    .00000    .00000    .00000    .00000    .00000    .47046-02 .10646-11 .00000
4 .20343+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
  .947+05    .916+05   .112+02   .479+01   .000      .000      .000      .000                .000      .000
1 .93832-01 .89668+00 .15697+01 .31463+00 .48073-02 .15713+00 .37777+02 .38271+02 .58864-07 .00000
2 .13657+00 .29822+00 .38786+01 .32838-04 .70121-04 .89245-01 .46716-02 .52079-01 .10277-07 .00000
3 .11080+00 .00000    .00000    .00000    .00000    .00000    .00000    .34913-02 .10653-11 .00000
4 .20034+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
  .949+05    .916+05   .112+02   .477+01   .000      .000      .000      .000                .000      .000
1 .97829-01 .93935+00 .16652+01 .30500+00 .50692-02 .17510+00 .38008+02 .38685+02 .60348-07 .00000
2 .14429+00 .31723+00 .41325+01 .16964-04 .56591-04 .94993-01 .34316-02 .40027-01 .10267-07 .00000
3 .10876+00 .00000    .00000    .00000    .00000    .00000    .00000    .25920-02 .10659-11 .00000
4 .19731+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
STATE( 1707) PERMITS ONLY  .6930394093 OF THE PROPOSED UNIT CHANGE AT  36 +  .000 DAYS
  .951+05    .917+05   .112+02   .476+01   .000      .000      .000      .000                .000      .000
1 .10202+00 .99561+00 .17666+01 .30232+00 .53451-02 .19195+00 .38353+02 .39118+02 .61391-07 .00000
2 .15257+00 .33760+00 .44030+01 .83309-05 .49964-04 .10113+00 .28012-02 .33540-01 .10261-07 .00000
3 .18254+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .10666-11 .00000
4 .19475+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
  .953+05    .917+05   .112+02   .475+01   .000      .000      .000      .000                .000      .000
1 .10643+00 .10558+01 .18742+01 .31067+00 .56528-02 .20658+00 .38959+02 .39686+02 .61918-07 .00000
2 .16129+00 .35951+00 .46912+01 .51355-05 .49140-04 .10770+00 .25714-02 .31090-01 .10262-07 .00000
3 .17897+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .10673-11 .00000
4 .19143+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
STATE( 1697) PERMITS ONLY  .4596620612 OF THE PROPOSED UNIT CHANGE AT  37 +  .000 DAYS
  .955+05    .918+05   .112+02   .473+01   .000      .000      .000      .000                .000      .000
1 .11106+00 .11991+01 .21298+01 .33567+00 .63953-02 .23983+00 .42203+02 .43056+02 .67132-07 .00000
2 .25106+00 .40151+00 .52439+01 .00000    .48568-04 .12031+00 .00000    .28869-01 .10765-07 .00000
3 .17539+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
4 .18858+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
  .957+05    .919+05   .112+02   .472+01   .000      .000      .000      .000                .000      .000
1 .11630+00 .12766+01 .22693+01 .33411+00 .67717-02 .26245+00 .42552+02 .43589+02 .68104-07 .00000
2 .25979+00 .42872+00 .56051+01 .00000    .43824-04 .12848+00 .00000    .24692-01 .10751-07 .00000
3 .17191+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
4 .18578+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
STATE( 1505) PERMITS ONLY  .6230490580 OF THE PROPOSED UNIT CHANGE AT  38 +  .000 DAYS
  .959+05    .919+05   .112+02   .470+01   .000      .000      .000      .000                .000      .000
1 .12193+00 .13591+01 .24179+01 .32685+00 .71508-02 .28822+00 .42671+02 .44005+02 .69188-07 .00000
2 .26929+00 .45765+00 .59912+01 .00000    .38312-04 .13718+00 .00000    .20580-01 .10755-07 .00000
3 .16851+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
4 .18303+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
  .962+05    .920+05   .111+02   .469+01   .000      .000      .000      .000                .000      .000
1 .12766+00 .14474+01 .25763+01 .32945+00 .75647-02 .31269+00 .43044+02 .44509+02 .69900-07 .00000
2 .27958+00 .48878+00 .64040+01 .00000    .36354-04 .14652+00 .00000    .18490-01 .10754-07 .00000
3 .16517+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
4 .18034+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
  .964+05    .921+05   .111+02   .467+01   .000      .000      .000      .000                .000      .000
1 .13381+00 .15401+01 .27451+01 .29741+00 .78901-02 .34915+00 .42064+02 .44375+02 .71495-07 .00000
2 .29074+00 .52125+00 .68451+01 .00000    .27140-04 .15629+00 .00000    .13571-01 .10737-07 .00000
3 .16190+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
4 .17769+00 .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000    .00000
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 LICHEN HEATH WITH DATA FOR DECOMPOSITION RUN 1

