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Model Definition File - 25 character maximum for all text strings
Model Name= Frontiers Models
Model Version=    1.0.0
Model Time Unit= years
Model Contact= Edward B. Rastetter
Model Contact Address Line 1= The Ecosystems Center
Model Contact Address Line 2= Marine Biological Laboratory
Model Contact Address Line 3= Woods Hole, MA 02543

States (jk)
Name, Units, Symbol, Num array elements if applicable - Comma separated.
plant C, g C m-2, BC
plant N, g N m-2, BN
plant P, g P m-2, BP
Detrital C, g C m-2, DC
Detrital N, g N m-2, DN
Detrital P, g P m-2, DP
Inorganic N, g N m-2, EN
Inorganic P, g P m-2, EP
effort C, none, VC
effort N, none, VN
effort P, none, VP
End

Process
Process Name, Units, Symbol, Parameters, Process Type, Num array elements
Parameters for each process: Name, Units, Symbol
NPP, g C m-2 year-1, PN, 2, group1
      Max NPP rate, g C m-2 year-1, Pmax
      CO2 half sat, ppm, KC
Plant N uptake, g N m-2 year-1, UN, 2, group1
      Max N up rate, g C m-2 year-1, UNmax
      Plant N half sat, g N m-2, KN
Plant P uptake, g P m-2 year-1, UP, 2, group1
      Max P up rate, g C m-2 year-1, UPmax
      Plant P half sat, g P m-2, KP
Net C uptake, g C m-2 year-1, UnC, 0, group1
Net N Uptake, g N m-2 year-1, UnN, 0, group1
Net P Uptake, g P m-2 year-1, UnP, 0, group1
Plant litter C, g C m-2 year-1, L_C, 2, group1
      Active turnover const, year-1, aA
      Wood turnover const, year-1, aW
Plant litter N, g N m-2 year-1, L_N, 2, group1
      Actve litter C:N, g C g-1 N, qLNA
      Wood litter C:N, g C g-1 N, qLNW
Plant litter P, g P m-2 year-1, L_P, 2, group1
      Actve litter C:P, g C g-1 P, qLPA
      Wood litter C:P, g C g-1 P, qLPW
microbial respiration, g C m-2 year-1, Rm, 0, group1
Gross N mineralization, g N m-2 year-1, MN, 0, group1
Gross P mineralization, g P m-2 year-1, MP, 0, group1
microbial DC use, g C m-2 yr-1, GmC, 4, group1
      Soil C trunover const, year -1, rmC
      Soil N trunover const, year -1, rmN
      Soil P trunover const, year -1, rmP
      max microb C efficiency, fraction, epsilonCx
microbial C efficiency, fraction, epsilonmC, 0, group1
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microbial N efficiency, fraction, epsilonmN, 0, group1
microbial P efficiency, fraction, epsilonmP, 0, group1
microbial DN use, g C m-2 yr-1, GmN, 0, group1
microbial DP use, g C m-2 yr-1, GmP, 0, group1
N immobilization, g N m-2 year-1, UmN, 3, group1
      N immob rate const, year -1, betaN
      microb N half sat, g N m-2, KmN
      microb C:N, g C g-1 N, qmN
P immobilization, g P m-2 year-1, UmP, 3, group1
      P immob rate const, year -1, betaP
      microb P half sat, g P m-2, KmP
      microb C:P, g C g-1 P, qmP
Net N min, g N m-2 year-1, Nmin, 0, group1
Net P min, g P m-2 year-1, Pmin, 0, group1
Organic C loss, g C m-2 year-1, QOC, 1, group1
      DOC loss const, year-1, alphaOC
Organic N loss, g N m-2 year-1, QON, 1, group1
      DON loss const, year-1, alphaON
Organic P loss, g P m-2 year-1, QOP, 1, group1
      DOP loss const, year-1, alphaOP
Inorganic N loss, g N m-2 year-1, QN, 1, group1
      DIN loss const, year-1, alphaN
Inorganic P loss, g P m-2 year-1, QP, 1, group1
      DIP loss const, year-1, alphaP
Active biomass, g C m-2, BA, 2, group2
      maximum active biom, g c m-2, BAmax
      allometric const, none, gammaB
woody biomass, g C m-2, BW, 0, group1
Opt Plant C:N, g C g-1N, q_N, 2, group2
      C:N active biom, g C g-1 N, qNA
      C:N wood, g C g-1 N, qNW
Opt Plant C:P, g C g-1P, q_P, 2, group2
      C:P active biom, g C g-1 P, qPA
      C:P wood, g C g-1 P, qPW
Plant C:N, g C g-1N, AqN, 0, group2
Plant C:P, g C g-1N, AqP, 0, group2
Litter C:N, g C g-1N, LqN, 0, group2
Litter C:P, g C g-1N, LqP, 0, group2
Requirement C, g C m-2 year-1, RC, 0, group5
Requirement N, g N m-2 year-1, RN, 0, group5
Requirement P, g P m-2 year-1, RP, 0, group5
Mean Up:Req, none, PSI, 1, group5
      acclim rate, year-1, a
symbiotic N fixation, g N m-2 year-1, UNfix, 3, group2
      max symb N fix, g N g-1 C yr-1, FNF
      BA at canopy closure, fraction, BNF
      canopy inhibition, m2 g-1 C, kNF
stoichio net N growth, g N m-2 yr-1, PsiN, 0, group1
fixation potential, g N m-2 yr-1, FNP, 0, group1
non-symbiotic N fixation, g N m-2 year-1,INF, 1, group2
      N-S fixation constant, g N g-2/3 C m-2/3 yr-1, gammaNF
Growth N:C, gN g-1 C, phiN, 0, group1
Growth P:C, gP g-1 C, phiP, 0, group1
Model options, none, MODEL, 13, group5
      Plant flag,0=UnC 1=Lib 2=Conc 3=Accl, flag1
      Microb flag,0=UnC 1=Lib 2=Conc 3=Accl, flag2
      Plant mult weighting, g C m2 yr2 g-1 Ng-1P, rhoM
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      Microb mult weighting, m4 yr2 g-1N g-1 P, rhomM
      Q10 NPP, none, Q10Pn
      Q10 plant N up, none, Q10UN
      Q10 plant P up, none, Q10UP
      Q10 Nfix, none, Q10Nfix
      Q10 Soil C turnover, none, Q10DC
      Q10 Soil N turnover, none, Q10DN
      Q10 Soil P turnover, none, Q10DP
      Q10 microbe N up, none, Q10mUN
      Q10 microbe P up, none, Q10mUP
microb effort C, none, etaC, 0, group1
microb effort N, none, etaN, 0, group1
microb effort P, none, etaP, 0, group1

