A MODEL ON DOÑANA RABBITS

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SUMMARY

For the use of ecosystems with savage fauna it is essential to dispose of -- instruments which can let one to simulate the effects that natural circums-- tances or human actions could have on them.

Because ecosystems are extremely complicated and because we are not able to experiment "in real life" -behavior are irreversible- it becomes necessary - "to experiment in the laboratory" the effects of the different events that - may affect its future life.

This "laboratory tests" can be done with the construction of an ecosystem (a model is a formal representation in scale) that later will have to be implan ted on a bearing, and will be the object of simulation exercices.

A good procedure of the construction of the model and the simulation is what we calle "System Dynamics" (DS).

The non existence of previous proofs in the use of ecosystem with savage -- fauna leads conscious of unconsciously to the disappearance of going down of the species in specific ecosystems.

The examples of Kaibab's land, the "Urogallo cantábrico" or of the grouse -- are paradigmatic. The purpose of this work is to introduce concisely the -- model and the conclusions obtained from its use, for the study of the evolu- tion of the rabbit population in a plot of 10 hectares in South Spain. The - rabbit (Oryctolagus cuniculus, L.) has been chosen for its enormous value as a prey for upper birds of prey (Imperial eagle, Royal kite, Black kite, Linx and Fox, etc. etc.).

The fundamental elements of the system are:

- The rabbit population and its composition by age and sex.
- The incidence of birds of prey and "mixomatosis" on the rate of death.
- The production of fresh biomass.
- The rates and reasons of mounthly fecundety.
- External climatic factors.

The causal diagram and the model's calibration are carried out by consulting experts that have investigated the area and with the published studies about the iberian rabbit.

KEY WORDS
Use of ecosystems - Simulation - Dynamic of systems - Rabbits - Upper birds of prey - Linx - Fox - Milvus.

FIGURE Nº 1

CAUSAL DIAGRAM OF THE MODEL "RABBITS"