REPORT NO. 1 ON FEB   9 1978 (I.E., AFTER  39 DAYS OF SIMULATION)                                    4.123 SECONDS ELAPSED

CONSTITUENTS OF DEAD ORGANIC MATERIAL, G. OR KCAL. PER HECTARE
   TYPE OF MATERIAL          NITROGEN     ANIONS      CATIONS     PROTEIN C    RESERVE C   STRUCTURAL C  TOTAL C    DRY MATTER
DEAD LICHEN                    2467.16      219.32      1453.97      8463.66     46677.59    141790.38   196931.62   490968.14
DEAD MOSS                       340.43         .50       164.75      1161.70      2079.98     10728.40    13970.09    34675.79
WOODY LITTER                    891.31         .10       142.16      3033.25       158.00     26019.25    29210.50    72088.22
HERBACEOUS LITTER             13995.00      650.68      3641.24     47936.87     82447.27    306865.89   437250.03  1080253.02
DEAD ROOTS 0-2CM                209.78         .00          .00       716.11       231.05      4488.22     5435.38    13332.74
DEAD ROOTS 2-8CM               1659.87       44.79       284.58      5624.29      2941.13     57144.16    65709.57   162607.38
DEAD ROOTS 8-18 CM             1155.99       62.99       234.99      3974.96      2041.98     39678.58    45695.51   113109.03
DEAD ROOTS 18-35 CM             433.00       24.00        89.00      1490.00       765.99     14879.89    17135.89    42417.21
DUMMY MICROBES(N)              1115.19     1132.78     10199.16     10132.77     10398.33     10066.39    30597.48    82354.54
DUMMY MICROBES(D)            1102783.59  1096574.44  1097861.62  1102733.06  1097954.89   112714.50  3327832.44 10902024.25
      TOTAL                  1125051.31  1100709.58  1114071.47  1185266.67  1245696.19  1738805.62  4169768.47 12993830.25

SOIL VARIABLES
                               NITROGEN    ANIONS      CATIONS     PROTEIN C    RESERVE C   STRUCTURAL CTOTAL C    ORG.O.M.
ORGANIC MATTER CONSTITUENTS
  FROM   0. TO   20. MM.      955442.41    3558.74    166710.35   328468.37    865464.12 16587913.87 20737846.25 41475692.50
  FROM  20. TO   80. MM.      386854.00   14377.28     75386.50  1329812.60    258794.98  7745560.69  9334168.12 18668336.25
  FROM  80. TO  180. MM.      797239.97   28802.81    153604.19  2740502.12    523508.39 15936000.00 19200010.50 38400021.00
  FROM 180. TO  350. MM.      266476.48   16310.99     87026.49   915970.87    171992.98  9791993.62 10879957.37 21759914.75
      TOTAL                  2406012.84   91049.81    482727.52  8270753.81   1819760.44 50061468.00 60151982.00120303963.00
IN MINERAL FRACTION
  FROM   0. TO   20. MM.        1274.48     3493.47     78566.19
  FROM  20. TO   80. MM.          82.21     3443.39     29415.07
  FROM  80. TO  180. MM.          65.97    16000.04     27200.05
  FROM 180. TO  350. MM.          35.56    27200.00     40800.01
      TOTAL                     1458.22    50136.90    175981.32

TOTAL, SOIL AND DEAD
   ORGANIC MATERIAL          3532522.34  1241896.28  1772780.30  9456020.37  3065456.62  5180273.50 64321750.00133297793.00

TOTAL IN ECOSYSTEM           3532522.34  1241896.28  1772780.30  9456020.37  3065456.62  5180273.50 64321750.00133297793.00


ACCUMULATED NET GAIN OR LOSS TO ECOSYSTEM
                                WATER      MINERAL SOIL   NITROGEN     ANIONS       CATIONS        TOTAL C
 TO OR FROM ATMOSPHERE            .00            .00        118.79         .00           .00     -51374.07
 BY RUN-OFF OR RUN-ON             .00            .00           .00         .00           .00           .00
 TO OR FROM SUBSOIL               .00            .00           .00         .00           .00           .00