End

Drive
Name, Units, Symbol, Num array elements - Comma separated.
CO2, MJ m-2 year-1, CO2
N deposition, g N m-2 year-1, I_N
P inputs, g P m-2 year-1, I_P
temperature, oC, Temp
End

Other Double Variables
Name, Units, Symbol - Comma separated.
dum,dum,dum
microb C use ,gC m-2 yr-1,UmC
End

Other Integer Variables
Name, Units, Symbol - Comma separated.
End

Functions
End Functions

Equations -See the Computer Programming handout for instructions on writing equations in
Pascal. Semicolons the end of each statement.

MODEL:=flag1;
if EN<0  then    EN:=0;
if EP<0  then    EP:=0;

dum:=VC+VN+VP;
VC:=VC/dum;
VN:=VN/dum;
VP:=VP/dum;

AqN:=BC/BN;
AqP:=BC/BP;

BA:=BAmax*gammaB*BC/(BAmax+gammaB*BC);
BW:=BC-BA;

q_N:=BC/(BA/qNA + BW/qNW);
q_P:=BC/(BA/qPA + BW/qPW);
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PN:=power(Q10Pn,(Temp-15)/10)*BA*Pmax*CO2/(kC+CO2);
UN:=power(Q10UN,(Temp-15)/10)*BA*UNmax*EN/(kN+EN);
UP:=power(Q10UP,(Temp-15)/10)*BA*UPmax*EP/(kP+EP);

L_C:=aA*BA + aW*BW;
L_N:=(aA*BA/qLNA + aW*BW/qLNW)*BN*q_N/BC;
L_P:=(aA*BA/qLPA + aW*BW/qLPW)*BP*q_P/BC;

LqN:=L_C/L_N;
LqP:=L_C/L_P;


phiN:=sqr(BA)*(1/qNA-1/qNW)/(gammaB*sqr(BC))+1/qNW;
phiP:=sqr(BA)*(1/qPA-1/qPW)/(gammaB*sqr(BC))+1/qPW;

UnC:=PN-L_C;
UnP:=UP-L_P;

PsiN:=min(phiN*UnC, phiN*UnP/phiP);
FNP:=max(0, PsiN-Un+L_N);
UNfix:=power(Q10Nfix,(Temp-15)/10)*FNF*BA*FNP/(1+exp(kNF*(BA-BNF)));
UnN:=UN+UNfix-L_N;


if BW>0 then INF:=gammaNF*power(BW,2/3) else INF:=0;

RC:=L_C*sqrt(sqrt(q_N*BN*q_P*BP/sqr(BC)));
RN:=L_N*sqrt(BC/(BN*q_N));
RP:=L_P*sqrt(BC/(BP*q_P));
PSI:=Power(PN/RC,VC)*Power((UN+UNfix)/RN,VN)*Power(UP/RP,VP);

dVCdt:=0;
dVNdt:=0;
dVPdt:=0;


if abs(flag1-1)<0.1 then {Liebig}
   begin
      UnC:=min(UnC,min(UnN/phiN,UnP/phiP));
      UnN:=UnC *phiN;
      UnP:=UnC *phiP;
      PN:=UnC+L_C;
      UNfix:=max(0,UnN-UN+L_N);
      UN:=UnN+L_N-UNfix;
      UP:=UnP+L_P;
   end;
if abs(flag1-2)<0.1 then  {concurrent}
   begin
      Pn:=rhoM*Pn*(UN+UNfix)*UP/sqr(BA);
      UnC:=Pn-L_C;
      UnN:=UnC *phiN;
      UnP:=UnC *phiP;
      UN:=max(0,UnN-UNfix+L_N);
      UNfix:=UnN+L_N-UN;
      UP:=UnP+L_P;
   end;
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```
if abs(flag1-3)<0.1 then  {adaptive}
   begin
      PN:=3*VC*PN;
      UN:=3*VN*UN;
      UNfix:=3*VN*UNfix;
      UP:=3*VP*UP;