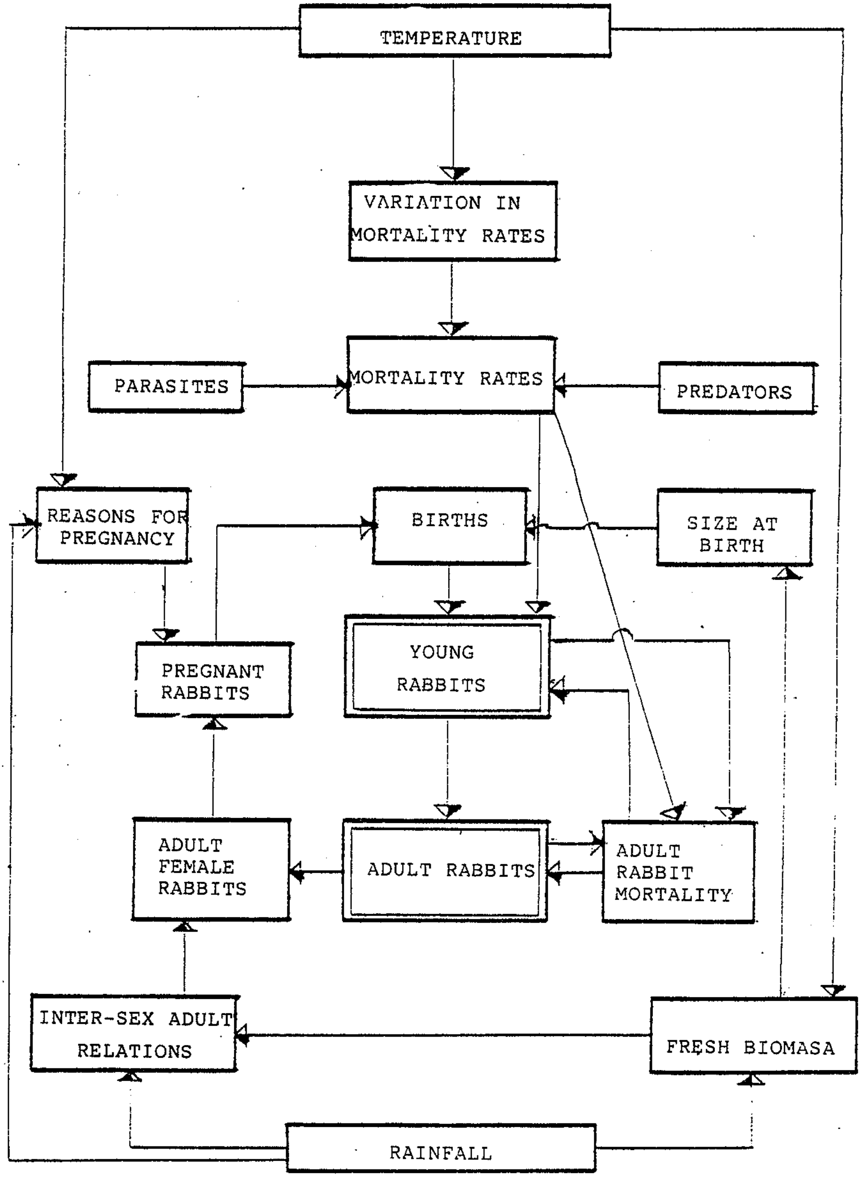


TABLE Nº 1

CLIMATOLOGY AND PASTURE

DATE	LLU	TEMPE	BIOFRES
1	95.000	8.000	18.980
2	103.000	11.500	23.760
3	72.000	13.000	26.230
4	41.000	15.500	25.970
5	39.000	19.000	15.740
6	20.000	22.800	5.200
7	1.000	24.000	3.900
8	11.000	24.500	2.530
9	33.000	20.500	2.570
10	90.000	17.500	2.870
11	79.000	11.500	7.450
12	138.000	10.000	15.030

TABLE Nº 2

BIOMETRIC PARAMETERS

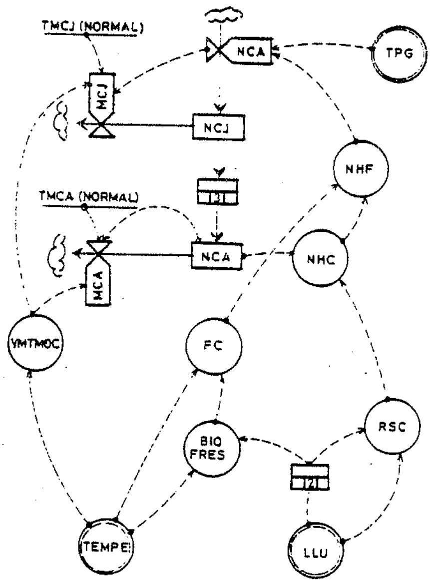
DATE	TMO	VMTMOC	RSC	FC	TPC
1	60.000	.779	.660	35.000	3.350
2	68.500	.889	.685	55.000	2.850
3	80.500	1.045	.700	68.000	3.550
4	85.000	1.103	.720	67.000	3.550
5	87.000	1.129	.615	37.000	3.800
6	79.500	1.032	.605	24.000	3.200
7	82.000	1.064	.605	22.000	3.200
8	98.500	1.279	.577	20.000	3.200
9	80.500	1.045	.600	18.000	3.200
10	77.000	1.000	.600	24.000	3.200
11	70.000	.909	.580	50.000	4.000
12	65.000	.844	.580	38.000	3.300

Source: Based on Ramón C. Soringuer. Op. cit.

FIGURE Nº 2

MDS DIAGRAM OF THE MODEL "RABBITS"

TMCJ (NORMAL)	:	MORTALITY RATES YOUNG RABBITS
NAC	:	RABBIT BIRTHS
TPG	:	NORMAL SIZE AT BIRTH
MCJ	:	YOUNG RABBIT MORTALITY
NCJ	:	NUMBER OF YOUNG RABBITS
TMCA (NORMAL)	:	ADULT RABBIT MORTALITY RATES
NCA	:	NUMBER OF ADULT RABBITS
NHC	:	NUMBER OF FEMALES
MCA	;	ADULT RABBIT MORTALITY
VMTMOC	:	MONTHLY VARIATION IN MORTALITY RATES
FC	:	PREGNANCY FACTOR
BIOFRES	:	FRESH BIOMASA
RSC	;	INTER-SEX RELATIONS
LLU	;	RAINFALL
TEMPE	:	TEMPERATURE



The system to be modeled is a population of wild rabbits (Oryctolagus cunicu lus) in the Doñana National Park. The fundamental reason for this choice -- lies in that the rabbit is a species which forms the basic diet of a great - quantity of superior predators in that park. The ultimate geal of this study is to dispose of a simulation instrument from which it may be determined how different events affect the evolution of the total number of rabbits.

The causal scheme of the model is in Figure 1. We should therefore examine - and quantify the principal variables of the diagram. We shall begin with the exogenous variables:

1. Geographical Situation.- The area of the study is located in an ideal -- place in the south of Spain. It has an extension of 10 Hectares (24 Acres).

