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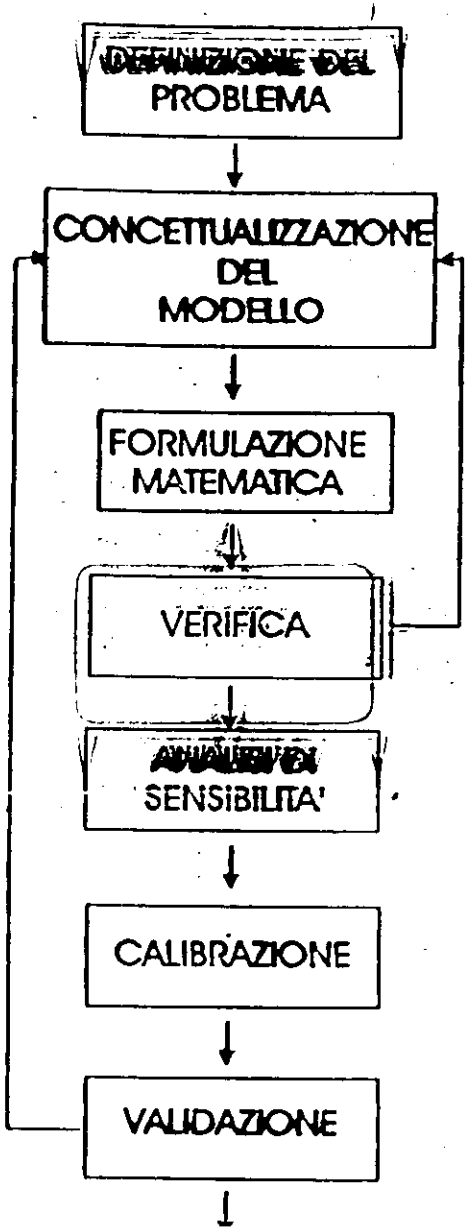
SMR/1108 - 12

COURSE ON
"MEDITERRANEAN SEA(S) CIRCULATION & ECOSYSTEM FUNCTIONING"
2 - 20 November 1998

Trieste, Italy

"Introduction to Ecological Modeling"
(Part I)



* analisi del problema e dei dati disponibili
*scelta dei limiti e delle scale spaziali e temporali
* individuazione di sottosistemi

* individuazione delle funzioni forzanti
* individuazione delle variabili di stato
*individuazione delle relazioni funzionali
*disegno di un diagramma concettuale
*individuazione della complessità

