INTERNAL REPORT 122

OREGON INTENSIVE STUDY SITE

1972 ANNUAL REPORT

R. H. Waring, et al.
Oregon State University

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OREGON IBP
1972 ANNUAL REPORT

R.H. Waring
Site Director

INTRODUCTION

With the completion of one full season of field work, the emphasis since last fall has been on synthesis of data and development of an operational model for a watershed. This focus has lead to major structural changes in the administration of the program and the initiation of a functional data bank and central laboratory. In this report an overview of the model and steps leading to its development are presented.

MODELING OBJECTIVES

The overall objective was to develop a general model that could predict water and nutrient outflow from an entire watershed at a weekly resolution. The model was required to have sufficient internal structure to permit structural changes in different parts of a watershed and separate investigation of the terrestrial and stream ecosystems.

DEVELOPMENT OF THE MODEL

Even during the field season, it became apparent that coordination of sampling and processing of data required far more effort than principal investigators could spend or graduate students could be expected to accomplish. This, with the beginning of the fall synthesis effort and the planned budget reduction for 1973, a number of post-doctorate researchers were requested to assume new roles. They were to coordinate data reduction by graduate students in a specified area, aid in the development of subsystem models, and identify priorities in data synthesis and additional research.

As a point of departure, the Round I modeling session and a preliminary stratification of Watershed 10 was divided into soil-vegetation units (Fig. 1). With the special effort of Drs. Mary Ann Strand and Charles Grier, a vertical structure was developed for each of the major soil-vegetation units (Fig. 2). The vertical strata included: a) canopy, b) subordinate vegetation, c) forest floor, d) rooting-zone soil, and e) subsoil. These are all linked to the aquatic system. From this limited structure, we organized the assemblage of data by identifying key people responsible and data sources (Table 1). Further development of the watershed model structure progressed under the leadership of Dr. Strand. She, working closely with the appointed coordinators, coupled the Round I subsystem process models (Fig. 3) to the vertical structure (Fig. 2). The results of this effort are illustrated in figures 4 through 8.

As the data began to be assembled, the initial watershed stratification (Fig. 1) was changed to reflect the accurate vegetation survey data of Glenn Hawk.

FIGURE 5

SUBORDINATE VEGETATION LAYER

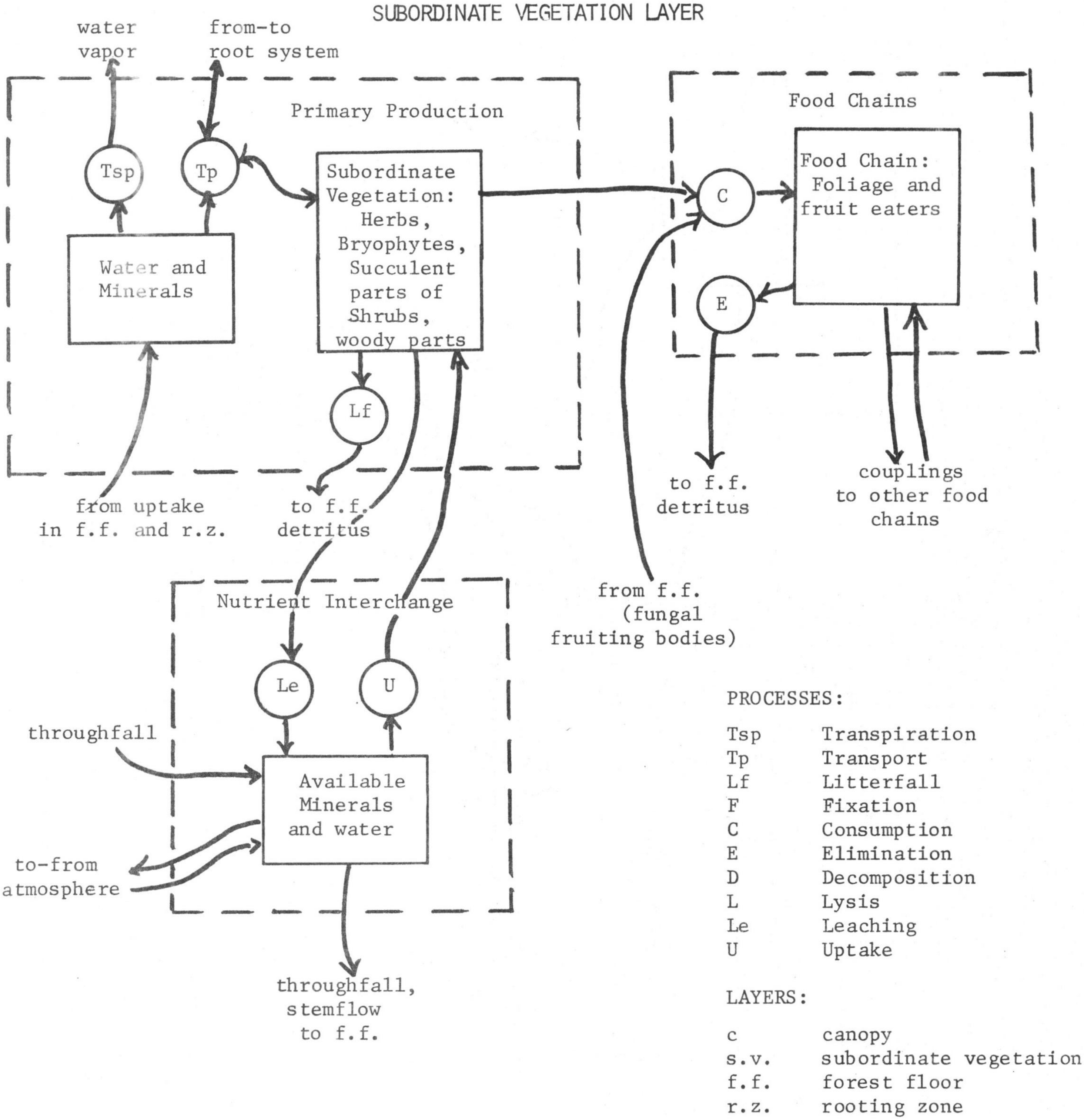
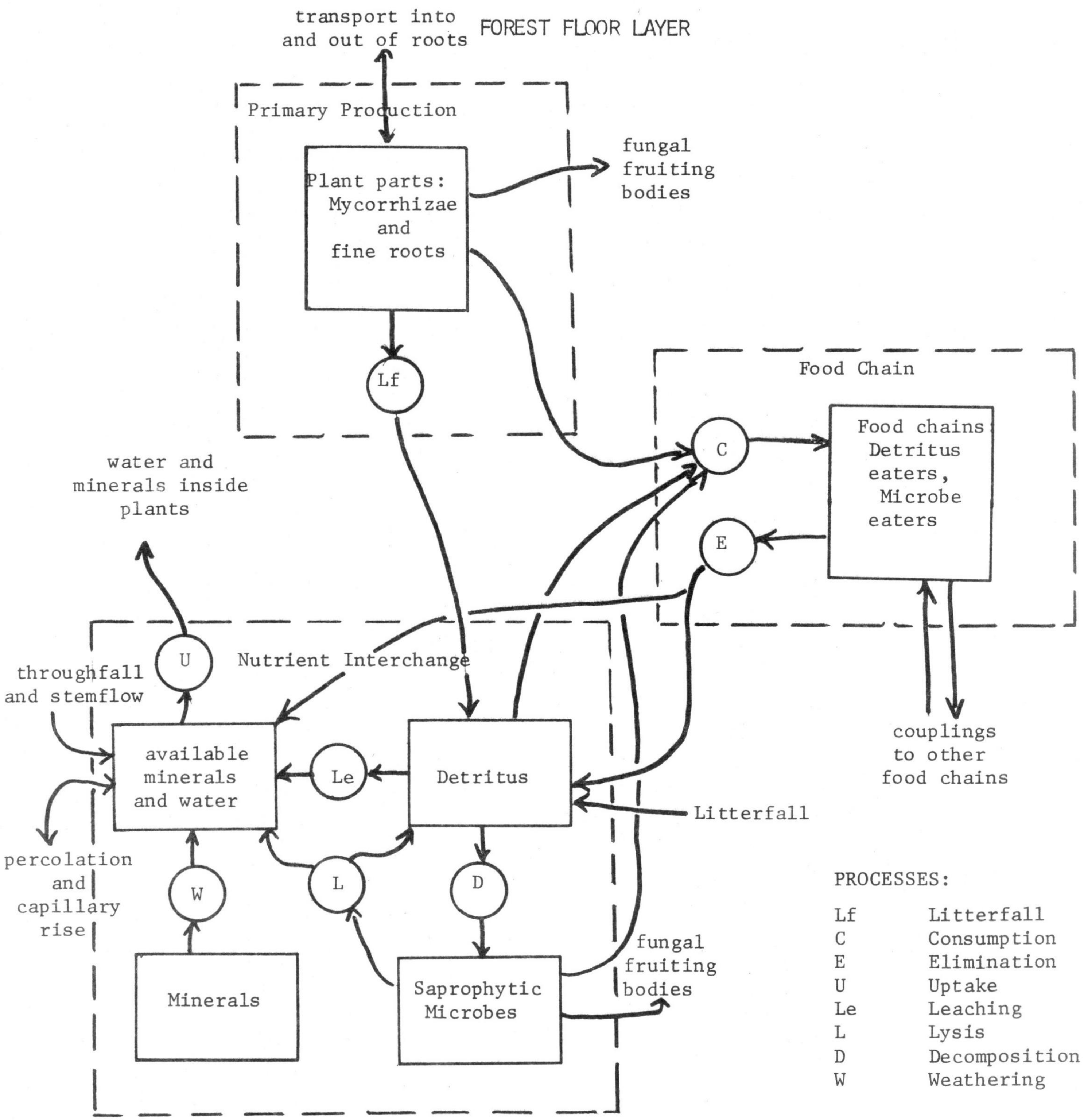


FIGURE 6



PROCESSES:

Lf	Litterfall
C	Consumption
E	Elimination
U	Uptake
Le	Leaching
L	Lysis
D	Decomposition
W	Weathering