2. Climatology.- The climate is typically mediterranean. Table 1 shows the - evolution of monthly rainfall and temperature.

3. Biomass Production.- Table 2 shows the production of fresh and dry biomass of the natural pasture of the area under study.

4. Biometric Parameters of the rabbit.- Table 2 includes the monthly evolu-- tion of the principal parameters related to reproduction and mortality.

   To summarise briefly we may say that:

   1. The mortality rate of the Iberian rabbit is very high due to the high incidence of mixomatosis and the great quantity and diversity of the - predators.

   2. The reason for pregnancy (percentage of pregnant females) and the ave- rage size of the new-born are somewhat lower than the other sub-species (the Central European rabbit and the Australian rabbit).

   3. Sexual maturity is reached much earlier (3-4 months) in the Peninsular rabbit than in other subspecies. This is the basic explanation for -- their survival.

   4. Relationship between variables.- Using mathematical techniques of sta- tistical inference we have obtained relationships between some biome-- tric parameters and certain variables (rainfall, temperature, biomass, etc.).

The main relations among variables of the loops diagramm are:

i) Temperature, which is the fundamental cause of monthly changes in morta lity rates. It should be obvious that each month and age-range take dif ferent values.

ii) Temperature and rainfall values cause differences in the "rate of preg- nancy" and thus affect the number of new-borns.

iii) Temperature and rainfall values do also cause changes in the values of fresh biomass. This variable measures the inter-sexuel relationship of the new-borns and their size.

iv) Finally, the number of predators and parasite illnesses do also affect the mortality rates. The number of predators and the existence of para- sites are exogenous to the model.

The fact of existence of a feedback between the population of rabbits and - that of predators is a consequence of the model's simplicity.

However, the fact that a large variety of predators affect the population - of rabbits under study, makes this simplification a desirable one. In fact, the Lyns (Lyns Pardina) and the Imperial Eagle (Aquila Heliaca) are fed -- almost exclusively of rabbits. However, other predators, such as the Red -- Kite and Black Kite (Milvus Migrans and Milvus Milvus) and fuchs (Vulpes -- Vulpes) diversity their diets.

These predators do also eat many rabbits given their large number in the -- Parque Nacional de Doñana.

Once the variables of the causal diagram (Figure 1) are classified according to the categories of the Dynamic Systems (DS), an MDS diagram is obtained - like that shown in Figure 2. The system of equations and the code of variables of the model RABBITS are given in Annex 1. The non-linear relations of the model are included in Annex 2.

The final part of this work deals with the evolution of rabbits taking into account internal or external events which are incidental to the ecosystem.- We shall experiment with the effects that the following phenomena have on - the quantitative and qualitative evolution of rabbits:

1. Aleatory Perturbation of the normal values.
2. rainfall.
3. Predators.
4. Mixomatosis.

The results are expressed graphically in Figures 3 to 7.

In order to be able to compare the diverse trajectories, a Nominal Trajectory is established. This has normalised values of the climatological conditions, biometric parameters and initial population of rabbits grouped according to age, which can be repeated periodically.

The four "scenarys" or hypothesis to be simulated:

First "scenary": Perturbation of the normal monthly values for rainfall, -- temperature, average size of new-born rabbit, intersex reasons, pregnancy - reasons (%of pregnant females) and mortality rates of each age group. The - generated perturbation is a normal distribution with average values and observed variance over a period of two years.

Second "scenary": Moderate dry season. This case is simulated reducing in a 10 percent the value of the rainfall variable given for the first scenary.

Thirs "scenary": Increasing the number of predators. This scenary is obtained increasing in a 10 percent the Normal values of the mortality rate.

Forth "scenary": Strong epidemia of mixomatosis simulated through a high -- mortality rates during the months of May to October (both included).

The main conclusions obtained from these simulation exercises can be summarized as follows:

1st. The Nominal Trajectory, which is obtained by repetition of the parameters over a period of four years, does not produce an identical trajectory every year. This shows that the different initial conditions referring to the age pyramid and population size generate different behavioral patterns.