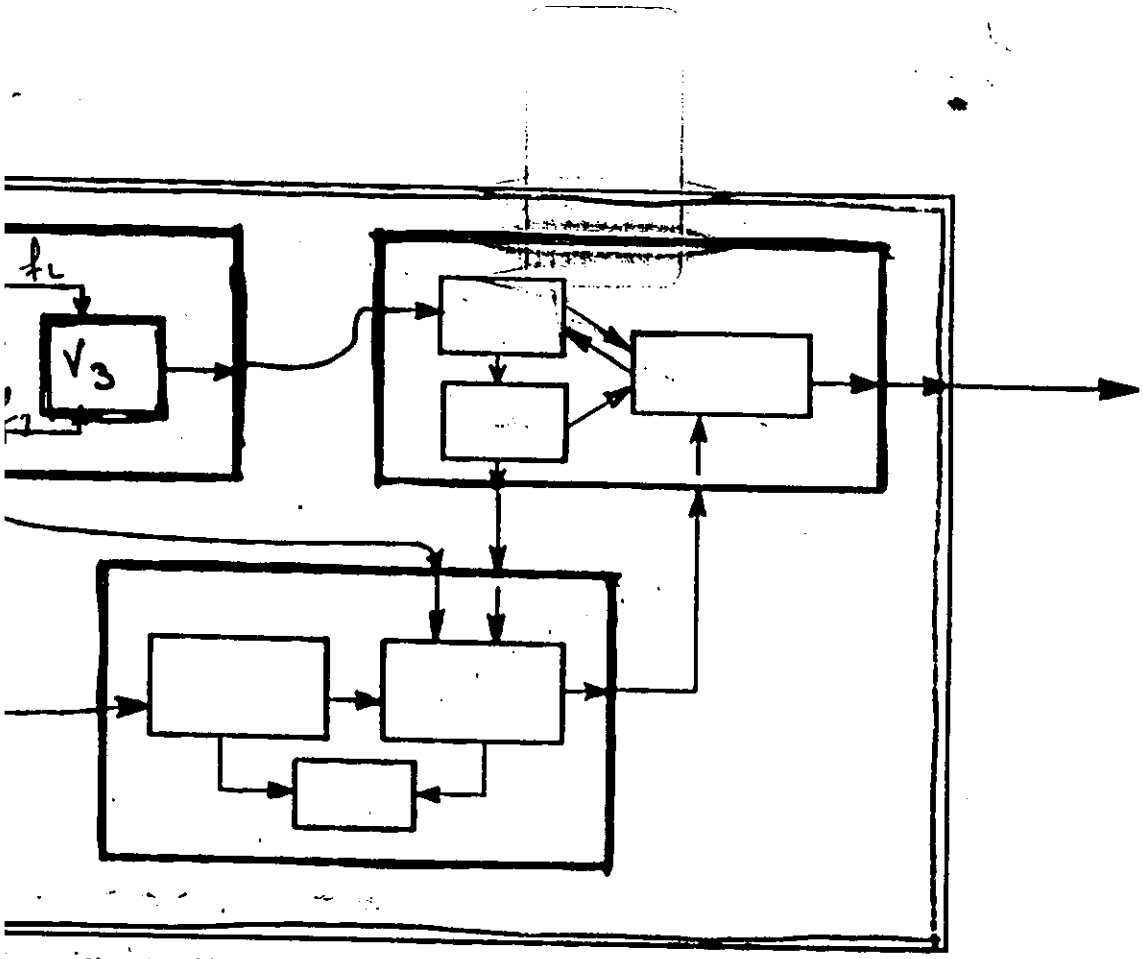
* scrittura di equazioni per ogni relazione
* individuazione delle costanti e dei parametri
* individuazione dei campi di variabilità dei parametri
*definizione del formalismo matematico

* risoluzione delle equazioni
* analisi del comportamento del modello

* variazioni dei valori delle funzioni forzanti
* analisi dei risultati

* risoluzione delle equazioni
* confronto con i dati sperimentali
* individuazione dei valori ottimali dei parametri

* conferma o variazione dei parametri



eptualization showing three levels of hierarchical organization.

Livelli gerarchici

di stato — compartimenti

forzanti — variabili di stato.

sistema.

del modello comportamentale ridicolo è la
del comportamento di V_3 in funzione delle variazioni