FIGURE 7

ROOTING ZONE LAYER

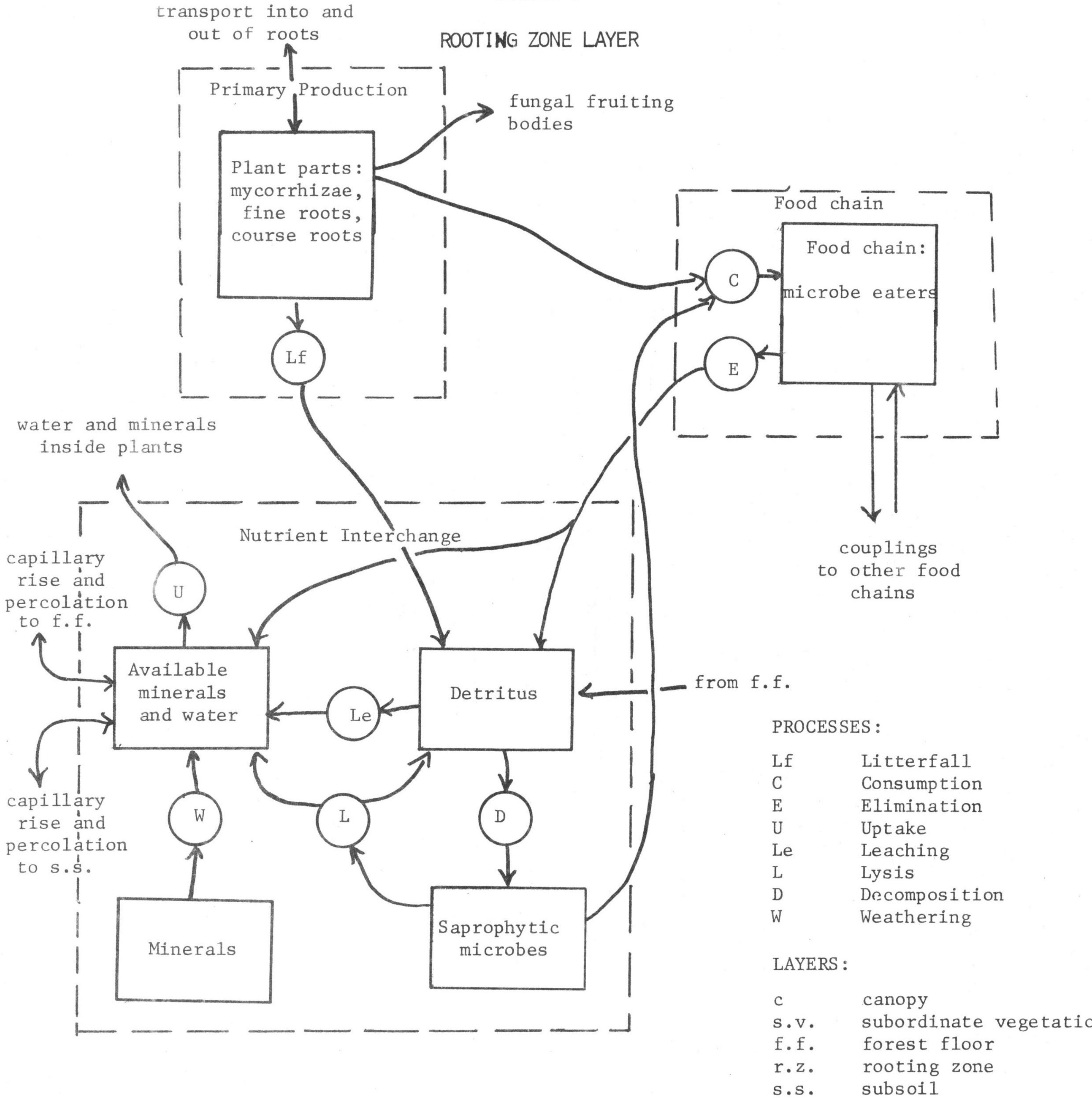
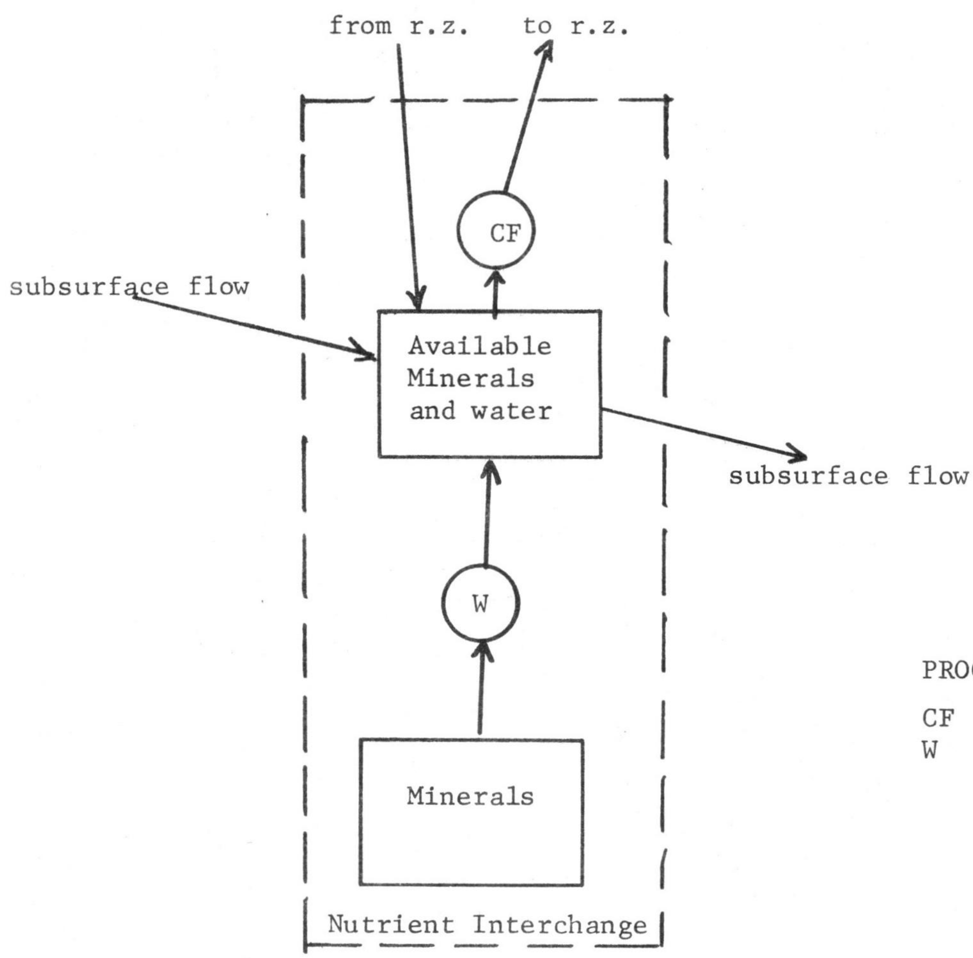


FIGURE 8

SUBSOIL LAYER



PROCESSES:

CF Capillary Flow
W Weathering

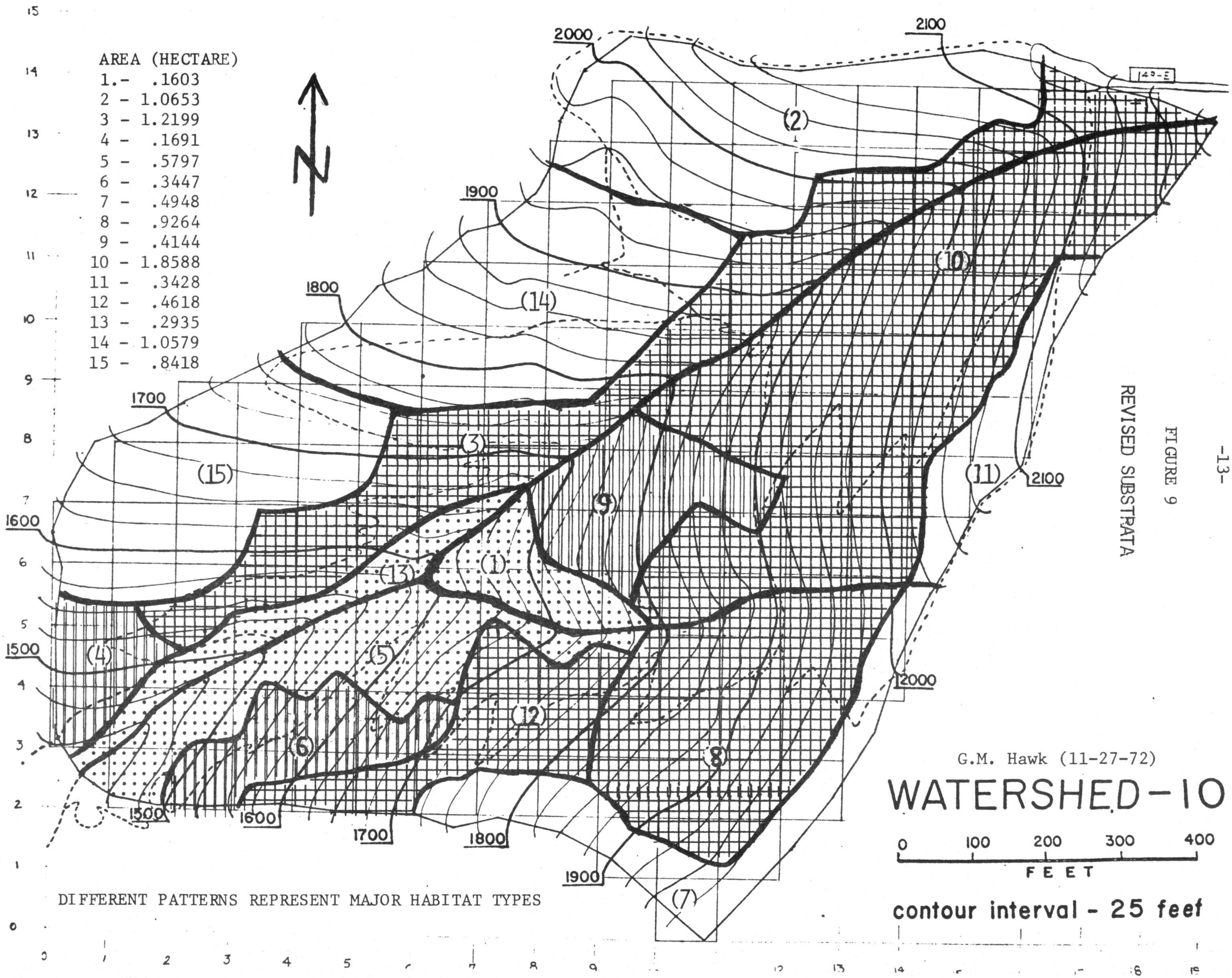


FIGURE 9
REVISED SUBSTRATA

Some of the models are briefly presented in the following section:

A. Primary Production
  - Fig. 10 - Structure of Primary Production Model for each Strata of Vegetation.
  - Fig. 11 - Net Daily Production as a Function of Light and Leaf Biomass
  - Table 2 - Biomass Organic Matter Distribution in Vegetation Mapping, Unit #4, Watershed #10

B. Food Chain Processes
  - Fig. 12 - Estimated Biomass Budget for Three Food Chains

C. Nutrient Interchange
  - Fig. 13 - Annual Biomass Budget for Watershed 10
  - Fig. 14 - The Expected seasonal pattern of Biomass Change in three components of the forest floor.
  - Fig. 15 - Litterfall Subsystem
  - Fig. 16 - Annual Nitrogen Budget for a Watershed in a 450 Year Old Stand of Douglas-fir
  - Fig. 17 - Nitrogen Capital in Forest Soils Succession Following Burning
  - Table 3

D. Hydrology
  - Fig. 18 - Hydrologic System Within a Typical Watershed Area
  - Fig. 19 - Comparison Between Computed and Observed Runnoff Rates for Watershed 2

E. Energy Budget and Evapotranspiration
  - Fig. 20 - Potential Distribution of Solar Radiation for Either 21 March or 21 September on Watershed 10

F. Transpiration and Water Uptake Model
  - Fig. 21 - General Structure of Water Uptake Model

G. Stream Model
  - Fig. 22 - Stream Subsystem

Data from these models are being gathered on Watershed 10 with the instrumentation listed in Table 4.

SECTION A

PRIMARY PRODUCTION MODEL

Sollins, Reed, Emmingham, White

In establishing the structure of a primary production model for the biome, we divided the vegetation into 4 broad categories: 1) shade-intolerant species, 2) shade tolerant species, 3) deciduous species, 4) groundcover. Within each of the first 3 groups, the fine structure includes leaf, carbohydrate (CH_2O) pool, and woody tissue compartments (Fig. 10), a total of 7 in all. In the groundcover module, woody tissues are not separated from the CH_2O pool, while for deciduous species, the old foliage compartment is omitted.

We are currently investigating the behavior of the shade-tolerant module in detail. A model has been implemented on FLEX at weekly level of resolution with storages expressed as metric tons of carbon per hectare. The following assumptions form the basis of the model:

1) Although nutrients probably play a key role in determining limits to stand growth, initially the model contains only temperature, moisture, light intensity, and daylength as input variables.

2) Photosynthesis is a nonlinear function of total leaf biomass such that photosynthesis increases with increasing leaf biomass but at a decreasing rate. Net daily production (net daytime photosynthesis less nighttime respiration) reaches a maximum value at some value of biomass and then decreases (Fig. 11).

3) Photosynthesis of new foliage finances primarily the growth of new foliage while old foliage produces the photosynthate used in stem and root growth.

4) Buds set during a growing season set an upper limit on leaf development the following growing season.

5) New foliage photosynthesis is allocated according to the following sequence of priorities: a) new leaf respiration, b) new leaf growth, c) bud growth, d) translocation to the CH_2O pool.

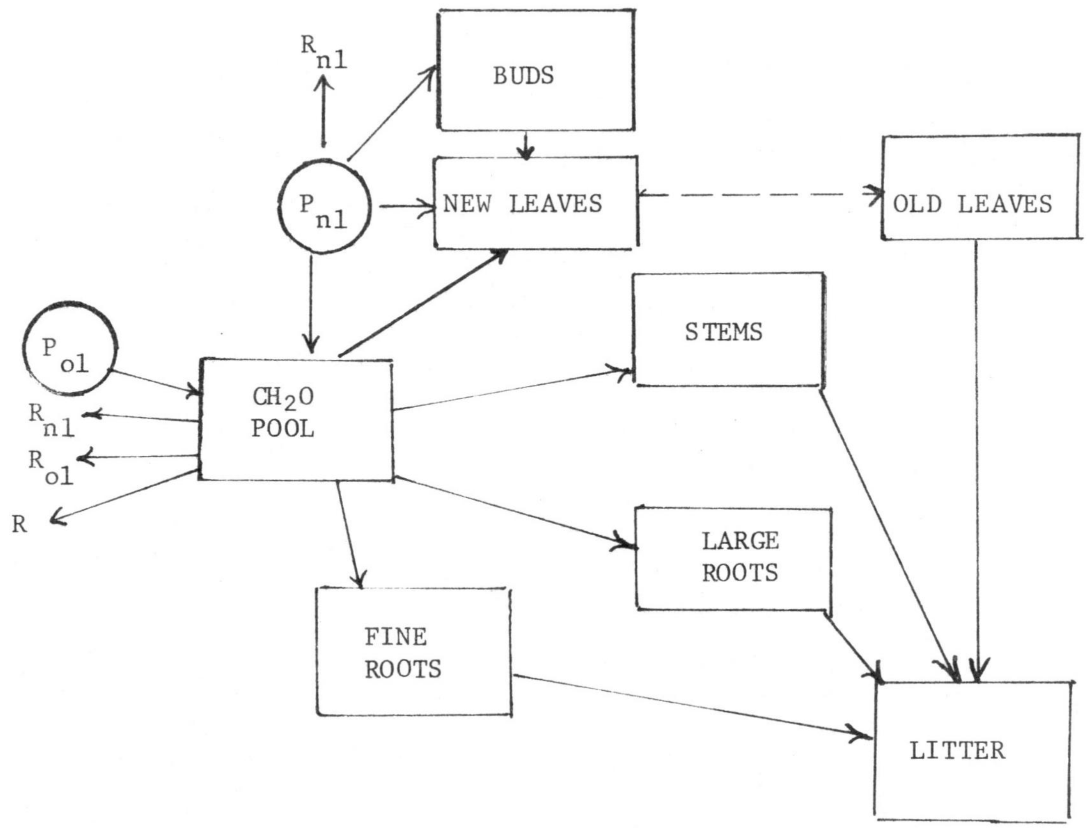
6) Fine root growth is independent of CH_2O pool size under normal conditions, while stem and large root growth are affected strongly by pool size.