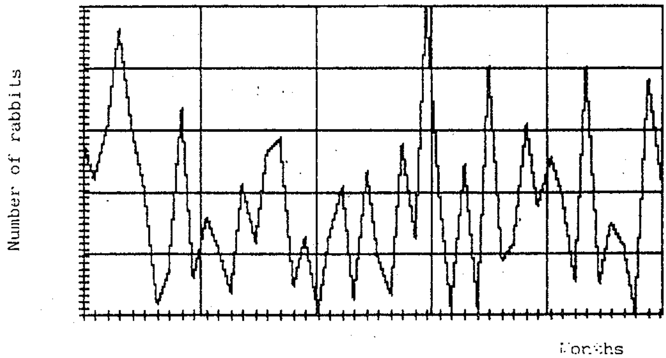
2nd. The short duration of the dry season does not produce a qualitative behavior that is different from the Perturbed Trajectory. The specie has a capacity to recuperate promptly.

3rd. The increase in the predator activity produces a significant decrease in the total population size. The intra-annual oscillations are very similar.

4th. The high incidence of mixomatosis does not produce a strong effect on the population size; however, there exist different behavior patterns in the intra-annual oscillations.

5th. Provisionally it can be accepted that in the very long run (more than 10 years), there exists a tendency for the population size to stabilize with very low values.

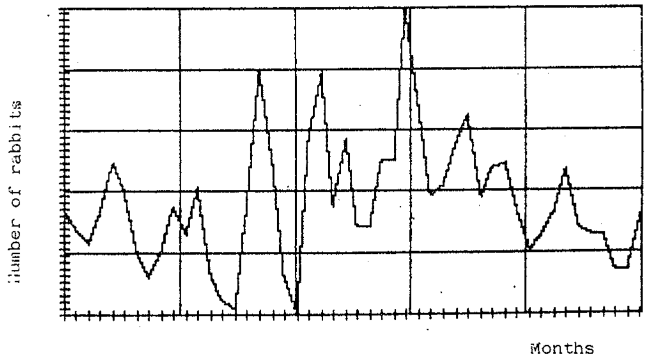
FIGURE 3
NOMINAL TRAJECTORY



Normal climatological conditions (Figure 3)
Normalized values of the mortality rates according to age group.
Initial conditions: 150 young individuals and 100 adult individuals.

X-AXIS : 1 - 48 D = 1
Y-AXIS :12 -581 D =12

FIGURE 4
PERTURBED TRAJECTORY

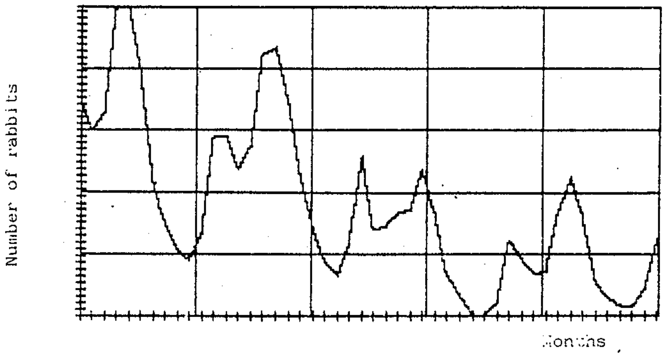


Random climatological conditions above normal values.
Other initial conditions similar to the Nominal Trajectory.

X-AXIS : 1 - 48 D = 1
Y-AXIS :19 -340 D = 6

FIGURE 5

TRAJECTORY DURING MODERATE DRY SEASON

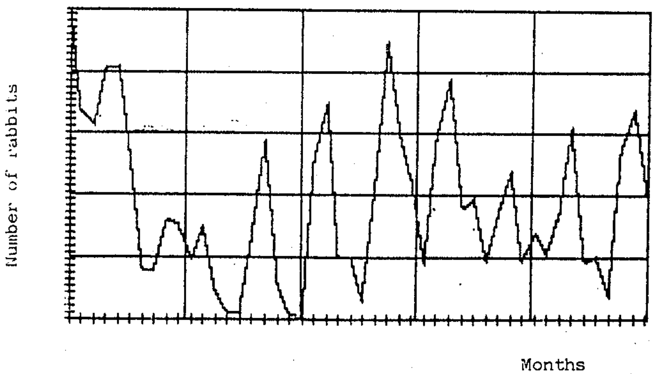


Rainfall conditions lower by 10% than the Perturbed Trajectory.
Other initial conditions similar to the Nominal Trajectory.

