INTERNAL REPORT 11A

Foliage-Consuming Insects in Mixed Douglas-fir and Western Hemlock Forests
Annual Biomass Budget for Spruce Budworm

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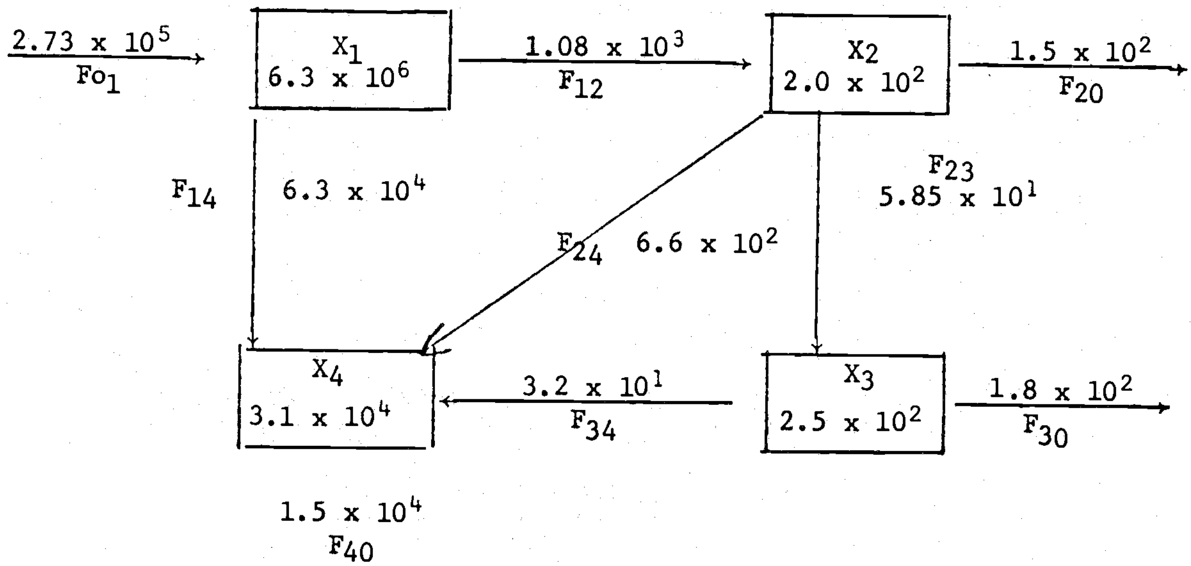

values in boxes are mg/m^2
values on lines are $mg/m^2/yr$

X_1 = foliage
X_2 = spruce budworm
X_3 = predators of spruce budworm
X_4 = detritus

assuming linear donor control

equation

$\dot{X}_1 = 27300 - .0117X_1$

$\dot{X}_2 = .0017X_1 - 4.34X_2$

$\dot{X}_3 = .13X_2 - .73X_3$

$\dot{X}_4 = .01X_1 + 3.46X_2 - .5X_4$

steady state soln.

$X_1 = 2.3 \times 10^7$ mg/m^2

$X_2 = 8.9 \times 10^3$ mg/m^2 = 80 insect/m^2

$X_3 = 1.5 \times 10^3$ mg/m^2 = 30 pred/m^2

$X_4 = 5.0 \times 10^5$ mg/m^2

The year biomass budget for the spruce budworm population was undertaken to gather together estimates of the order of magnitude of the energy flowing through an herbivorous insect population in a forest system. The linear donor control model was used so a stable state would be generated for purposes of comparison.

From the stable state solutions, it can be seen that 2 larvae/m^2 is a low estimate for an endemic population. The model demonstrates that 80 insects/m^2 would provide a balanced endemic population.

The estimates for the transfer functions and for the standing biomass are documented. They represent gross approximations of the real system but were used only to gain insights into the order of magnitude of the effects of insect herbivory.

DOCUMENTATION OF VALUES

1. $X_1 = 6.3 \times 10^6$ mg/m^2

    30 dry kg/m^2 = mean biomass per unit area in a temperate forest

    from: Whittaker, R. H. 1970. Communities and Ecosystems. page 83

    Assume tree 80% water

    150 kg/m^2 = wet wt.