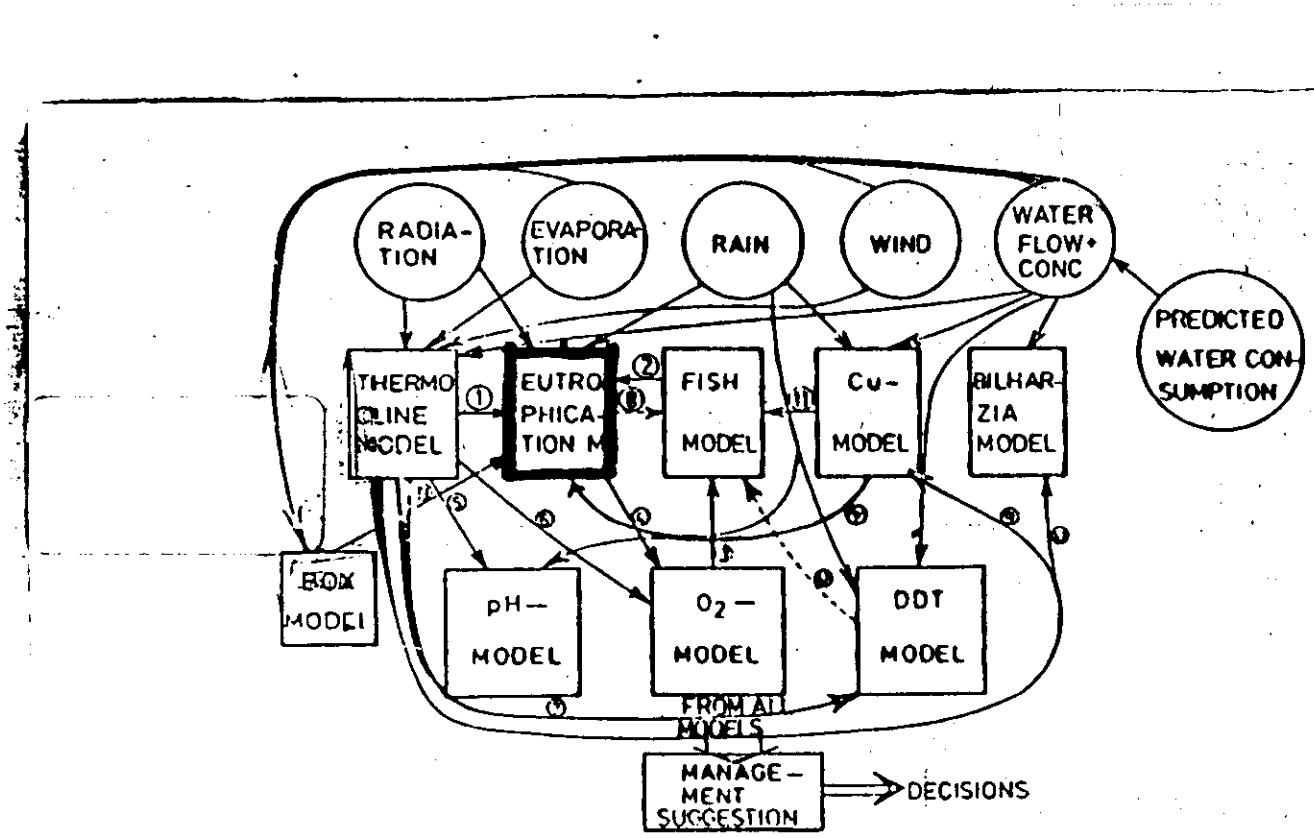
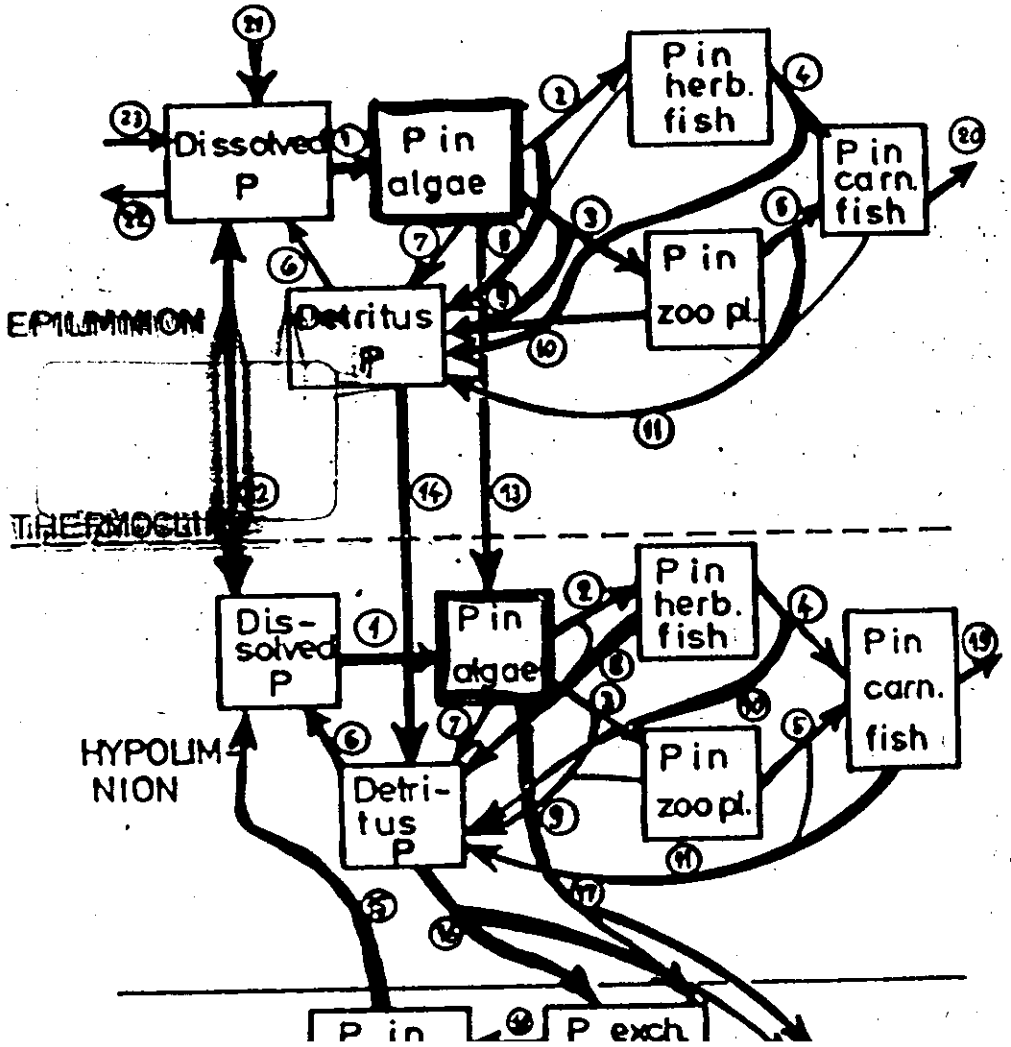