7) Respiration of woody tissues is proportional to the rate of translocation of CH_2O to these tissues (either growth or to replace wood lost through mortality).

The behavior of this 7-compartment module has been investigated for two sets of initial conditions and parameter values corresponding to a 70-year stand at the Thompson Research Center and a 450-year stand on the H.J. Andrews Experimental Forest (Table 2). Much data must be obtained before output will be meaningful. This includes respiration rates of woody tissues, mortality of roots, photosynthetic parameters, light extinction coefficients, and growth rates. Data are for the several species groups at different ages and densities as well as under a variety of environmental regimes.

FIGURE 10

STRUCTURE OF PRIMARY PRODUCTION MODEL FOR EACH STRATA OF VEGETATION



P_{nl} = Photosynthesis of new leaves

P_{ol} = Photosynthesis of old leaves

R = Respiration, non-foliage

R_{nl} = Respiration of new leaves

R_{ol} = Respiration of old leaves

FIGURE 11

NET DAILY PRODUCTION AS A FUNCTION OF LIGHT AND LEAF BIOMASS

$K_I = 0.4605$
$X_3 = 0.01$

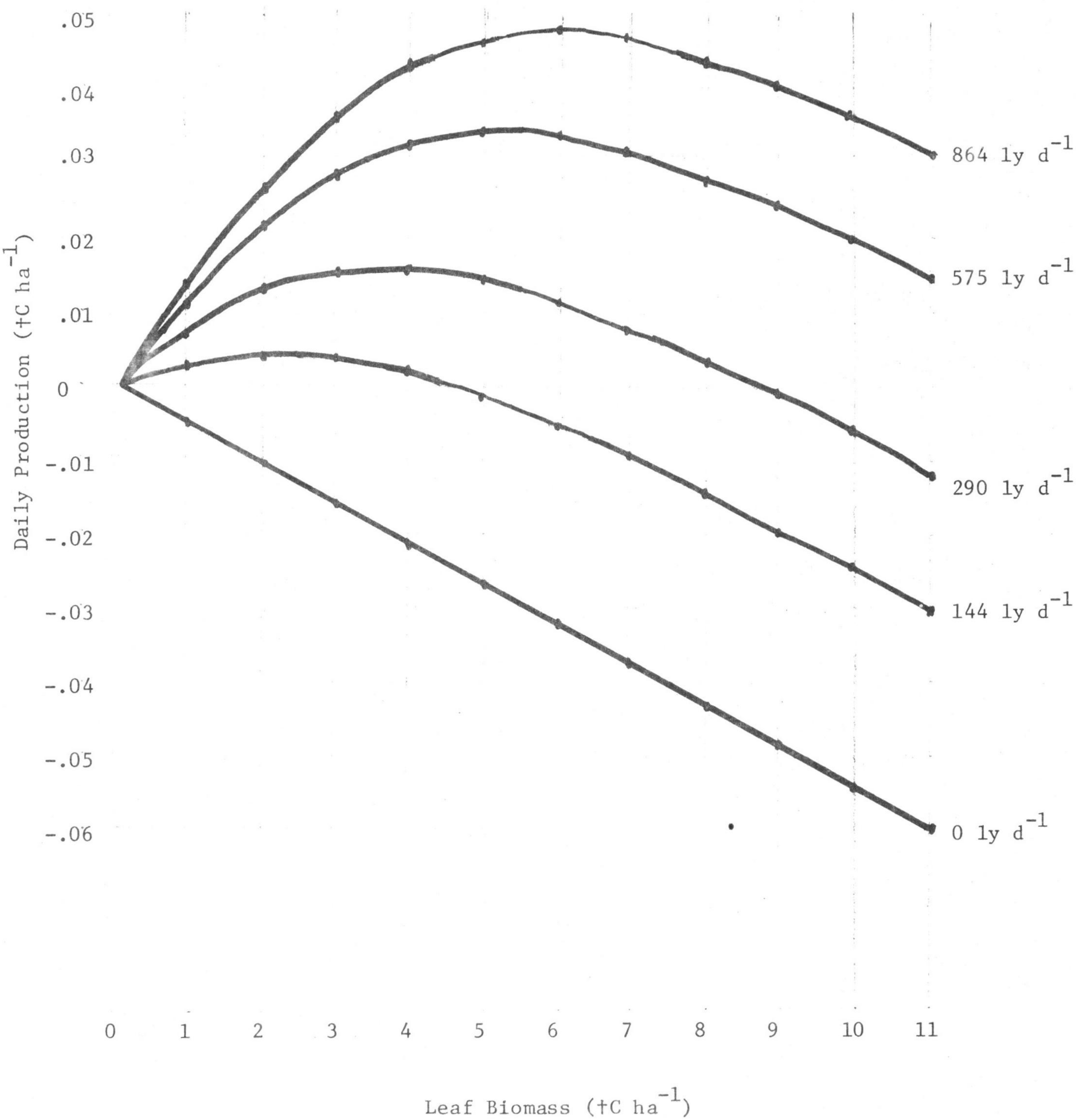


TABLE 2

BIOMASS ORGANIC MATTER DISTRIBUTION IN VEGETATION MAPPING
UNIT # 4, WATERSHED # 10 - H.J. ANDREWS EXPERIMENTAL FOREST, OREGON

TREES	Kg/ha	
FOLIAGE - Current	7,040	
Older	28,160	
BRANCHES	60,489	
Stem - Wood	368,620	
Bark	55,080	
ROOTS	72,714	
TOTAL TREES		592,103
SUBORDINATE VEGETATION		4,250
LITTER LAYER* 01		5,576
SOIL*		
02 + A1 (to 10 cm)		42,168
B2 + B3 (10 - 100 cm)		75,000
TOTAL SYSTEM		719,097

* Litter layer and soil horizons are subdivided according to compartments used in decomposition model.

SECTION B

FOOD CHAIN PROCESSES

Strand and Nussbaum

CANOPY FOOD CHAIN

Annual Behavior (with regard to biomass flux)

It is difficult to discuss the annual behavior of the canopy food chain in the old growth coniferous forest because of the widely different behavior of this food chain in different localities. Flux rates may change significantly from one year to the next when population numbers are fluctuating. The triggers of these fluctuations are incompletely known, however, local weather factors are probably critical. Currently in the Andrews forest, the populations are at endemic levels, but epidemic conditions in such forests are not unknown. At the present population levels, the annual flux of materials through the canopy food chain may be assumed to be an essentially constant proportion of annual primary production. Endemic conditions in old growth forests have not been studied, so there is no way to justify this assumption.

Seasonal Behavior (with regard to biomass flux)

The seasonal behavior of the entire food chain is inferred by examining the activities of the component populations. During the winter, the flow of materials into the canopy food chain takes place primarily as a result of seed consumption by the resident bird populations. The arthropods are in a dormant state and their respiration is minimal. A significant proportion of annual mortality probably occurs in the winter. Larval emergence and arrival of migratory birds begin in the spring. The birds switch from plant food to consumption of insects. The primary food source for the food chain is newly growing Douglas-fir needles. Peak standing crop probably occurs in the summer. Flux rates which are temperature dependent may decrease as the temperature passes their optima. Needle consumption decreases and seed consumption increases in the fall. Most insects pupate and remain in the pupae form over winter or become adults, lay eggs, and overwinter in the egg stage. Migratory birds leave the area. These occurrences give a general pattern in the total food chain standing crop of low winter densities and peak densities occurring in the summer.

SUBORDINATE VEGETATION FOOD CHAIN

Annual Behavior (with regard to biomass flux)

Wide fluctuations are probably characteristic of the annual behavior of the understory consumers. The reasons for these annual cycles are not understood, however, they may be related to local weather conditions and fluctuating cone crops. It is assumed that these fluctuations occur around some base level and that this level stablizes with stabilization of primary production.

Seasonal Behavior (with regard to biomass flux)

Although there are many arthropods in the subordinate vegetation, mammals make up a significant number of the consumers in this food chain. For this reason, a higher degree of winter activity is expected of this food chain than of the canopy food chain. Spring and fall mark periods of maximum activity. Most members of this food chain are year round residents.

DETRITUS FOOD CHAIN

Annual Behavior (with regard to biomass flux)

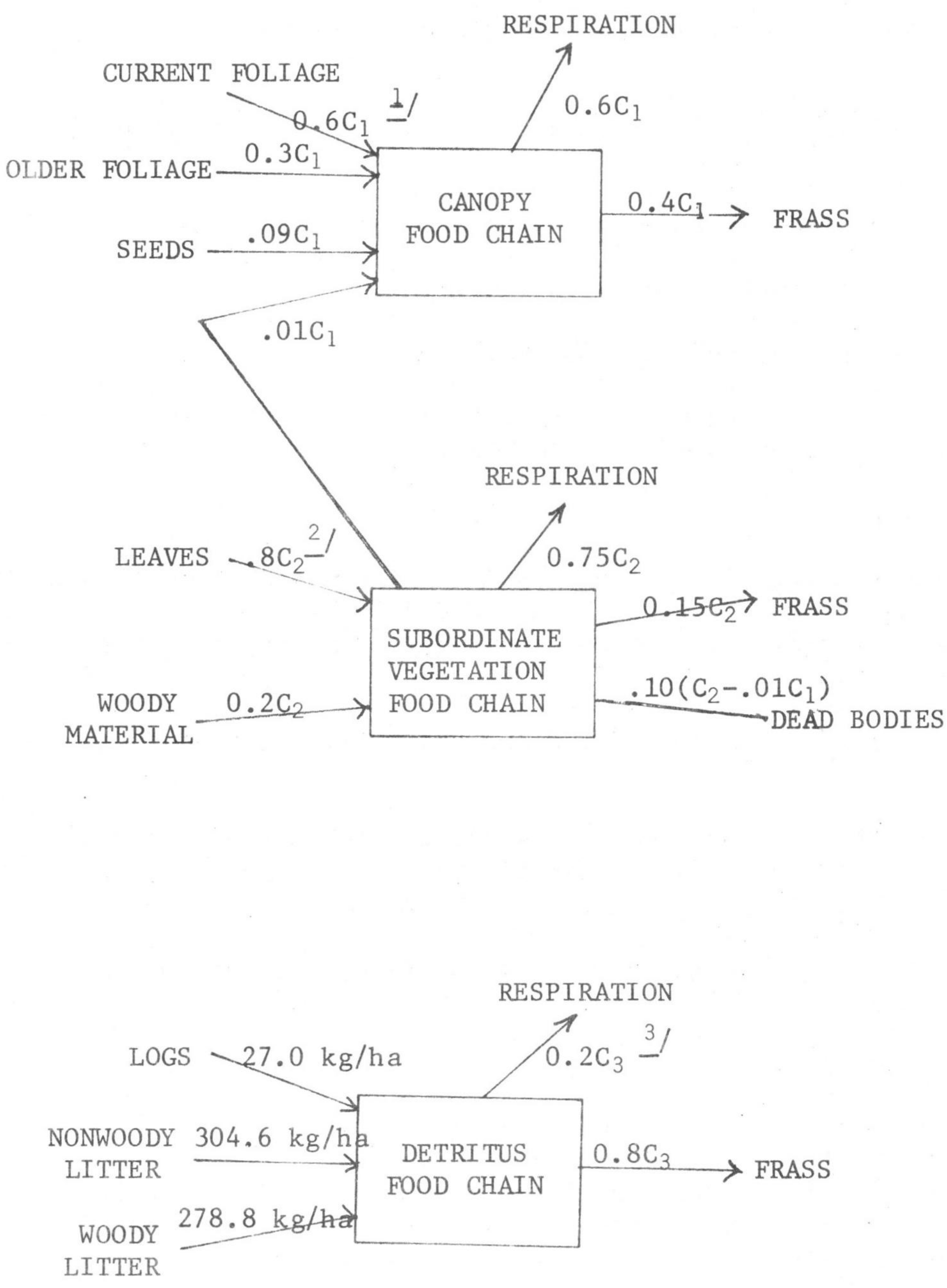
If the mass of the litter layer and organic matter in the upper soil horizons may be assumed not to be changing from one year to the next, the activities of the detritus food chain may be assumed to be annually stable. Wide fluctuations would not be expected as long as litter inputs remained the same.

Seasonal Behavior (with regard to biomass flux)

Populations of soil fauna are known to migrate vertically during periods of environmental stress. The activities of these organisms at any given level may appear strikingly seasonal; whereas, their total activity may show only moderate seasonality. They are probably more active in the upper litter layers in the spring and fall and move to lower levels in winter and summer.

FIGURE 12

ESTIMATED BIOMASS BUDGET FOR THREE FOOD CHAINS



1/ C_1 = Total annual consumption, it is assumed to be about 5% of net canopy foliage production

2/ C_2 = Total annual consumption, it is assumed to be about 10% of net subordinate vegetation foliage production

3/ C_3 = Total annual consumption, it is assumed to be about 10% of litter input, 610.4 kg/ha

SECTION C

NUTRIENT INTERCHANGE

Strand, Cromack, Grier, Fogel, and Biome Committee

DOCUMENTATION OF VALUES IN THE ANDREW'S ANNUAL BIOMASS BUDGET

1/ Nonwoody litter input: needles, hardwoods, lichens, and mosses (p. 37, Abee 1972)

2/ Woody litter input: cones, twigs, branches, and bark (p.37, Abee, 1972)

3/ Throughfall input: estimated by Carroll.