X-AXIS : 1 - 48 D = 1
Y-AXIS :91 -321 D =

FIGURE 6

TRAJECTORY WITH AN INCREASE OF PREDATORS

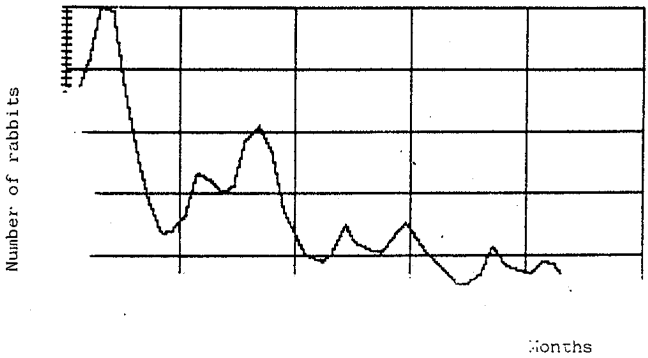


Random climatological conditions above normal values.
Normalized mortality rates with an increase of 0.1.
Other initial conditions similar to the Nominal Trajectory.

X-AXIS : 1 - 48 D = 1
Y-AXIS : 1 -200 D = 4

FIGURE 7

TRAJECTORY WITH INCREASE OF MIXOMATOSIS



Random climatological conditions above normal values.
Mortality rates between June and September increase 10% above normal values.
Other initial conditions similar to the Nominal Trajectory.

X-AXIS : 1 - 48 D = 1
Y-AXIS :20 -327 D = 6

(1) Taken from J. Kormandy, Ecology Concepts, Alianza Editorial. Madrid, - 1.971.

(2) L. von Bertalanffy, "History and Situation of the General Systems -- Theory", in Tendencies in General Systems Theory. Alianza Editorial,- madrid, 1.978.

(3) The studies by I. Prigogine on the subject are numerous, but at a di-- vulgatory level the most representative is Only an Illusion. An Exploration from Chaos to Order.Tusquetts,Editores. Barcelona.

(4) The Data for this work has been elaborated and based on R.C. Soringuer work, Biología y Dinámica de una Población de Conejos en Andalucía Occidental,. Revista de Vertebrados, CSIC, Seville, 1.981.

(5) These works may also be consulted: Silvio Martínez and Alberto Requena,- Manual de Operaciones para Modelos de Dinámica de Sistemas, monografía - nº 10. DEA, 1.984 and Javier Aracil, Introducción a la Diámica de Sistemas, Alianza Editorial, (Second Impression, 1.984).

(6) For several examples of ecological models see: Silvio Martínez y Alberto Requena, Dinámica de Sistemas: simulación por ordenador y Dinámica de Sistemas: modelos. Alianza Editorial, Madrid, 1.986.