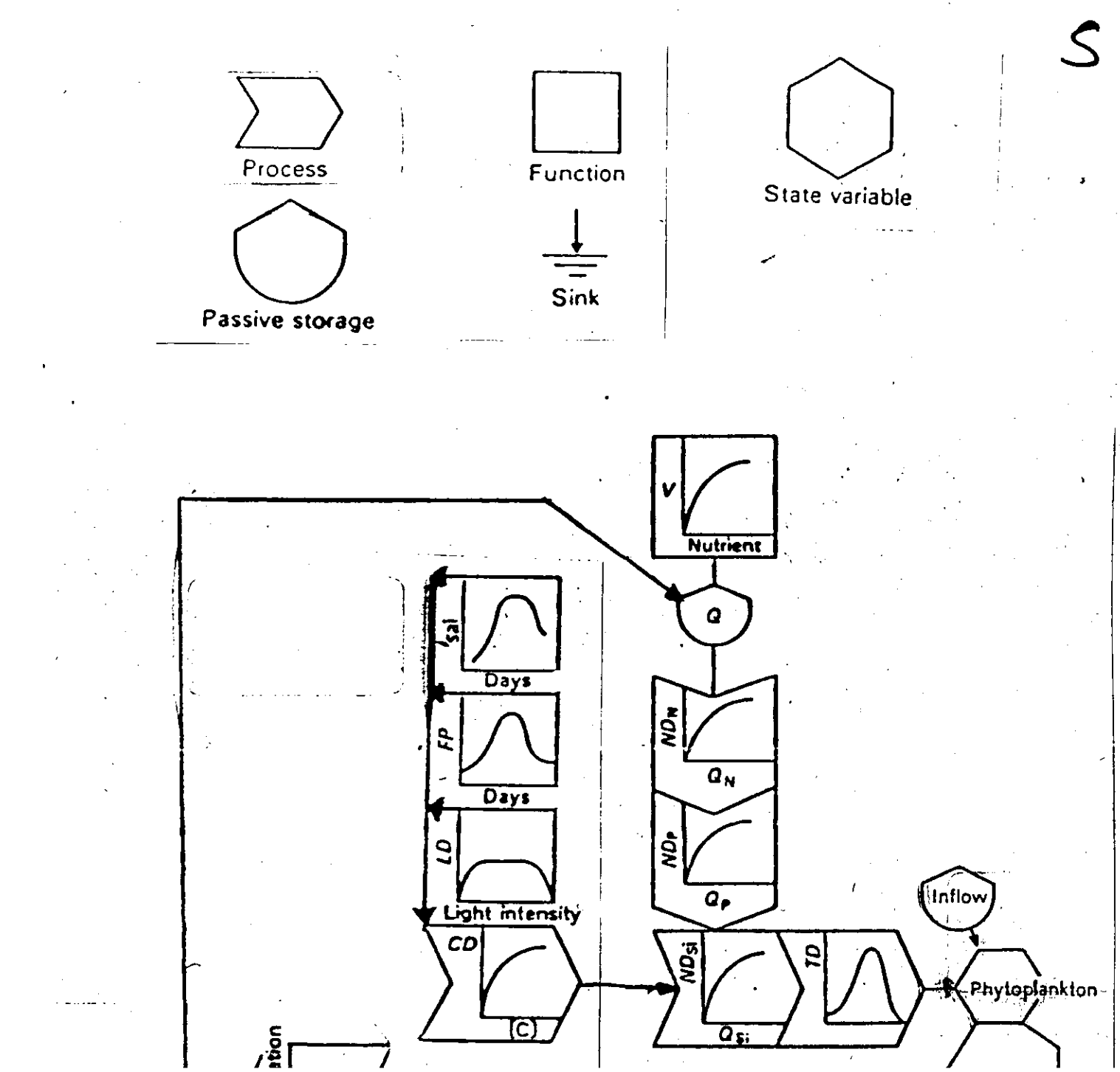