4/ Log standing crop: estimated by Fogel.

5/ Log input: Fogel estimates a 200 year turnover time for logs, so assume 1/200 of standing crop comes in each year.

6/ Fine litter input: estimated by Carroll.

7/ Mineral soil standing crop: includes A 1 horizon and below to a depth of 1 meter. R. Brown and Fredriksen ound 3928 kg/ha of nitrogen and Grier and Cole (1972) data indicate that nitrogen is 2.5% of the biomass of the mineral soil.

8/ Organic soil standing crop: includes F and H layers; Youngberg made the estimate.

9/ Root death input to organic soil: assuming a 10% annual turnover in roots, 3146 kg/ha of dead roots were estimated by Grier to be in the two horizons. Assume 10% of this root death occurs in organic soil horizon.

10/ Root death input to mineral soil horizon: assume 90% of root death occurs in mineral soil horizon.

11/ Outflow to stream: no information

12/ Arthropod standing crop: mean value found by Wernz

13/ Woody litter standing crop: the total biomass of the litter layer was estimated by Youngberg to be 5987 kg/ha. Grier and Cole (1972) found litter layer at Cedar River to be 72% woody litter.

14/ Nonwoody litter standing crop: Grier and Cole (1972) found litter layer at Cedar River to be 28% nonwoody litter.

15/ Fine litter standing crop: assumed to be 25% of annual input.

16/ Woody litter respiration: assume 40% of input is respired.

17/ Nonwoody litter respiration: assume 60% of input is respired.

18/ Log respiration: assume 20% of input is respired.

19/ Transfer to arthropods: assume 10% of litter input is consumed.

20/ Arthropod respiration: assume 20% of input is respired.

21/ Fine litter respiration: assumed by Carroll to be 75% of input.

22/ Other transfers: calculated to fulfill assumption of annual stability of standing crop.

23/ Organic soil respiration: assumed to be 75% of input.

LITERATURE CITED

Abee, Albert. 1972. Nutrient cycling under 450-year-old Douglas-fir stands. MS Thesis. on file Oregon State University, Corvallis, Oregon. 64p.

Grier, C.C. and D.W. Cole. 1972. Elemental transport changes occurring during development of a second-growth Douglas-fir ecosystem. (In) J.F. Franklin, L.J. Dempster, and R.H. Waring (eds.) Proceedings- research on coniferous forest ecosystems - A symposium. p. 103-113. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

FIGURE 13

ANNUAL BIOMASS BUDGET FOR WATERSHED 10 (KG/HA)

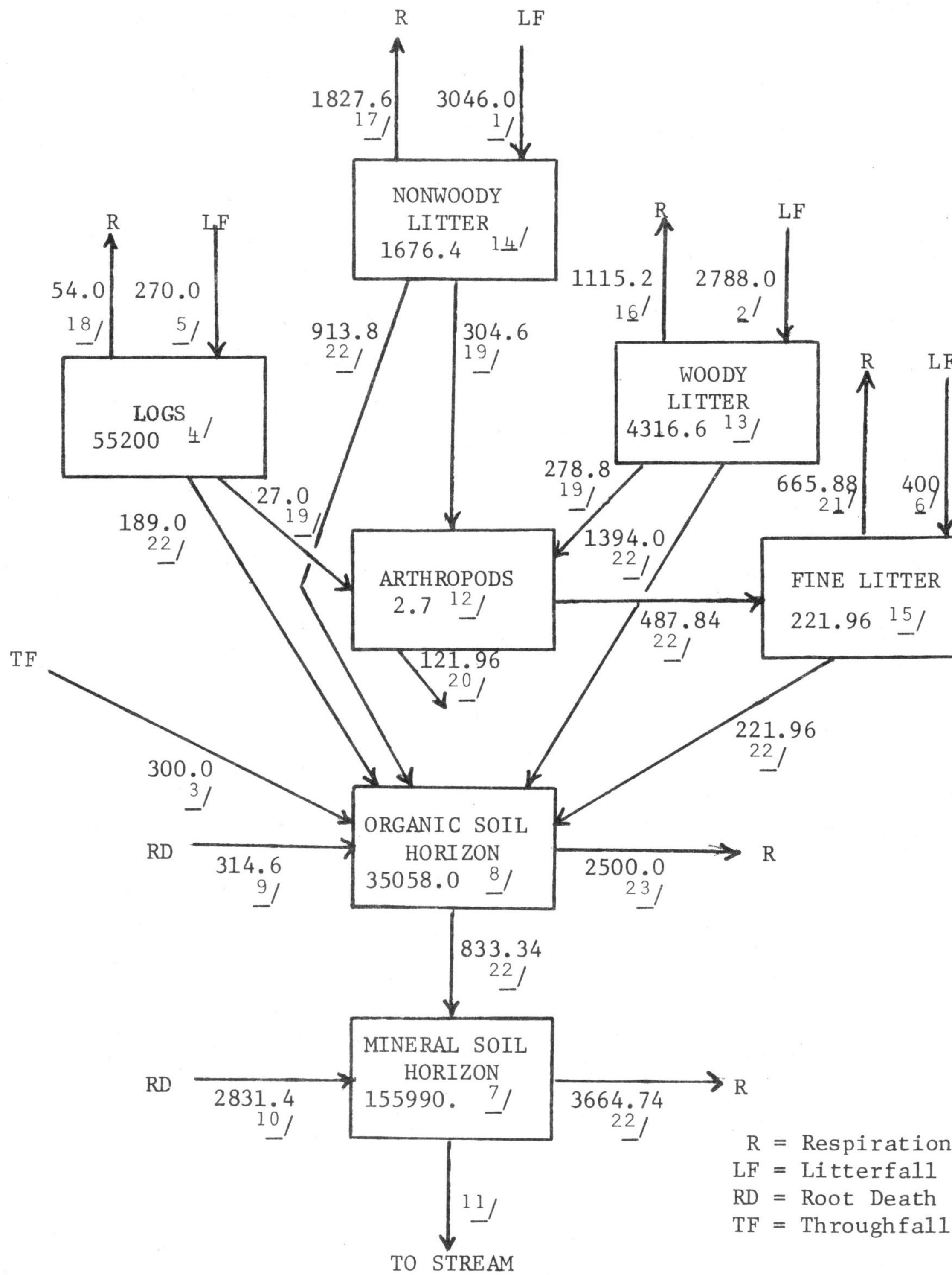


FIGURE 14

EXPECTED SEASONAL PATTERN OF BIOMASS CHANGE IN THREE COMPONENTS OF THE FOREST FLOOR

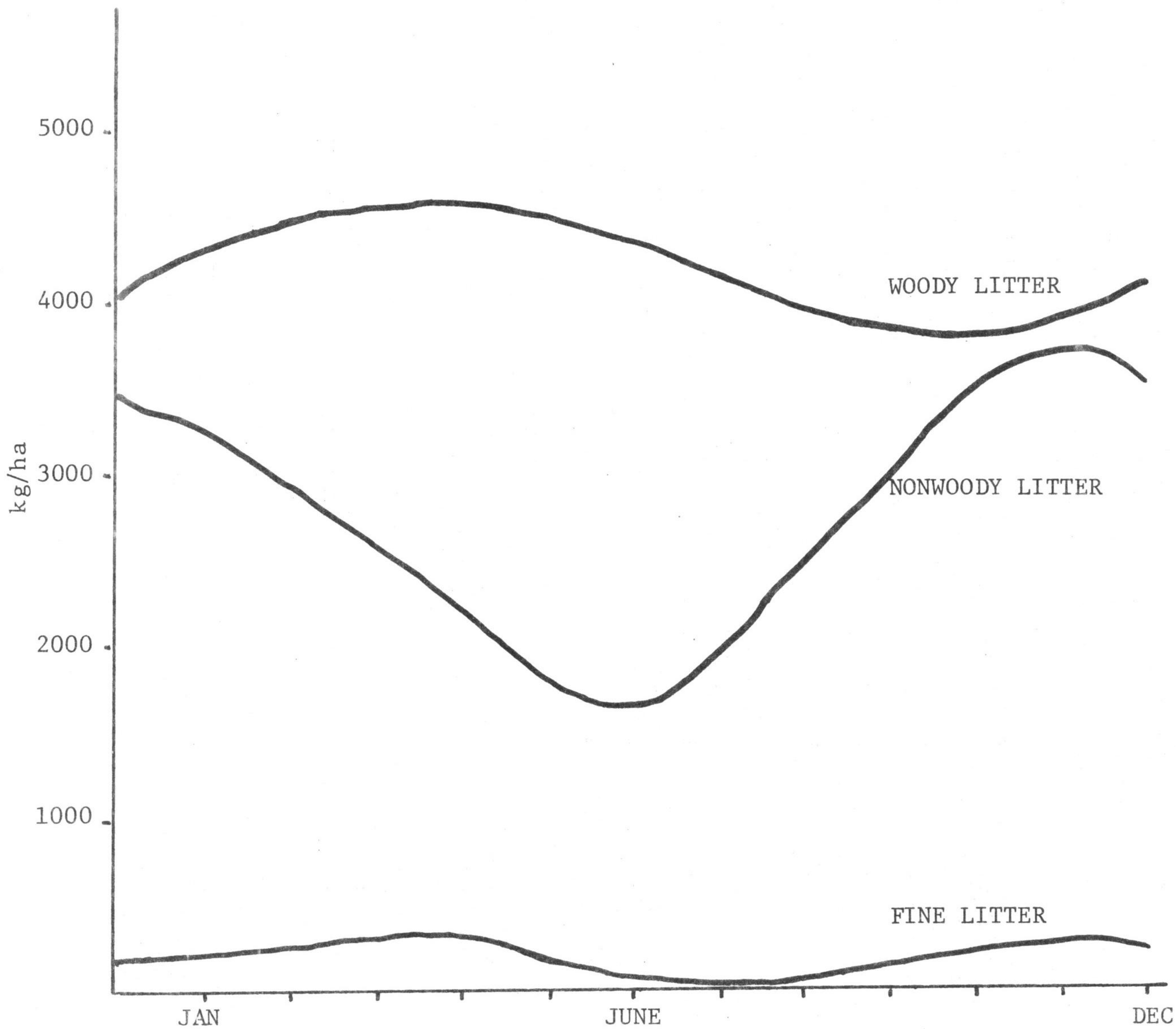
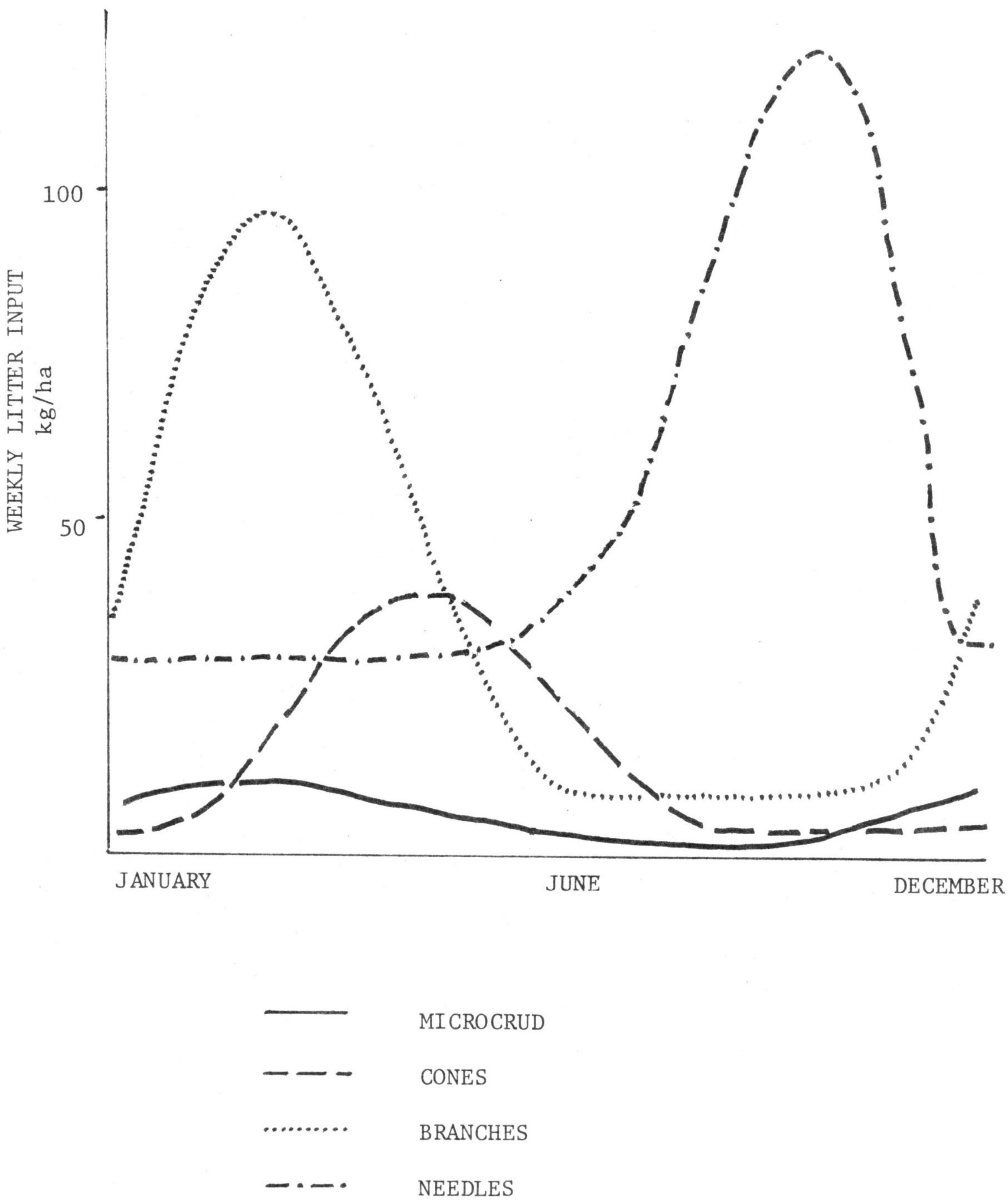


FIGURE 15

LITTERFALL SUBSYSTEM



DOCUMENTATION OF VALUES IN THE ANDREW'S ANNUAL NITROGEN BUDGET (Fig. 16)

1/ Nonwoody litter input: needles, hardwoods, lichens, and mosses (p. 43, Abee 1972)

2/ Woody litter input: cones, twigs, branches, and bark (p. 43, Abee 1972).