       TOTAL                      .00            .00        118.79         .00           .00     -51374.07

SOIL WATER POTENTIAL, ATM.
  FROM   0. TO   20. MM.       .00
  FROM  20. TO   80. MM.       .00
  FROM  80. TO  180. MM.       .00
  FROM 180. TO  350. MM.       .00

ACCUMULATED PRECIPITATION TO FEB   9 1978 INCLUSIVE IS     .0 MM. - THAT IS      .0 TONS PER HECTARE         .259 SECONDS ELAPSED
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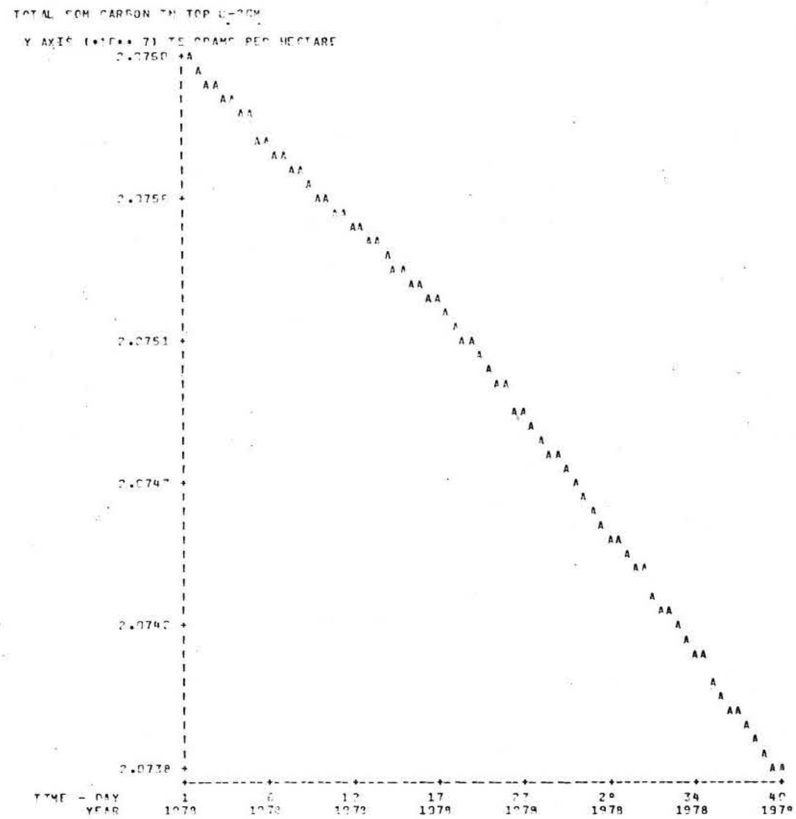
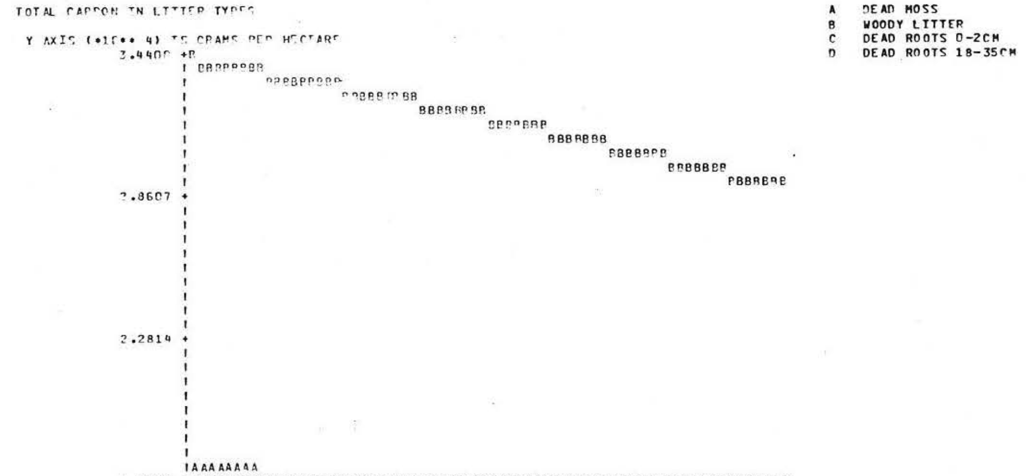
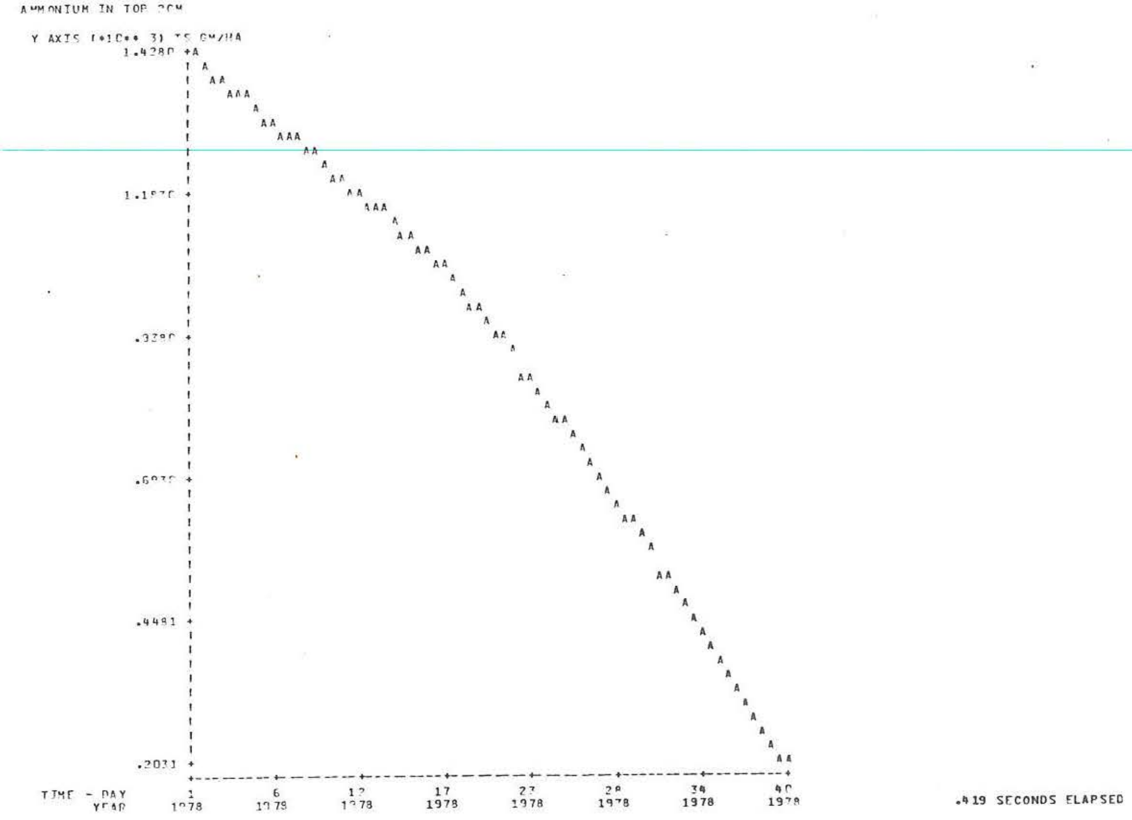
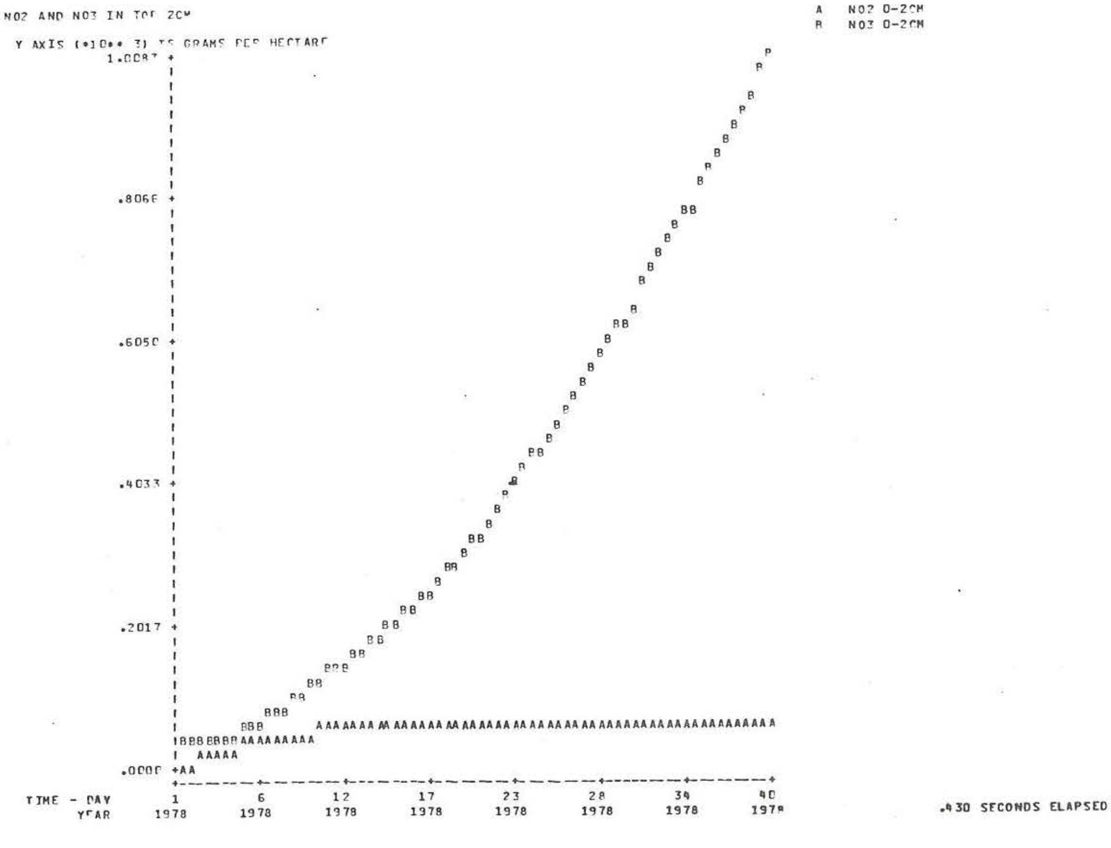