Fig. 3.3 Connections of models to form a total model of the Upper Nile La


Dissolved P
P in algae
P in herb. fish
P in carn. fish
P in zoo pl.
Detritus P
EPILIMNION
THERMOCLINE
HYPOLIMNION
Dis-solved P
P in algae
P in herb. fish
P in carn. fish
P in zoo pl.
Detri-tus P
P exch


Process
Function
State variable
Passive storage
Sink
V
Nutrient
Q
I_{sal}
Days
FP
Days
LD
Light intensity
NDI_N
Q_N
NDI_P
Q_P
Inflow
CD
C
NDI_{Si}
TD
Q_{Si}
Phytoplankton

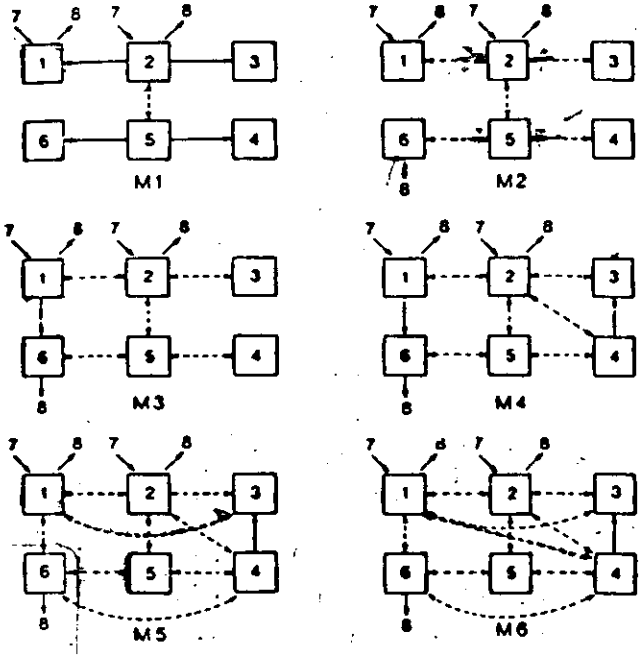


Fig. 3.1A:: Model structures for first set of models with six state variables. Suspended sediments (1), water (2), fish (3) benthos (4), pore water (5), bottom sediments (6), inputs (7), outputs to the environment (8). (Halfon 1983).