3/ Throughfall input: total dissolved N estimated as 7.5 kg/ha by Carroll, but Fredriksen (1972) found .99 kg/ha coming in precipitation, so 6.51 must be entering as throughfall.

4/ Log standing crop: the biomass of decaying logs was estimated by Fogel to be 55.2×10^3 kg/ha for Watershed 2. The nitrogen content of logs is about .1% (Bollen 1969). Assuming the same standing crop on Watershed 10, the nitrogen mass must be 55.2 kg/ha.

5/ Log input: Fogel estimates a 200 year turnover time for logs, so assume 1/200 of standing crop comes in each year.

6/ Fine litter input: estimate from Carroll.

7/ Mineral soil standing crop: includes A 1 horizon and below to a depth of 1 meter. Value is grand mean of R. Brown and R. Fredriksen's 10 plots.

8/ Organic soil horizon standing crop: includes F and H layers. Youngberg estimates mean organic mass of 35058 kg/ha. 1.2% N is reported for these layers in coastal Douglas-fir communities (Youngberg 1966).

9/ Root death input to organic soil horizon: assuming a 10% annual turnover of roots, 3146 kg/ha of dead roots biomass are estimated by Grier to be in the two soil horizons. The nitrogen content of roots is estimated to be .097% (Grier and Cole 1972). This gives 3.05 kg/ha of nitrogen total. Assume 10% of this root death occurs in organic soil horizon.

10/ Root death input to mineral soil horizon: assume 90% of root death occurs in mineral soil horizon.

11/ Outflow to stream: mean for 1969 and 1970 (Fredriksen 1972). Includes recent data for organic particulate N (Fredriksen, unpublished).

12/ Arthropod standing crop: 2.7 kg/ha of biomass is the mean found by Wernz. The nitrogen content of soil arthropods is estimated to be 10%

13/ Woody litter standing crop: the total biomass of the litter layer was estimated by Youngberg to be 5987 kg/ha. Grier and Cole (1972) found the litter layer at Cedar River to 72% woody litter and this litter to be .24% nitrogen. The standing crop is calculated assuming that these percentages are true for the Andrews.

14/ Nonwoody litter standing crop: estimated to be 28% of litter layer and to be 1.15% nitrogen by Grier and Cole (1972).

15/ Fine litter standing crop: assumed 25% of total input remains as standing crop.

16/ Transfer to arthropods: assumed to be 10% of litter input.

17/ Other transfers: caluclated to fulfill assumption of annual stability of standing crop.

18/ Plant uptake: assume all available nitrogen is taken up by plant and 90% of uptake occurs in mineral soil horizon and rest in organic soil horizon

DISCUSSION

There are several areas of very interesting "unknowns" in the annual nitrogen cycling budget as given here. The different possible strategies of nitrogen in the canopy and in the forest floor and soil remain to be clarified by further research. In special cases such as large logs, N-fixation may be important in the long term decomposition of such residues (Paul Aho, unpublished). The portion of nitrogen uptake allocated to stem growth will await stem increment data to be obtained in summer, 1973, by Chuck Grier and assistants. Duane Moore and Fred Glenn have just begun soil studies concerned with available nitrogen. Cromack, Fogel, and Todd plan a preliminary N-fixation study this summer in logs, litter and soil.

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Abee, Albert. 1972. Nutrient cycling under 450-year-old Douglas-fir stands. M.S. thesis on file Oregon State University, Corvallis. 64p.

Bollen, W.B. 1969. Properties of tree barks in relation to their agricultural utilization. USDA Forest Service Research Paper PNW-77, 36p.

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Grier, C.C. and D.W. Cole. 1972. Elemental transport changes occurring during development of a second-growth Douglas-fir ecosystem. (In) J.F. Franklin, L.J. Dempster, and R.H. Waring (eds.), Proceedings - research on coniferous forest ecosystems - a symposium, p. 103-113, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Youngberg, C.T. 1966. Forest floors in Douglas-fir forests: 1. Dry weight and chemical properties. Soil Science Society Amer. Proc. 30:406-409.

Zavitkovski, J, and M. Newton. 1968. Ecological importance of snowbrush *Ceanothus velutinus* in the Oregon Cascades. Ecol. 49:1134-1145.

FIGURE 16

ANNUAL NITROGEN BUDGET
FOR A WATERSHED IN A 450-YEAR-OLD STAND OF DOUGLAS-FIR (KG/HA)

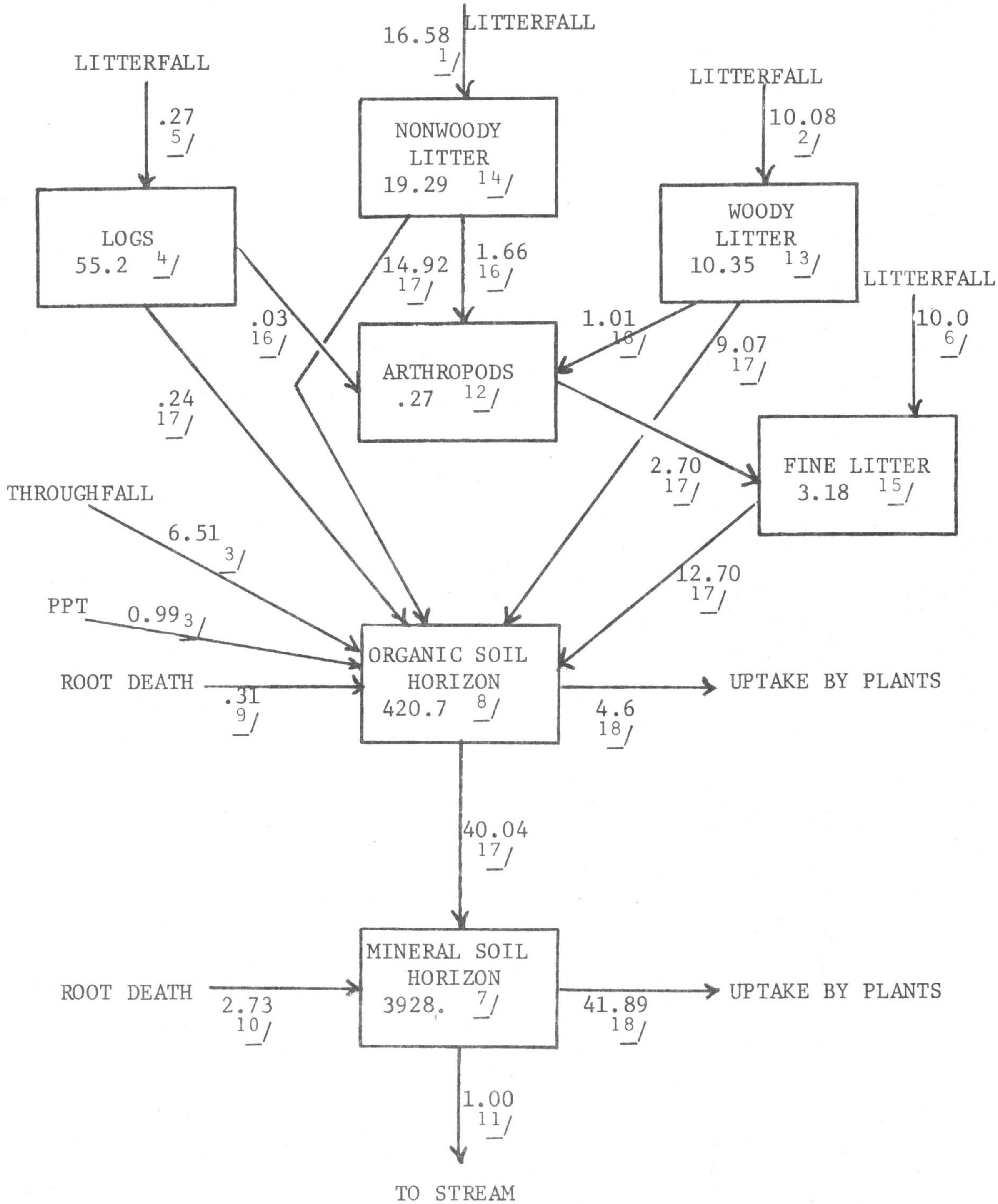
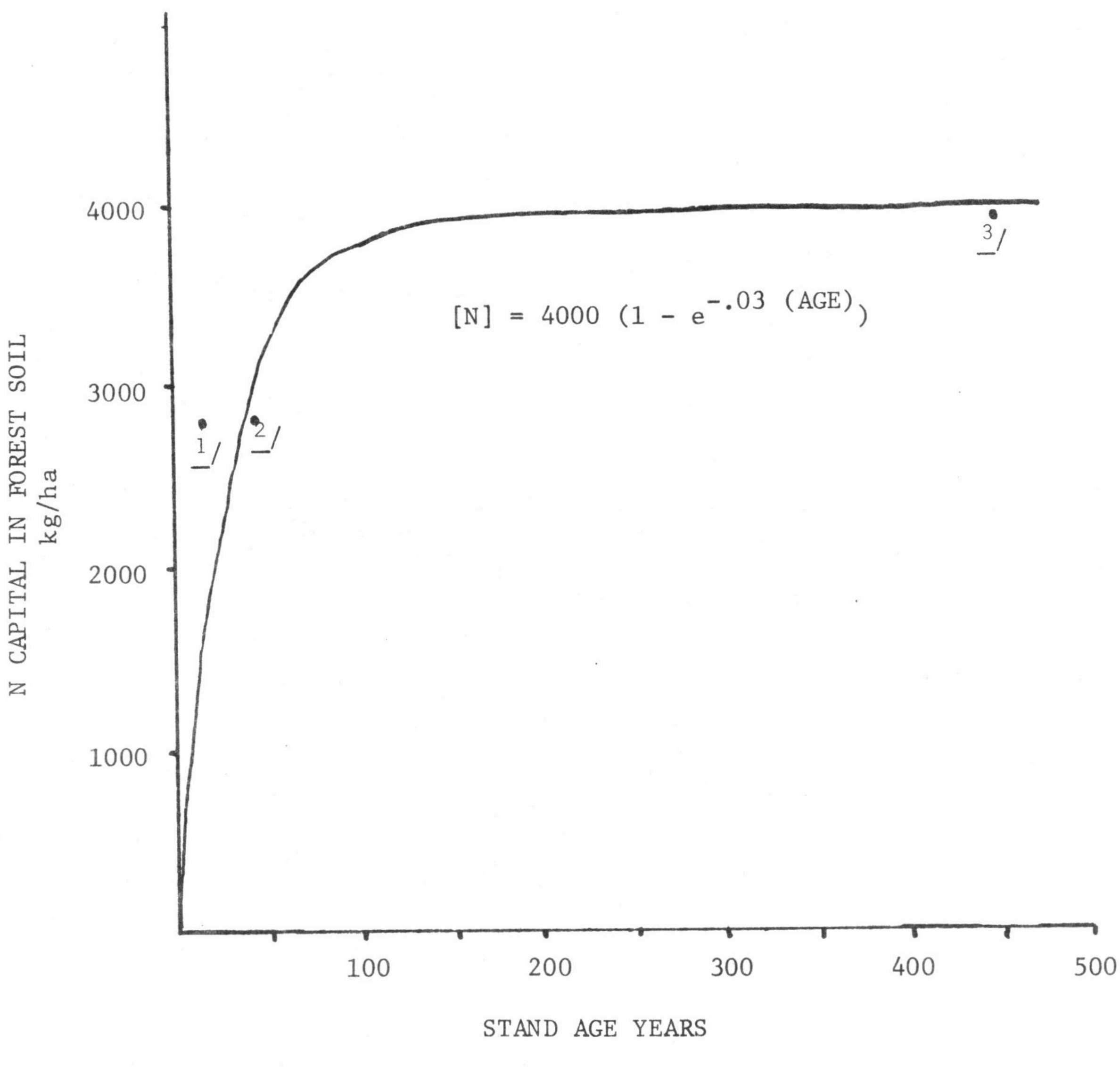


FIGURE 17

NITROGEN CAPITAL IN FOREST SOILS
SUCCESSION FOLLOWING BURNING



1/ Zavitkovski and Newton, 1968

2/ Grier and Cole, 1972

3/ Fredriksen and R. Brown (unpublished data)

TABLE 3

ANNUAL NITROGEN FIXATION RATES FOR A RANGE OF PERCENTAGES OF NITROGEN UPTAKE RETURNED IN LITTER

PERCENTAGE UPTAKE RETURNED IN LITTER	CANOPY FIXATION	SOIL FIXATION	TOTAL FIXED
	kg/ha		
78.1	10.74 [1]	0 [2]	10.74
55.0	10.74 [1]	19.77 [2]	30.51
40.0	10.74 [1]	44.81 [2]	55.55

[1] Calculated assuming 50% of nitrogen in fine litter, 50% of nitrogen in throughfall, and 1.50 kg/ha of nonwoody litter (constituting nitrogen in mosses and lichens, Abee 1972) result from fixation in the canopy.