      UnC:=PN-L_C;
      UnN:=UN+UNfix-L_N;
      UnP:=UP-L_P;

      if PSI>0 then
         begin
            dVCdt:=a*ln(PSI*RC/PN)*VC;
            dVNdt:=a*ln(PSI*RN/(UN+UNfix))*VN;
            dVPdt:=a*ln(PSI*RP/UP)*VP;
         end;
   end;

GmC:=power(Q10DC,(Temp-15)/10)*rmC*DC;
GmN:=power(Q10DN,(Temp-15)/10)*rmN*DN;
GmP:=power(Q10DP,(Temp-15)/10)*rmP*DP;

UmN:=power(Q10mUN,(Temp-15)/10)*betaN*DC*(DC/(qmN*DN))*EN/(kmN+EN);
UmP:=power(Q10mUP,(Temp-15)/10)*betaP*DC*(DC/(qmP*DP))*EP/(kmP+EP);

Rm:=GmC*(1-epsilonCx);
Rm:=max(Rm,GmC-qmN*(GmN+UmN));
Rm:=max(Rm,GmC-qmP*(GmP+UmP));

MN:=GmN+UmN-(GmC-Rm)/qmN;
MP:=GmP+UmP-(GmC-Rm)/qmP;

epsilonmC:=1-Rm/GmC;
epsilonmN:=1-MN/(GmN+UmN);
epsilonmP:=1-MP/(GmP+UmP);

if abs(flag2-1)<0.1 then {Liebig}
   begin
      UmC:=min(GmC*epsilonCx,min(qmN*(UmN+GmN),qmP*(UmP+GmP)));
      GmC:=UmC/epsilonCx;
      Rm:=GmC-UmC;
      GmN:=GmC*rmN*DN/(rmC*DC);
      GmP:=GmC*rmP*DP/(rmC*DC);
      MN:=GmN+UmN-(GmC-Rm)/qmN;
      MP:=GmP+UmP-(GmC-Rm)/qmP;
   end;
if abs(flag2-2)<0.1 then {Concurrent}
   begin
      UmC:=GmC*(UmN+GmN)*(UmP+GmP)*rhomM;
      GmC:=UmC/epsilonCx;
      Rm:=GmC-UmC;
      GmN:=GmC*rmN*DN/(rmC*DC);
      GmP:=GmC*rmP*DP/(rmC*DC);
      MN:=GmN+UmN-(GmC-Rm)/qmN;
      MP:=GmP+UmP-(GmC-Rm)/qmP;
   end;
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```
if abs(flag2-3)<0.1 then {Adaptive}
   begin
      dum:=MN/UmN + MP/UmP - Rm/(qmN*UmN) - Rm/(qmP*UmP);
      etaC:=   1+GmC/(qmN*UmN)-GmN/UmN;
      etaC:=etaC+GmC/(UmP*qmP)-GmP/UmP;
      etaC:=(3-dum)/etaC;
      etaN:=etaC*(GmC/(qmN*UmN)-GmN/UmN)+ MN/UmN- Rm/(qmN*UmN);
      etaP:=etaC*(GmC/(UmP*qmP)-GmP/UmP)+ MP/UmP- Rm/(qmP*UmP);
      GmC:=etaC*GmC;
      GmN:=etaC*GmN;
      GmP:=etaC*GmP;
      UmN:=etaN*UmN;
      UmP:=etaP*UmP;
      Rm:=GmC*(1-epsilonCx);
      Rm:=max(Rm,GmC-qmN*(GmN+UmN));
      Rm:=max(Rm,GmC-qmP*(GmP+UmP));

      MN:=GmN+UmN-(GmC-Rm)/qmN;
      MP:=GmP+UmP-(GmC-Rm)/qmP;
   end;

Nmin:= MN-UmN;
Pmin:= MP-UMP;

QOC:=alphaOC*DC;
QON:=alphaON*DN;
QOP:=alphaOP*DP;
QN:=alphaN*EN;
QP:=alphaP*EP;
End Equations

Derivatives - For array variables use jj as the array index. Same order as above.
dBCdt:=PN-L_C;
dBNdt:=UN+UNfix-L_N;
dBPdt:=UP-L_P;
dDCdt:=L_C-Rm-QOC;
dDNdt:=L_N+UmN-QON-MN;
dDPdt:=L_P+UmP-QOP-MP;
dENdt:=I_N+INF+MN-UN-UmN-QN;
dEPdt:=I_P+MP-UP-UmP-QP;
dVCdt:=dVCdt;
dVNdt:=dVNdt;
dVPdt:=dVPdt;
```