Table 3.2

Adjacency matrix of model M2. Element a_{jj}, j =1,6 may be zero (no internal recycling) or one (internal recycling) (reproduced from Halfon 1983).

Table 3.3

Boolean powers of the M4 model adjacency matrix and their first four sums. Calculation of $\bar{c}$ (reproduced from Halfon 1983).

A^1

0	1	0	0	0	1	0	1
1	0	1	1	1	0	0	1
0	1	0	0	0	0	0	0
0	1	1	0	1	0	0	0
0	1	0	1	0	1	0	0
0	0	0	0	1	0	0	1
1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0

A^2

1	0	1	1	1	0	0	1
0	1	1	1	1	1	0	1
0	1	1	1	0	0	1	1
1	1	1	1	1	1	0	1
1	1	1	1	1	0	0	1
0	1	0	1	0	1	0	0
1	1	1	1	1	1	0	1
0	0	0	0	0	0	0	0

A^3

0	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
0	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	0	0	1
1	1	1	1	1	0	0	1
0	0	0	0	0	0	0	0

A^4

1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
0	0	0	0	0	0	0	0

A^1

0	1	0	0	0	1	0	1
1	0	1	1	1	0	0	1
0	1	0	0	0	0	0	0
0	1	1	0	1	0	0	0
0	1	0	1	0	1	0	0
0	0	0	0	1	0	0	1
1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0

$A^1 + A^2$

1	1	1	1	1	1	0	1
1	1	1	1	1	0	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
0	1	0	1	1	1	0	1
1	1	1	1	1	1	0	1
0	0	0	0	0	0	0	0

$A^1 + A^2 + A^3$*

1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
0	0	0	0	0	0	0	0

$A^1 + A^2 + A^3 + A^4$

1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
1	1	1	1	1	1	0	1
0	0	0	0	0	0	0	0

Table 3.4

Direct and indirect connectivity of the adjacency matrices for the first set of models with six state variables (reproduced from Halfon 1983).

Model	Direct connectivity	$\bar{c}$
Without internal recycling ($a_{jj} = 0$)		
M1	0.15625	0.18359
M2	0.23438	0.44531
M3	0.25000	0.44922
M4	0.29688	0.68164
M5	0.37500	0.71289
M6	0.40625	0.72070
with internal recycling ($a_{jj} = 1$)		
M1	0.25000	0.38281
M2	0.32813	0.68945
M3	0.34375	0.69531
M4	0.39063	0.71289
M5	0.46875	0.72852
M6	0.50000	0.73243

ecological parameters are rarely known as exact values

due to the model simplification, ecological parameters account for this simplification in the model, and are slightly different from reality

ecological parameters account for spatial variation in lumped parameter models

ecosystems are flexible ecological parameters have to account for this flexibility A structural

Parameter estimation

Parameters are sensitive to environmental factors

Parameters are influenced by environmental factors

environmental factors are interactive

Parameters can be determined indirectly

Parameters are influenced by feedback mechanisms.

VERIFICATION

A model is said verified, if it behaves in the way the modelist want it to behave (Fridisen et al 1978)

⇓

model set up ⇒ • equations
• parameter values reasonable
• experimental data

a) <u>control of verification on error</u>

simulated − observed = error = $\bar{E}$

1) $\overline{error} = 0$

2) $\bar{E}$ not mutually correlated

3) $\bar{E}$ not correlated with input