    4.2% of biomass = foliage in oak-pine forest

    from Whittaker 1970 p. 79. $150 \cdot .042 = 6.3$ kg/m^2

2. $X_2 = 2.0 \times 10^2$ mg/m^2

    Let condition be endemic with 2 insects per m^2

    Feeding stage of insect reaches $\sim$ 100 mg

    From F. Schmidt experiments

3. $X_3 = 2.5 \times 10^2$ mg/m^2

    Assume 5 predators /m^2 at 50 mg each

4. $X_4 = 3.1 \times 10^4$ mg/m^2

    Assume half litter which arrives stays

5. $Fo_1 = 2.73 \times 10^5$ mg/m^2/yr

    Fo_1 is net primary productivity, hence there is no F_{10}

    1,300 dry g/m^2/y

    from Whittaker 1970 p. 83

    Assume 80% water

    $\frac{1300}{.2} = 6500$ dry g/m^2/yr

    4.2% of biomass is foliage - so assume same % of production is foliage

    $6.5 \times 10^6 \text{ mg} \cdot .042 = 2.73 \times 10^5$ mg/m^2/yr

6. $F_{12} = 1.08 \times 10^3$ mg/m^2/yr

$Wt._{final} = 97.63$ mg $Wt._{initial} = .0043$ mg/insect

Gain = 97.63 mg from Fred Schmidt exp.

$\frac{ECI}{100} = 1.8$ median value for wet wt.

from Waldbauer, G. P. 1968 Advances in Insect Physiology 5: 258-9

$$ECI = \frac{\text{wt gained}}{\text{wt food consumed}} \times 100$$

$$.18 = \frac{97.63}{\text{food}}$$

542. 36 mg food eaten/larva, if assume 2 larvae/m^2

then 1084.72 mg/m^2/yr

7. $F_{24} = 660.16$ mg/m^2/yr

F_{24} = insect feces + insect mortality

$F_{24} = (1 - AD/100)$ (amount eaten) $+ d_{24} X_2$

$\frac{AD}{100} = .44$ median value from Waldbauer. 1968

$$AD = \frac{\text{amount eaten} - \text{feces}}{\text{amount eaten}} \times 100$$

d_{24} = proportion of larvae dying from causes other than predation

= .541

from Morris, R. F. 1963. The dynamics of epidemic spruce budworm populations. Mem. Ent. Soc. Can. No. 31. p. 17.

X_2 = mean wt of larvae during year

$$= \frac{.0043 + 97.63 \times 2 \quad \text{for 2 larvae/m}^2}{2}$$

= 97.63

$F_{24} = (.56)(1084.72) + .541\,(97.63)$

8. $F_{23} = 58.48$ mg/m^2/yr

$= X_2 \cdot d_{23}$

d_{23} = death rate - prop. of larvae dying from predation

= .599

from Morris, R. F. (1963) p. 17

X_2 = mean wt. of larvae during year

9. F_{34} = 32.75 $mg/m^2/yr$

F_{34} = contribution from budworms to detritus which has been routed through predators

if we assume no death of predators:

$F_{34} = (1 - AD/100)\ d_{23}\ X_2$

$\frac{AD}{100}$ = .44 assumed median for insects since most predators on insects are often other insects.

from Waldbauer, 1968.

$F_{34} = .335 \cdot X_2$

10. $F_{14} = 6.3 \times 10^4$

1% of total biomass falls as litter each year

from Rodin and Basilevic for Southern Taiga fir forest

11. $F_{20} = 1.5 \times 10^2$

.73 = prop. of total calories respired by insects

from Teal 1962 - Energy flow in a salt marsh around Sapelo Is. Ga., based on grasshopper respiration.

$.73(2.0 \times 10^2) = F_{20}$

12. $F_{30} = 1.8 \times 10^2$

.73 = prop. of total calories respired by insect

$.73(2.5 \times 10^2) = F_{20}$

13. $F_{40} = 1.5 \times 10^4$

Assume turnover of .5

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