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]LIST1380,

1380  REM  ***MODELO CONEJOS5***
1390  REM
1400  REM **ECUACIONES ANALITICAS**
1410  REM  NCA=NCA*(1-TMOCA)+N3*(1-TMO3)
1420  REM  N3=N2*(1-TMO2)
1430  REM  N2=N1*(1-TMO1)
1440  REM  N1=NAC
1450  REM  VMTMOC=FUNCION(TEMPE)
1460  REM  LLU=TABLA(TIEMPO) TA(25-36)
1470  REM  TEMPE=TABLA(TIEMPO) TA(25-36)
1480  REM  TPC=TABLA(TIEMPO)   TA(13-24)
1490  REM  BIOFRESN=TABLA(TIEMPO) TA(42-53)
1500  REM  BIOFRES=FUNCION(TEMPE,LLU(-2))
1510  REM  RSC=FUNCION(LLU,LLU(-2))
1520  REM  FCN=TABLA(TIEMPO) TA(54-65)
1530  REM  FC=FCN*FUNCION(BIOFRES/BIOFRESN)
1540  REM  TMO1=VMTMOC*TNMO1
1550  REM  TMO2=VMTMOC*TNMO2
1560  REM  TMO3=VMTMOC*TNMO3
1570  REM  TMOCA=VMTMOC*TNMOCA
1580  REM  LLU(-2)=FUNCION DE RETARDOS(LLU) TA(40-41)
1600  REM  NHCA=NCA*RSCA
1610  REM  NHFA=NHCA*FC
1620  REM  NAC=NHFA*TPC
1630  REM
1640  REM **CODIGO DE VARIABLES**
1650  REM  N1=NUMERO DE CONEJOS DE 1 MES,#01
1660  REM  N2=NUMERO DE CONEJOS DE 2 MESES,#02
1670  REM  N3=NUMERO DE CONEJOS DE 3 MESES,#03
1680  REM  NCA=NUMERO DE CONEJOS ADULTOS,#04
1690  REM  NC=NUMERO TOTAL DE CONEJOS,#23
1700  REM  NAC=NACIMIENTOS DE CONEJOS,#10
1710  REM  MO1=MORTALIDAD EN 1 MES,#11
1720  REM  MO2=MORTALIDAD EN 2 MESES,#05
1730  REM  MO3=MORTALIDAD EN 3 MESES,#06
1740  REM  MCA=MORTALIDAD DE CONEJOS ADULTOS,#11
1750  REM  VMTMOC=VARIACION MENSUAL DE TASAS DE MORTALIDAD,#21
1760  REM  TMO1=TASA DE MORTALIDAD PARA 1 MES,#13
1770  REM  TMO2=TASA DE MORTALIDAD PARA 2 MESES,#07
1780  REM  TMO3=TASA DE MORTALIDAD PARA 3 MESES,#08
1790  REM  TMOCA=TASA DE MORTALIDAD PARA ADULTOS,#14
1800  REM  NHCA=NUMERO DE HEMBRAS ADULTAS,#17
1810  REM  NHFA=NUMERO DE HEMBRAS PRENADAS,#16
1820  REM  TPC=TAMANO MEDIO DEL PARTO,#19
1830  REM  RSCA=RELACION INTERSEXOS EN ADULTOS,#15
1840  REM  FC=RAZON DE PRENEZ(% HEMBRAS PRENADAS),#16
1850  REM  LLU=PRECIPITACION MENSUAL(mm),#24
1860  REM  TEMPE=TEMPERATURA MEDIA MENSUAL(GRADOS CENTIGRADOS),#25
1870  REM  LLU(-2)=PRECIPITACION DOS PERIODOS ANTES,#28
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1880  REM  LOGTEMPE=LOGARITMO NATURAL DE TEMPE,#26
1890  REM  BIOFRESN=PRODUCCION DE BIOMASA FRESCA,VALOR NORMAL(gr./400 cm2
    ),#29
1900  REM  FCN=RAZON DE PRENEZ,VALOR NORMAL(%),#30
1910  REM  M(FC/BIO)=MULTIPLICADOR DEL VALOR NORMAL DE FC,#31
1920  REM  NC(-1)=NUMERO DE CONEJOS EN T-1,#20
1925  REM  NC(-2)=NUMERO DE CONEJOS EN T-2,#22
1926  REM  NC(-3)=NUMERO DE CONEJOS EN T-3,#32
1930  REM
1940  REM
1950  REM **ECUACIONES MDS**
1960  REM
1970  IF T <  > TI THEN 1990
1980  GOTO 2030
1990 VN(4) = VN(4) * (1 - VN(14)) + VN(3) * (1 - VN(8))
2000 VN(3) = VN(2) * (1 - VN(7))
2010 VN(2) = VN(1) * (1 - VN(13))
2020 VN(1) = VN(10)
2021 VN(22) = VN(20)
2022 VN(20) = VN(23)
2030 QQ% = QQ% + 1
2040 IX = 01:DX = 01:N% = 12:M% = 01:X = QQ%: GOSUB 1290:VN(24) = TR
2050 IX = 01:DX = 01:N% = 12:M% = 42:X = QQ%: GOSUB 1290:VN(29) = TR
2060  GOSUB 590
2070 VN(24) = VN(24) + 2 * 10 * AL: IF VN(24) < 0 THEN VN(24) = 0
2080 IX = 01:DX = 01:N% = 12:M% = 25:X = QQ%: GOSUB 1290:VN(25) = TR
2090  GOSUB 590
2100 VN(25) = VN(25) + 2 * 0.5 * AL