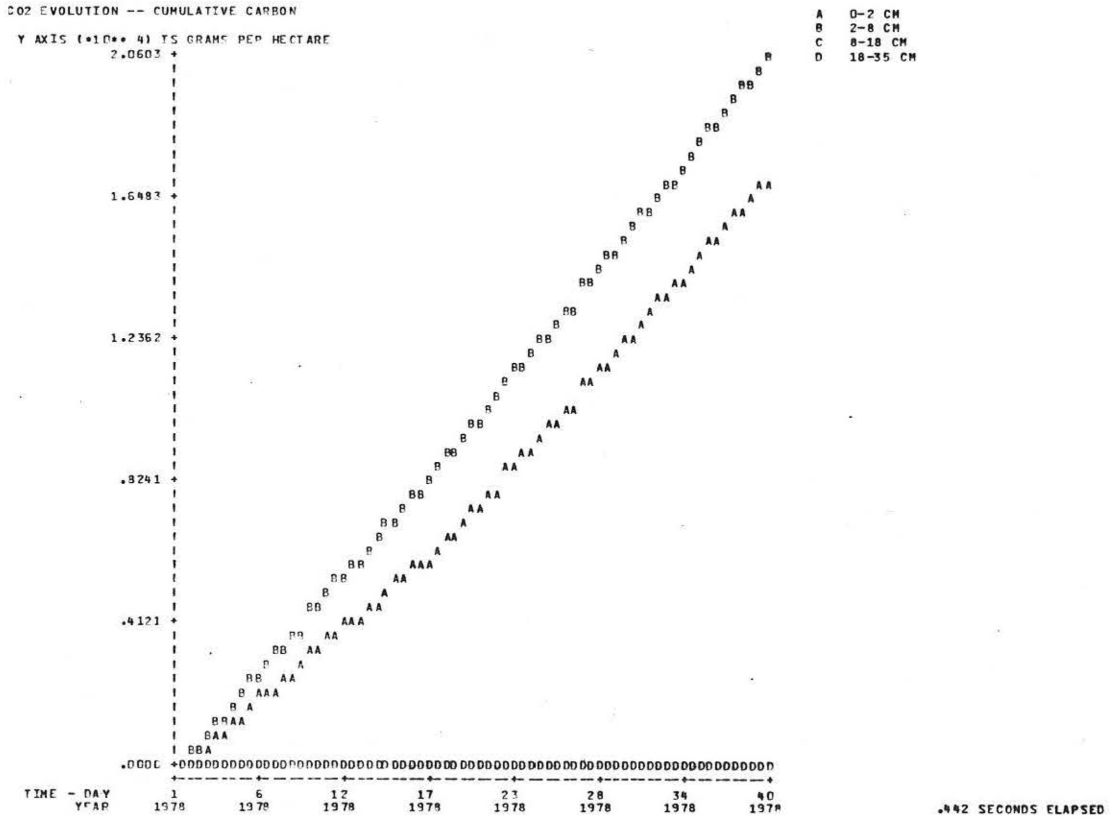
.420 SECONDS ELAPSED

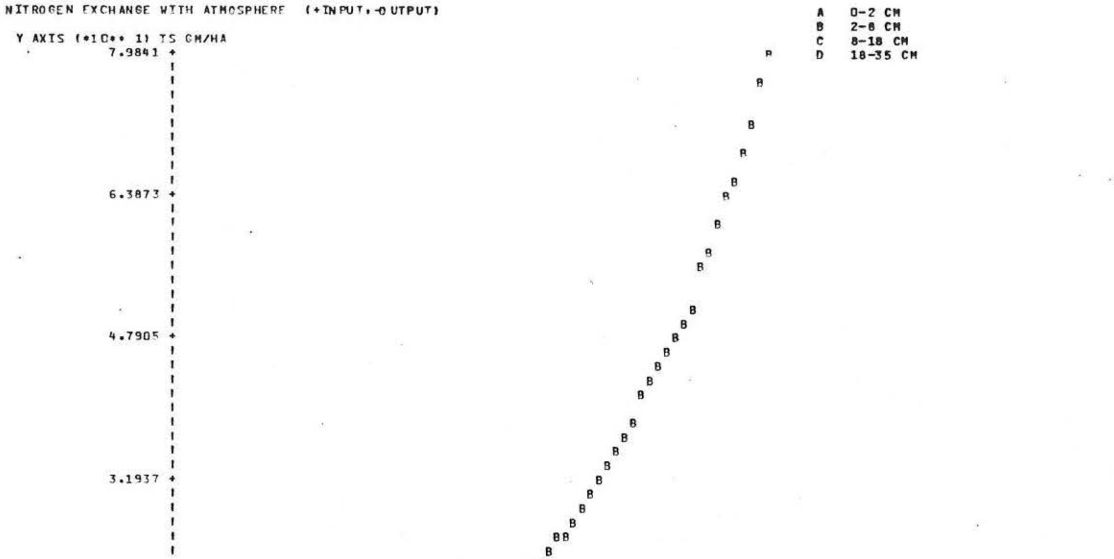


.444 SECONDS ELAPSED


AMMONIUM IN TOP 2CM
Y AXIS (*10** 3) IS GM/HA
1.4280
1.1830
.9380
.6930
.4481
.2031
TIME - DAY
YEAR
1
1978
6
1978
12
1978
17
1978
23
1978
28
1978
34
1978
40
1978
.419 SECONDS ELAPSED


NO2 AND NO3 IN TOP 2CM
A NO2 0-2CM
B NO3 0-2CM
Y AXIS (*10** 3) IS GRAMS PER HECTARE
1.0083
.8066
.6050
.4033
.2017
.0000
TIME - DAY
YEAR
1
1978
6
1978
12
1978
17
1978
23
1978
28
1978
34
1978
40
1978
.430 SECONDS ELAPSED


CO2 EVOLUTION -- CUMULATIVE CARBON
Y AXIS (*10** 4) IS GRAMS PER HECTARE
2.0603
1.6483
1.2362
.8241
.4121
.0000
A 0-2 CM
B 2-8 CM
C 8-18 CM
D 18-35 CM
TIME - DAY 1 6 12 17 23 28 34 40
YEAR 1978 1978 1978 1978 1978 1978 1978 1978
.442 SECONDS ELAPSED


NITROGEN EXCHANGE WITH ATMOSPHERE (+INPUT,-OUTPUT)
Y AXIS (*10** 1) IS GM/HA
7.9841
6.3873
4.7905
3.1937
1.5968
.0000
A 0-2 CM
B 2-8 CM
C 8-18 CM
D 18-35 CM
TIME - DAY 1 6 12 17 23 28 34 40
YEAR 1978 1978 1978 1978 1978 1978 1978 1978
.443 SECONDS ELAPSED