[2] Calculated assuming that the system is annually balanced with respect to nitrogen inputs and outputs.

SECTION D

HYDROLOGY

COMPUTER SIMULATION OF FOREST WATERSHEDS

Riley and Shih

A primary objective of effective watershed management is to maintain normal operation of the hydrologic system on a drainage area under various kinds of continuous resource use. The specific objectives of this study are: (1) to develop and test a generally applicable simulation model of the hydrologic system of a forest watershed, and (2) to estimate through model sensitivity studies the relative importance of various processes within the hydrologic system of each study area.

The model is capable of employing various resolutions in the space and time dimensions, but in the current studies a daily time increment is most commonly adopted. The time and space increments adopted are dependent upon data availability and problem requirements. Inputs to the model are precipitation, temperature, potential evaporation indices, and watershed characteristics, such as area, slope and aspect, vegetation and soil properties. Streamflow records are used to check the goodness of fit of the model. The model components include snow-rain differentiation, interception, snow accumulation and melt, infiltration, soil moisture storage, evapotranspiration, surface flow, interflow, channel flow, and groundwater flow (Fig. 18).

The model parameters which cannot be estimated from available data are calibrated through a pattern search program to minimize the difference between recorded and computed results. The model is being calibrated and tested on selected forest watersheds, including watersheds No. 10 and No. 2 in the H.J. Andrews Experimental Forest, Oregon. To date good agreement has been achieved between predicted and observed outflow rates from the watershed areas to which the model has been applied (Fig. 19). The model is being used to provide insight into data sensitivities and as a framework through which to integrate efforts in other aspects of the overall program of the Biome.

FIGURE 18

HYDROLOGIC SYSTEM WITHIN A TYPICAL WATERSHED AREA

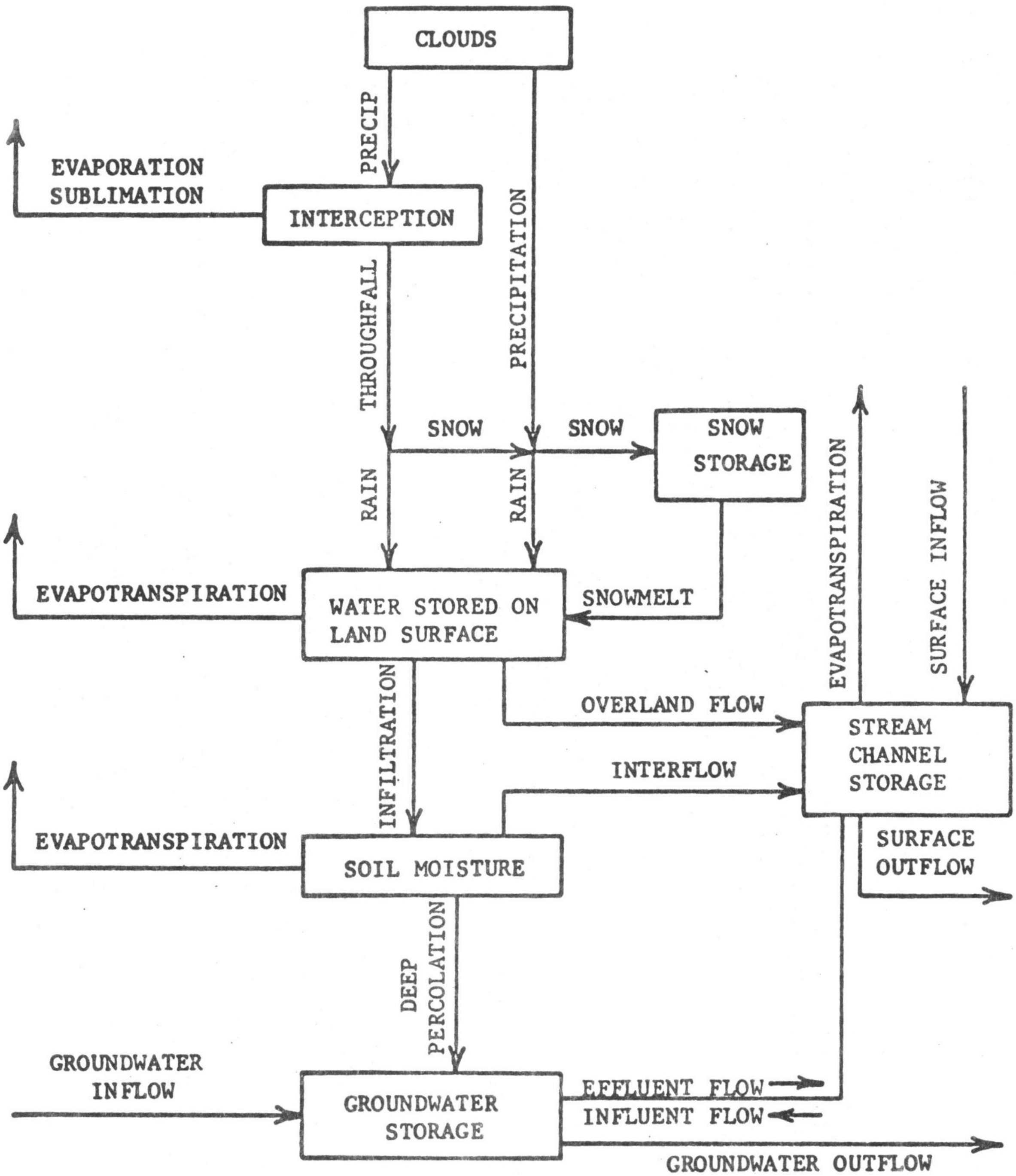
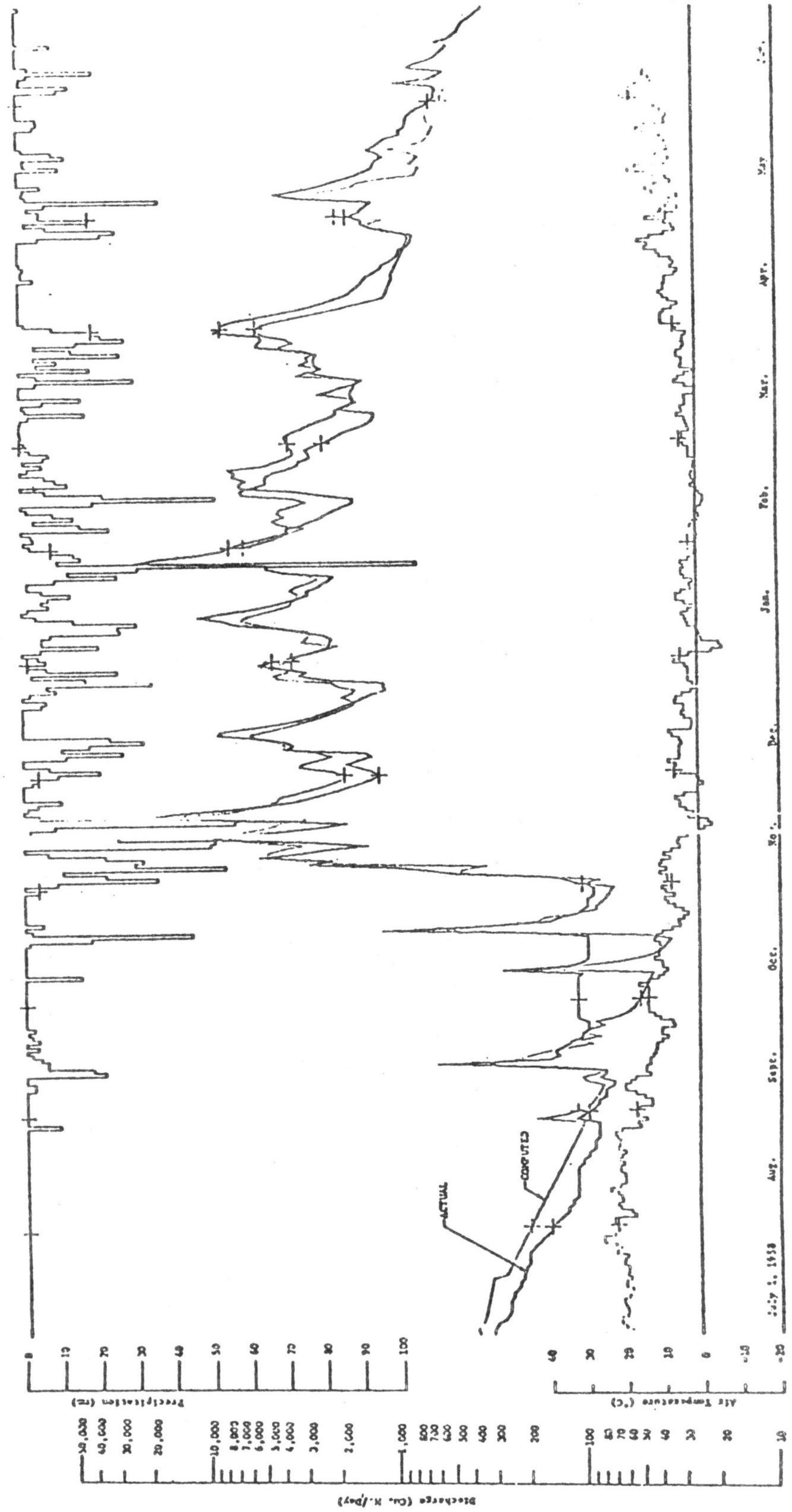


FIGURE 19

COMPARISON BETWEEN COMPUTED AND OBSERVED RUNOFF RATES
WATERSHED NO. 2, H.J. ANDREWS EXPERIMENTAL FOREST, OREGON



MOVEMENT OF SUBSURFACE WATER IN STEEP TOPOGRAPHY

Harr

Field data collection during the 1972-73 rainy season was limited by the lack of storm events. Only one large storm (a total of 18 cm of water including snowmelt) occurred. However, some information on soil moisture content and extent of saturated flow was obtained. No saturated flow was detected except near the toe of the study slope. Three mercury manometer tensiometers were installed in late February at several locations on the study slope. Hydraulic gradients parallel to the slope were 3 to 5 times as large as the vertical gradients during small storms. Generally, the mercury manometer tensiometers were too insensitive to changes in matric potential because of the low matric potentials encountered.

Construction of water level recorders for selected piezometers is nearing completion. Manometer tensiometers using di-bromo methane (density 2.5 gm cm^{-3}) instead of mercury are being constructed and will provide adequate sensitivity during winter storm events. Analyses of hydrologic properties of soils is continuing. Unsaturated conductivity has been estimated from moisture characteristics and hydraulic conductivity data of several hundred soil samples. Such unsaturated conductivity values will be used in conjunction with hydraulic gradient data obtained from tensiometry to evaluate velocity of water flow at various soil depths during winter storms.

In preparation for the coming winter field season this project's study plan is being altered somewhat to tie in more closely with Fredriksen, Moore, and Swanston's nutrient cycling study. During this summer, a protable rock core drill will be used to obtain samples of the saprolite and bedrock underlying Watershed 10. Additional piezometers will be installed to augment the present grid. Present and future installations will be mapped and leveled.

SECTION E

ENERGY BUDGET AND EVAPOTRANSPIRATION

Holbo and Fritschen

A. Energy Budget Framework

$$Q^* + G + H + \lambda ET = 0$$

B. Functional Approximations

Component	Available Measurements
1. $Q^* = f$ (K↓, albedo, latitude, time of day and year, slope)	K↓, T_f, T_{dew}
2. $G = f$ (C_f, ΔT over Δt, ΔZ)	T_a, T_f, T_{soil}, h
3. $H = f$ (ΔT, Δu, stand structure, e.g. roughness)	T_f, T_a, u_i, h
4. $ET = f$ (Δe, Δu, stand structure, e.g. roughness)	T_{dew}, u_i, h

C. Simplifying Assumptions

1. Unit (subdividion of watershed) values of Q* can be readily estimated from measured K↓ , estimated albedo, and adjusted for slope of the unit surface.

2. G can be estimated from measurements of soil and forest temperatures (Zobel, 19 sites).

3. Units on the watershed can be assumed to exchange energy normal to their surfaces only, with negligible amounts being transferred across slope.

4. Slope of unit surfaces has negligible effect on the profiles of wind and temperature.

5. The roughness, z_o, of the canopy, and other characteristics of stand structure, are independent of wind speed, direction, or atmospheric stability, and further that these characteristics are estimable from available stand measurements, e.g. h (Hawks).

6. Above canopy windspeed, u(z), is expressable as a function of instrument shelter windspeed, u(i), and also, that $u(z_o) = 0$.