2110 IX = TI:DX = 1:N% = 12:M% = 13:X = QQ%: GOSUB 1290:VN(19) = TR
2120  GOSUB 590
2130 VN(19) = VN(19) + 2 * 0.01 * AL
2140 IX = 01:DX = 01:N% = 12:M% = 54:X = QQ%: GOSUB 1290:VN(30) = TR
2150  IF QQ% >  = 12 THEN QQ% = Ø
2160 XR% = 08:XO% = 40:TU = 2:N% = 02: GOSUB 1210:VN(28) = R
2170 X = VN(24):XR% = 08:XO% = 52:TU = 02:N% = 02: GOSUB 1130
2180  GOSUB 590
2190 VN(15) = 0.589931 - (0.0004 + 2 * 0.00003 * AL) * VN(24) + (0.000070
    55 + 2 * 0.000003 * AL) * VN(29)
2200 VN(26) =  LOG (VN(25))
2210  GOSUB 590
2220 VN(21) = 0.303377 + (0.249372 + 2 * 0.03 * AL) * VN(26)
2230  GOSUB 590
2240 VN(27) = 8.775150 - (0.321309 + 2 * 0.01 * AL) * VN(25) + (0.139392 +
    2 * 0.01 * AL) * VN(28)
2250  GOSUB 590
2260  IF VN(27) < 2 THEN VN(27) = 2
2270 IX = 00:DX = 0.20:N% = 11:M% = 66:X = VN(27) / VN(29): GOSUB 1290:VN
    (31) = TR
2280 VN(16) = VN(30) * VN(31)
2290  IF T = TI THEN VN(28) = 79
2300 VN(13) = TA(77) * VN(21)
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2310 VN(14) = TA(78) * VN(21)
2320 VN(07) = TA(79) * VN(21)
2330 VN(08) = TA(80) * VN(21)
2340 VN(11) = VN(1) * VN(13)
2350 VN(12) = VN(4) * VN(14)
2360 VN(17) = VN(4) * VN(15)
2370 VN(18) = VN(17) * VN(16) / 100
2380 VN(10) = VN(18) * VN(19)
2390 VN(10) =  INT (VN(10)) + 1
2400 VN(11) =  INT (VN(11))
2410 VN(12) =  INT (VN(12))
2420 VN(20) =  INT (VN(20))
2430 VN(32) =  INT (VN(32))
2440 VN(33) =  INT (VN(33))
2450  FOR I = 1 TO 4:VN(I) =  INT (VN(I)): NEXT I
2460  IF VN(2) < 0 THEN VN(2) = 0
2470 VN(16) =  INT (VN(16))
2480 VN(24) =  INT (VN(24))
2490 VN(25) =  INT (VN(25))
2500 VN(27) =  INT (VN(27))
2510 VN(23) = VN(1) + VN(2) + VN(3) + VN(4): IF T = TI THEN VN(23) = VI(0
   1) + VI(2) + VI(3) + VI(4)
2512 XR% = 01:XO% = 37:TU = 3:N% = 3: GOSUB 1210:VN(32) = R
2513 X = VN(23):XR% = 01:XO% = 37:TU = 3:N% = 3: GOSUB 1130
2518  IF T = TI THEN VN(20) = 200:VN(22) = 230:VN(32) = 210
2519  IF T = TI + 1 THEN VN(22) = 200:VN(32) = 230
2520  IF T = TI + 2 THEN VN(32) = 200
2525  RETURN
2530  DATA  1,48,1,1
2540  DATA  04,80,32
2550  DATA    050,050,050,100
2560  DATA   95,103,72,41,39,20,01,11,33,90,79,138
2570  DATA 3.35,2.85,3.55,3.55,3.80,3.20,3.20,3.20,3.20,3.20,4.00,3.30
2580  DATA  8.0,11.5,13.0,15.5,19.0,20.0,24.0,24.5,20.5,17.5,11.5,10.0
2590  REM  !LAS TASAS 37,38 Y 39 NO SE UTILIZAN!
2600  DATA  50,80,100
2610  DATA  138,79
2620  DATA  19,24,26,26,16,05,04,03,03,03,07,15
2630  DATA  35,55,68,67,37,15,10,08,15,30,58,38
2640  DATA    0.75,0.80,0.82,0.85,0.95,1.00,1.01,1.05,1.07,1.10,1.12
2650  DATA      0.68,0.12,0.37,0.28
2660  DATA      N1,N2,N3,NCA,MO2,MO3,TMO2,TMO3,N9
2670  DATA   NAC,MO1,MCA,TMO1,TMOCA,RSCA,FC,NHCA,NHFA,TPC,NC(-1),VMTMOC,N
   C(-2)
2680  DATA  NC
2690  DATA  LLU,TEMPE,LOGTEMPE,BIOFRES,LLU(-2)
2700  DATA  BIOFRESN,FCN,M(FC/BIO)
2705  DATA  NC(-3)
2710  HOME
2720  PRINT "
2730  FOR I = 1 TO NR
2740 N$ = NE$(I)
2750  PRINT  CHR$ (4);"OPEN ";N$;",L25"
2760  PRINT  CHR$ (4);"WRITE ";N$;",RO": PRINT I9
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ANALISIS DE REGRESION ENTRE VARIABLES CLIMATOLOGICAS, PASTOS Y PARAMETROS BIOMETRICOS

SMPL 1 - 12
OLSQ // DEPENDENT VARIABLE IS BIOSEC

	COEF	S.E.	T-STAT
C	-3.631370	1.057401	-3.434240
BIOFRES	0.210235	0.028194	7.456568
TEMPE	0.259932	0.047267	5.499219

R-SQUARED = 0.86223
ADJUSTED R-SQUARED = 0.83162
OBSERVATIONS = 12
SUM OF SQUARED RESIDUALS = 4.122929
S.E. OF REGRESSION = 0.676833
DURBIN-WATSON STATISTIC = 1.62211
F-STATISTIC = 28.1645

SMPL 1 - 12
OLSQ // DEPENDENT VARIABLE IS VMTMOC

	COEF	S.E.	T-STAT
C	0.303377	0.102188	2.968807
LOGTEMPE	0.249372	0.037037	6.732917

R-SQUARED = 0.81927
ADJUSTED R-SQUARED = 0.80120
OBSERVATIONS = 12
SUM OF SQUARED RESIDUALS = 0.020830
S.E. OF REGRESSION = 0.045640
DURBIN-WATSON STATISTIC = 1.11257
F-STATISTIC = 45.3321

SMPL 1 - 12
CORC // DEPENDENT VARIABLE IS FC
RHO = .32518

	COEF	S.E.	T-STAT
C	28.47404	13.61123	2.067248
BIOFRES	1.338431	0.431311	3.103166
TEMPE	-0.972903	0.843696	-1.153144

R-SQUARED = 0.81576
ADJUSTED R-SQUARED = 0.77482
OBSERVATIONS = 12
SUM OF SQUARED RESIDUALS = 655.0610
S.E. OF REGRESSION = 8.531386
DURBIN-WATSON STATISTIC = 2.13802
F-STATISTIC = 19.9259

SMPL 3 - 12
CORC // DEPENDENT VARIABLE IS BIOFRES
RHO = .54678

	COEF	S.E.	T-STAT
C	6.775150	5.072336	1.335706
TEMPE	-0.321309	0.230541	-1.393714
LLU-2	0.139392	0.023607	5.904583

R-SQUARED = 0.95778
ADJUSTED R-SQUARED = 0.94572
OBSERVATIONS = 10
SUM OF SQUARED RESIDUALS = 33.75604
S.E. OF REGRESSION = 2.195971
DURBIN-WATSON STATISTIC = 2.08319
F-STATISTIC = 79.4157

SMPL 1 - 12
OLSQ // DEPENDENT VARIABLE IS BIOSEC

	COEF	S.E.	T-STAT
C	-3.631370	1.057401	-3.434240
BIOFRES	0.210235	0.028194	7.456568
TEMPE	0.259932	0.047267	5.499219

R-SQUARED = 0.86223
ADJUSTED R-SQUARED = 0.83162
OBSERVATIONS = 12
SUM OF SQUARED RESIDUALS = 4.122929
S.E. OF REGRESSION = 0.676833
DURBIN-WATSON STATISTIC = 1.62211
F-STATISTIC = 28.1645

SMPL 1 - 12
OLSQ // DEPENDENT VARIABLE IS BIOSEC

	COEF	S.E.	T-STAT
C	2.915270	0.430123	6.777754
BIOFRES	0.163946	0.026609	6.161138
LLU	-0.028397	6.012E-3	-4.723750

R-SQUARED = 0.82735
ADJUSTED R-SQUARED = 0.78899
OBSERVATIONS = 12
SUM OF SQUARED RESIDUALS = 5.166715
S.E. OF REGRESSION = 0.757680
DURBIN-WATSON STATISTIC = 1.60994
F-STATISTIC = 21.5656

SMPL 1 - 12
OLSQ // DEPENDENT VARIABLE IS FC

	COEF	S.E.	T-STAT
C	17.32507	4.346820	3.985689
BIOFRES	1.664774	0.280592	5.933078

R-SQUARED = 0.77876
ADJUSTED R-SQUARED = 0.75664
OBSERVATIONS = 12
SUM OF SQUARED RESIDUALS = 796.6272
S.E. OF REGRESSION = 8.869200
DURBIN-WATSON STATISTIC = 1.76906
F-STATISTIC = 35.2014

SMPL 1 - 12
CORC // DEPENDENT VARIABLE IS FC
RHO = .25889

	COEF	S.E.	T-STAT
C	36.18624	23.07493	1.568205
BIOFRES	1.891793	0.553300	3.419104
TEMPE	-1.777157	1.040527	-1.707938

R-SQUARED = 0.35963
ADJUSTED R-SQUARED = 0.32844
OBSERVATIONS = 12
SUM OF SQUARED RESIDUALS = 1112.528
S.E. OF REGRESSION = 11.11819
DURBIN-WATSON STATISTIC = 2.41715
F-STATISTIC = 27.5603