7. λET can be more accurately obtained as the residual in the energy budget equation, rather than independently estimated. However, there will also be measurements available to do this for comparitive purposes.

D. Solution for Evapotranspiration

$$ET = -(Q^* + G + H)/\lambda$$

E. Closer Approximations

1. $Q^* = f\ (K_{slope}\{1 - \text{albedo}\} + L^*$

   $K_{slope} = f$ (slope angle, time, latitude and $K\downarrow$)

   $L^* = f\ (T_f,\ T_{dew},$ assumptions about atmosphere)

2. $G = \Sigma C_f\ (\Delta T/2)_f\ \Delta z_f/\Delta t$

   Δt = time increment between measurements

   C_f is the volumetric heat capacity of the canopy and soil layer

   Δz is the thickness of this layer

   $\Delta T = (T_{f(t-1)} - T_{f(t)}) + (T_{soil\ (t-1)} - T_{soil(t)})$
   changes in T over the time increment

3. $H = \rho \underbrace{Cp}_{\text{constants}} k^2 \Delta T \Delta u\ /\ (\Delta \ln z)^2$

   $\Delta T = (T_a - T_f)$ } mean values over the time period

   $\Delta u = u(z),\ z \simeq 3h$

   $\Delta \ln z = \ln(z-d) - \ln z_o \simeq \ln 11\ h$

   $d \simeq 0.7\ h \qquad z_o \simeq 0.2\ h$

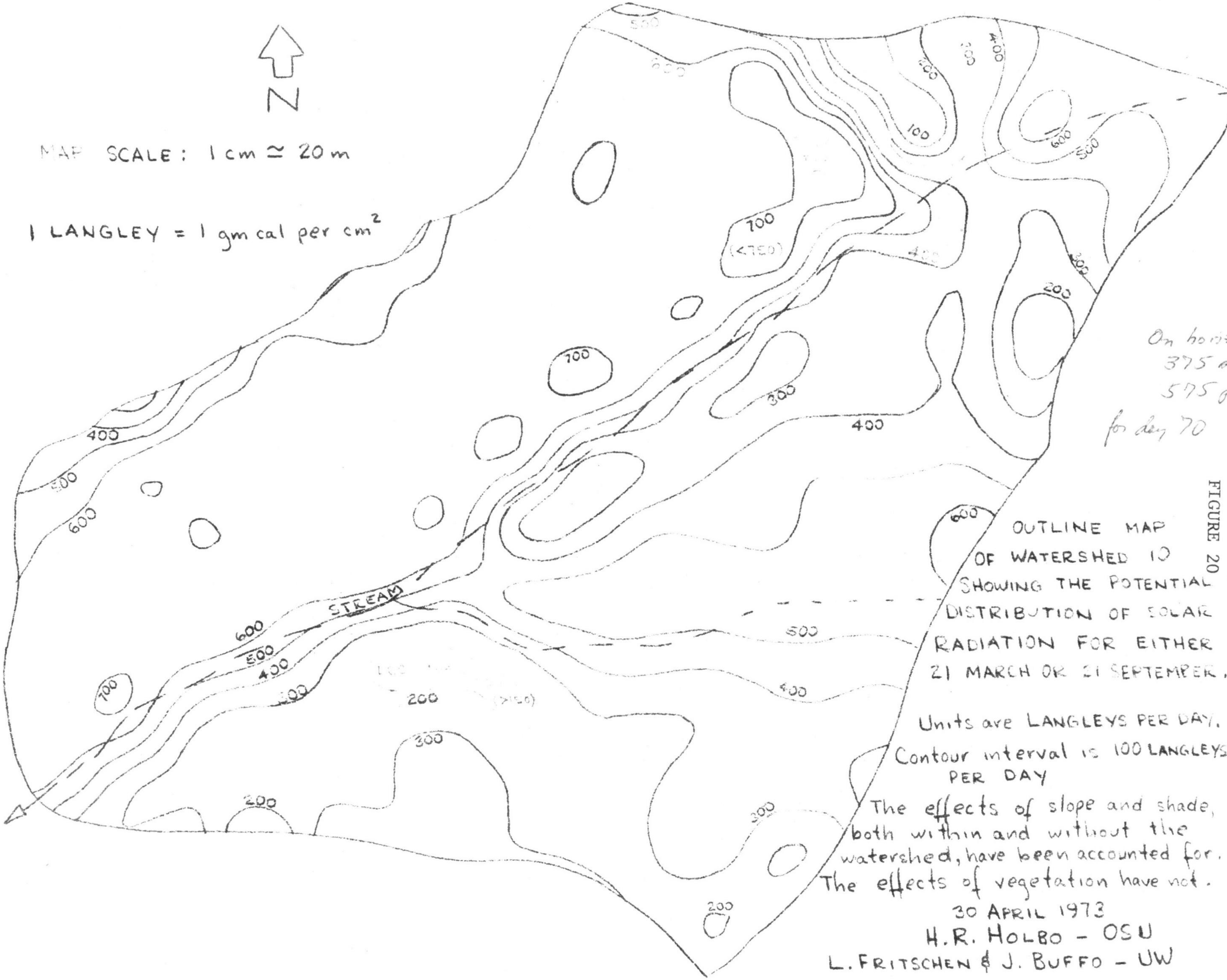
   $u(z) = f(u(i))$

4. Relationships similar to 3 for ΔET

5. Use results of 1, 2, and 3 to independently get R, the canopy resistance (see Waring).

MAP SCALE: 1 cm ≃ 20 m

1 LANGLEY = 1 gm cal per cm^2



On horiz about 375 actual 575 potential for day 70

FIGURE 20 – above atmos.

OUTLINE MAP OF WATERSHED 10 SHOWING THE POTENTIAL DISTRIBUTION OF SOLAR RADIATION FOR EITHER 21 MARCH OR 21 SEPTEMBER.

Units are LANGLEYS PER DAY.

Contour interval is 100 LANGLEYS PER DAY

The effects of slope and shade, both within and without the watershed, have been accounted for. The effects of vegetation have not.

30 APRIL 1973

H.R. HOLBO – OSU

L. FRITSCHEN & J. BUFFO – UW

SECTION F

TRANSPIRATION-WATER UPTAKE MODEL

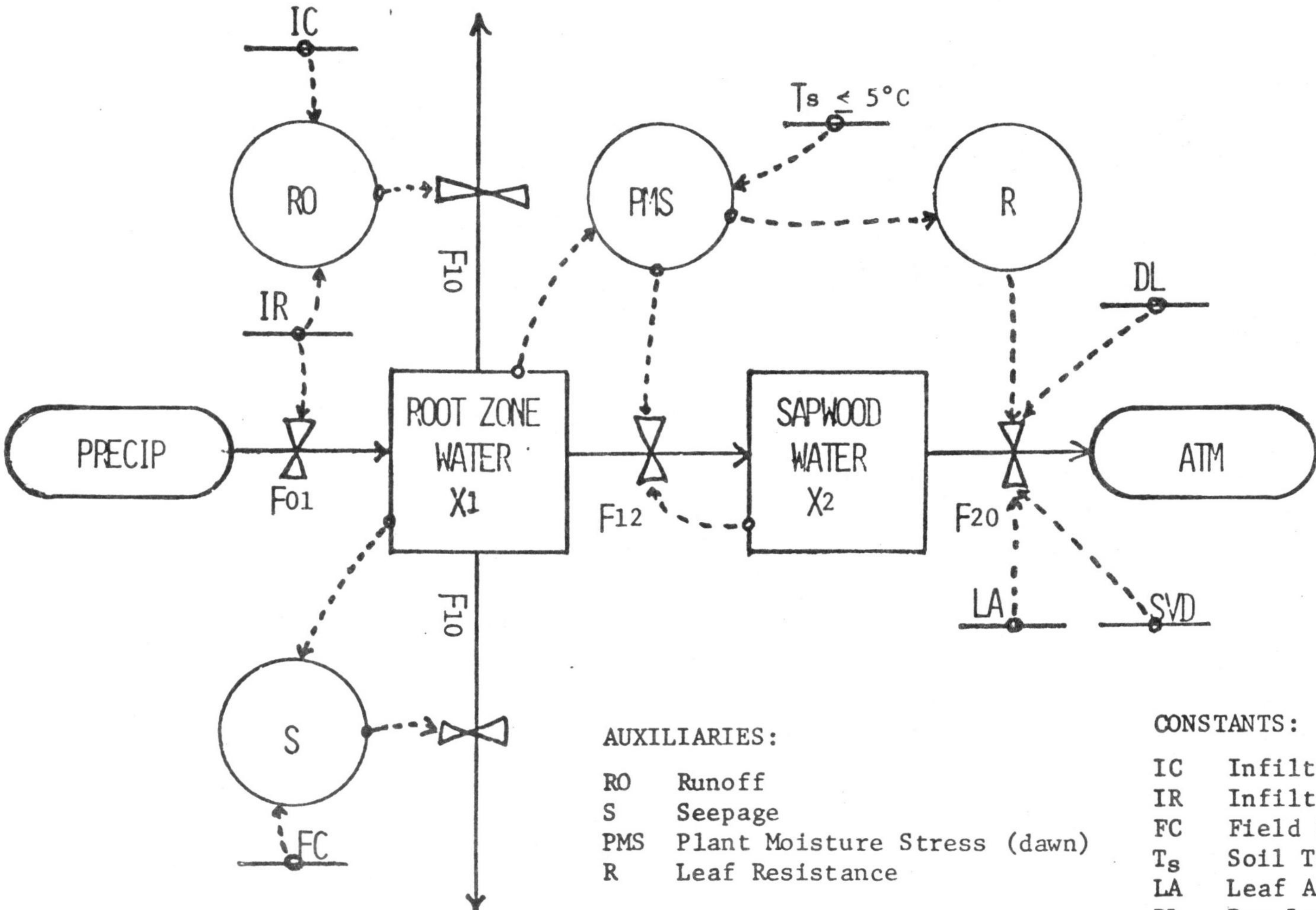
Waring, Running, Kline, and Rydell

The transpiration-water uptake model (Fig. 21) serves as a subroutine of the hydrologic model (Fig. 18). It is driven by the vapor concentration gradient between the atmosphere and the leaf during the day. Control by the plant is exerted through increased stomatal resistance brought about by cold soil temperatures or limiting soil water. Soil water is modelled as being depleted by horizons from the surface downward. When 80 percent of the available water in the root zone is depleted, stomatal control begins through increased moisture stress. Leaf resistances vary from 5 sec cm^{-1} to 300 sec cm^{-1} in seedlings of Douglas-fir. Older foliage and larger trees are assumed to have higher initial resistances averaging 30-40 sec cm^{-1}. Leaf area must be known to calculate transpiration. It is estimated for Doulgas-fir at about 150 sq. cm/g of foliage. The dry weight of foliage is estimated by linear relationship with cross-sectional area of sapwood at DBH (R^2 = .93).

The changes in soil water status are inputs to decomposition and root growth models. Leaf resistance values estimated daily are input to the photosynthesis subroutine in the primary production model (Fig. 10). A fuller discussion of the model is presented in Internal Report No. 79.

FIGURE 21

GENERAL STRUCTURE OF WATER UPTAKE MODEL



AUXILIARIES:

RO	Runoff
S	Seepage
PMS	Plant Moisture Stress (dawn)
R	Leaf Resistance

CONSTANTS:

IC	Infiltration Capacity
IR	Infiltration Rate
FC	Field Capacity
T_s	Soil Temperature
LA	Leaf Area
DL	Day Length
SVD	Saturated Vapor Deficit

SECTION G

STREAM SUBSYSTEM

McIntire, Hall, Sedell, and Biome Subcommittee

The basic nature of small streams in coniferous forest systems is to act as processors and exporters of organic matter. The main features of the aquatic subsystem include a periphyton (algae and associated microflora) component, an input of organic matter from litterfall with associated decomposer organisms, and a consumer subsystem. The microorganisms are tightly coupled in both periphyton and litter.

Another major feature of the system is to convert inputs of energy into consumer biomass. The conversion of solar energy into periphyton, plus the seasonal input of leaf litter provides the energy that drives the consumer biomass. Although the streams on the average are heterotrophic (terrestrial litter is the primary energy source), photosynthesis can be important during the part of the year when light is most available. In most systems this period of peak periphyton production occurs in the spring and fall.

Evidence from experimental data and from the model suggests that such systems are strongly light-limited in a heavily-shaded stream such as Watershed 10; the majority of the energy input comes from leaf input. However, when light is at high levels, such as would occur following clearcutting, the periphyton can assimilate large amounts of energy, even though present at low biomass. Model behavior thus far has demonstrated the possible existence of an inverted biomass pyramid often hypothesized for aquatic systems, where comparatively little of the energy is stored in biomass of primary producers. For example, turnover ratios of periphyton (annual production/mean biomass) may range from 10 to 70.

A pervasive feature of these stream systems is export of organic matter, most of it originating from the terrestrial vegetation. Some has been processed by the stream biota, and some is exported in nearly the same state in which it reached the stream. The export is seasonal, related to both the major input of organic matter in the fall and the winter freshets. It is estimated that as much as 90% of the export occurs during the two or three largest storms of the year.

The consumer biota of the stream system processes the inputs of organic matter in several states of breakdown. Shredding insect larvae process the intact leaf material, making it available to collector type insects. The bulk of the energy transfers occur at the fine particulate organic material (FPOM) level. A third group of aquatic invertebrates scrape the periphyton and its associated fine particulate organic matter from rocks. The quality and quantity of various particle sizes of organic material is extremely important in determining the productive capacity of a stream.

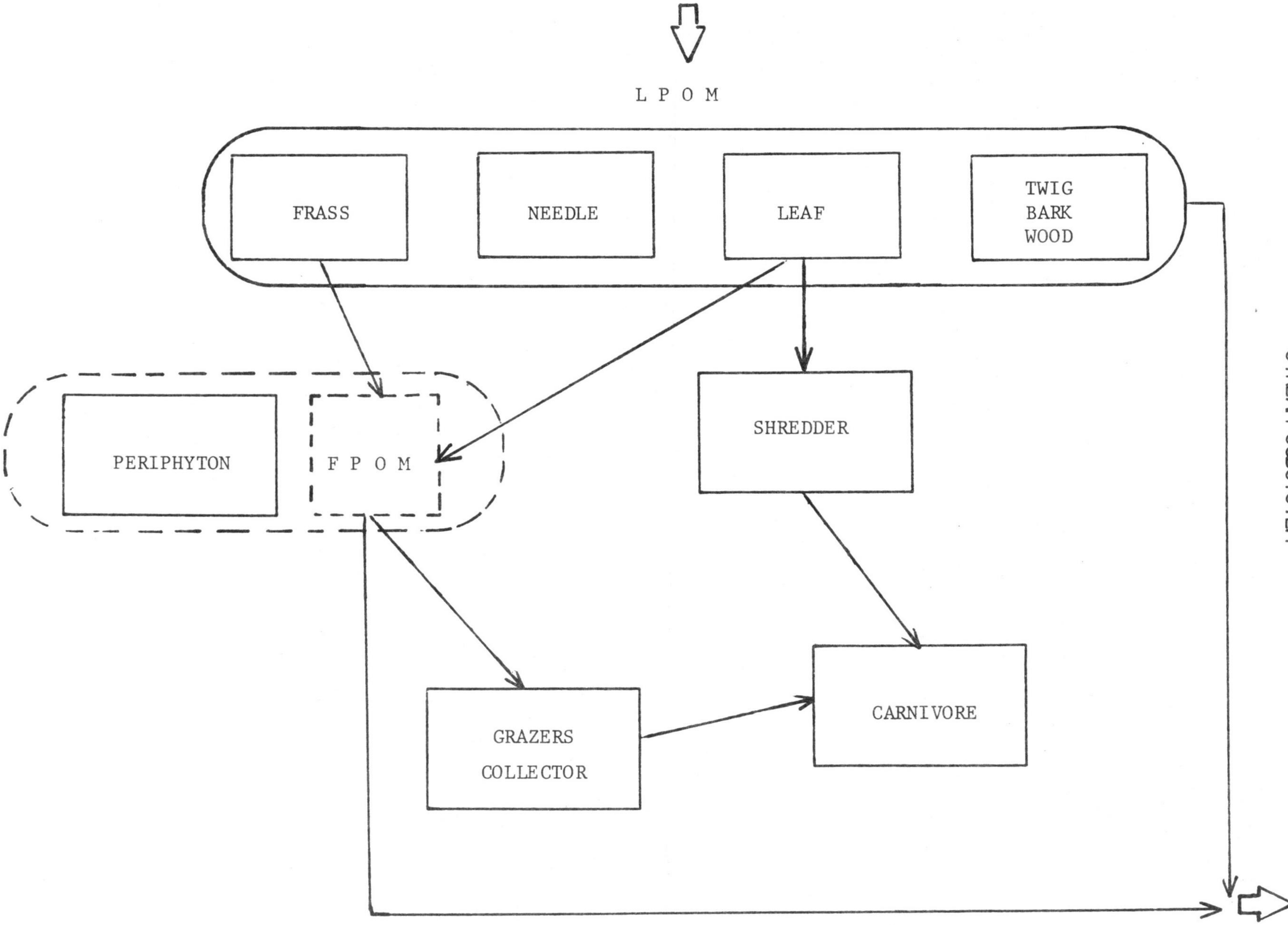


FIGURE 22

STREAM SUBSYSTEM

TABLE 4

WATERSHED 10 INSTRUMENTATION

Streamflow - H-type flume; analog record reduced to punch cards

Stream temperature - intermittent punch-tape record at stream gage

Water quality - proportional water sampler at stream gage

Rainfall - storage gage at top and at bottom of watershed; punch-tape recording gage on south aspect used during winter storms

Snowfall - snow depth and water equivalent measured at 3 locations after major snow storms

Snowmelt - snowmelt lysimeter on south aspect used during winter

Seepage - tipping bucket / event recorder measures flow from large seep during winter storms

Saturated flow - 45 piezometers located on south aspect; 12 equipped with water level recorders

Soil moisture - 35 neutron probe access tubes throughout watershed; measurements made periodically during the spring, summer, and fall and daily at some points during winter storms; percent by volume

Soil temperature - two continuous recording stations; data summarized daily

Air temperature - measured at one meter; two continuous recording stations under forest cover; summarized daily with integrated averages for day and night; daily maxima and minima

Shortwave radiation - continuous record in open; hourly and daily summaries on punch cards; located southwest of Watershed 10

Air temperature - continuous record in open; location and summary as for shortwave radiation above

Dew point - continuous record in open; location and summary as for shortwave radiation above

Suspended sediment - 80 micron net at mouth of flume

Bedload erosion - sediment basin

Additional temperature and soil and litter moisture measurements made during growing season with portable equipment.

Plant moisture stress is measured at variable periods throughout the year at three locations comparing dominant with one meter high trees.

PROGRESS IN VEGETATION AND ENVIRONMENTAL CLASSIFICATION

I would like to mention the excellent research being done by Dr. Zobel, Dr. Dyrness, Glenn Hawk, and Art McKee in evaluaiing the stand structure, phenology, water stress patterns and temperatures associated with major plant communities present on the Oregon Intensive Site. Partial results are summarized in Table 5, with the general vegetation ordination present in Figure 23. These reference stands serve for comparing primary production, litterfall, and consumer populations. They also will be the basis for stand succession modeling. Through extension of this approach, we hope to extend many models across the Coniferous Forest Biome.

CENTRAL LABORATORY

With the heavy increase in soil, plant, and water chemistry analyses, Oregon has established a new central laboratory facility with the cooperation of the Pacific Northwest Forest and Range Experiment Station. The laboratory is supervised by a Forest Service employee and staffed by IBP technicians. Mrs. Laraine Noonan, a former lab supervisor with the Tundra Biome, is serving as a full-time IBP coordinator. Her job is to receive all prepared samples and schedule their analyses based on priorities set by the Site Coordinating Committee, of which she is a member. She also directs the summarization of data through a teletype linkage to the O.S.U. computer. A listing of the analyses are provided to the data bank and the principal investigators. Coordination between other laboratories at the University of Washington and the EPA lab in Corvallis, is being fostered. The laboratory has been updated with automatic atomic absorption equipment and other facilities to increase efficiency.

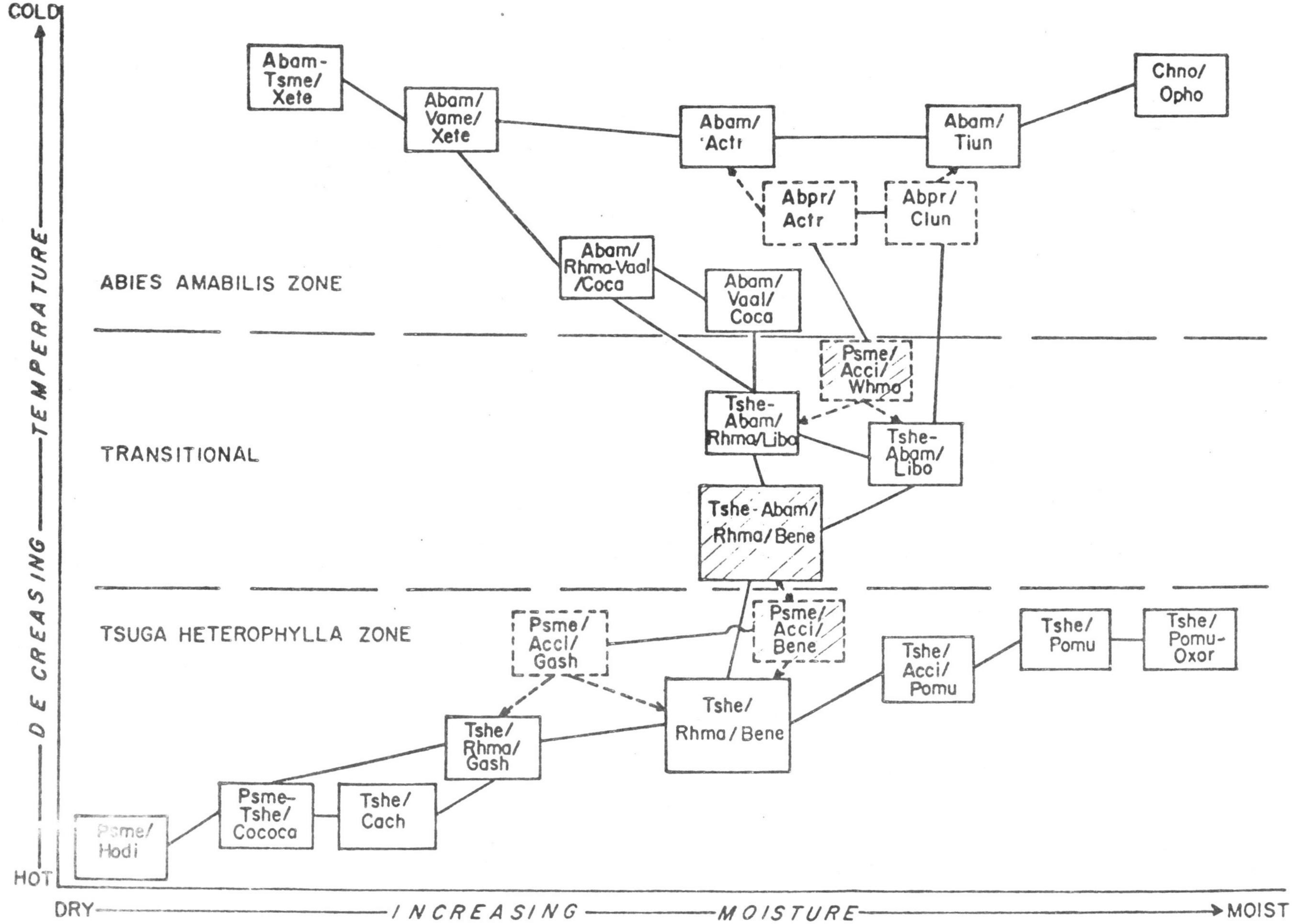
DATA BANK

In order to obtain an ecosystem model, a great deal of data had to be processed and stored in an accessible form. This required a full-time effort and lead to the establishment of an Oregon data bank manned by Mr. Greg Luckini and Mr. Rob Rydell. Mr. Luckini is responsible for processing data sets and providing investigators with results in as little as two weeks. All field data forms are now developed with his approval and programs written for data reduction before additional data are gathered. Mr. Luckini is also in charge of all key punching, clearing of accounts and supervising data abstract preparation. He and Mr. Rydell are both members of the Site Coordinating Committee which meets monthly. Mr. Rydell aids the process modelers in developing mathematical expressions of graphic relationships and in transferring all models to a common format. The present format is called FLEX and is a general systems processor developed by the Central Modeling group under the direction of Scott Overton. The FLEX system is interactive by teletype with the CDC 3300 at Oregon State University. We have teletype connections by phone to Seattle so that models can be run for workshops at either locations.

TABLE 5

REFERENCE STAND TEMPERATURE AND MOISTURE STRESS INDICES

	VEGETATION	BUD BREAK	TEMPERATURE INDEX	July 21, 1972 MOIST. STRESS (atm.)	Aug. 25, 1972 MOIST. STRESS (atm.)
1.	Psme/Hodi	27 May	86.4	18	24
2.	Tshe/Rhma/Bene	4 June	67.7	11	9
3.	Tshe-Abam/Libo	24 June	51.2	8	12
4.	Abam/Tiun	5 July	39.0	-	7
5.	Tshe-Abam/Rhma/Bene	10 June	59.0	8	11
6.	Tshe/Cach	23 May	77.0	-	-
7.	Tshe/Pomu-oxor	27 May	76.3	6	6
8.	Psme-Tshe/Cococa	19 May	82.4	12	18
9.	Tshe/Acci/Pomu	4 June	84.1	10	8
10.	Tshe/Rhma/Gash	28 May	69.5	12	11
11.	Psme/Acci/Bene	10 June	66.8	-	-
12.	Abam/Vaal/Coca	9 July	38.4	-	-
13.	Abpr/Actr	15 July	33.0	-	-
14.	Abam-Tsme/Xete	12 July	35.0	-	-



FIGURE

PLANT COMMUNITIES OF THE H.J. ANDREWS EXPERIMENTAL FOREST

ACCOUNTING

To improve efficiency, most of the accounting is now centrally done through the School of Forestry. This permits immediate status reports on budgets, the issuing of itemized listing to principal investigators monthly, and the pooling of travel and computer funds into single accounts. The centralization has also resulted in an allocation of overhead funds complementary with the biome's research objectives.