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SB-CORSICA
A Program to Support the Management of Corsican Pine Stands

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Abstract. This paper introduces program SB-CORSICA, for the supporting of the forestry of even-aged and uneven-aged stands of Corsican pine (*Pinus nigra* ssp. *laricio*). The program, that applies the theoretical findings of the author, is written in BASIC, and it has two subprograms: a) simulator SB-CORSO; b) subprogram SB-CORSICANA. The structure of the text reflects the structure of the program. In the first part, the author accomplishes the following: a) establishes the allometric equations for the biomasses of the tree components; b) he characterises the architecture of the tree; c) he proposes Gompertz equations for the biomasses of the components of the tree and of the self-thinned even-aged pure stands; d) he presents simulator SB-CORSO. The simulator, for the same stands of Corsican pine establishes the yield table, the biomasses table and the table of the weights of N, P, K, Ca, Mg retained in the biomasses. In the second part of the paper, the author presents subprogram SB-CORSICANA. Knowing the structure of a self-thinned even-aged pure stand of Corsican pine, at a given age, for its symmetric uneven-aged stand, the program establishes (a) the stand structure (age and dbh classes, frequencies, standing volume, area per tree), and (b) nine alternative management guidelines.

Key words: biomass table; even-aged stands; management guidelines; nutrient table; *Pinus nigra* ssp. *laricio*; simulation; uneven-aged stands; yield table

SB-CORSICA. Um Programa de Auxílio à Gestão dos Povoamentos de Pinheiro da Córsega

Sumário. Para os povoamentos de pinheiro da Córsega (*Pinus nigra* ssp. *laricio*) o autor propõe o programa SB-CORSICA, escrito em BASIC, e que compreende dois sub-programas: a) o simulador SB-CORSO e o sub-programa SB-CORSICANA. A estrutura do texto reflecte a do programa. Na primeira parte do artigo, o autor: a) estabelece as equações alométricas para as biomassas das componentes da árvore; b) caracteriza a arquitectura da árvore; c) propõe equações de Gompertz para as biomassas da árvore e dos povoamentos puros auto-desbastados regulares; d) apresenta o simulador SB-CORSO, que para os mesmos povoamentos de pinheiro da Córsega estabelece a tabela de produção, a tabela das biomassas e os pesos de N, P, K, Ca e Mg, retidos na biomassa. Na segunda parte, o autor apresenta o programa SB-CORSICANA. Conhecida a estrutura de um povoamento puro auto-desbastado regular de pinheiro da Córsega, numa dada idade, o programa, para o seu povoamento jardinado simétrico, estabelece a sua estrutura (classes de idade e dap, frequências, volume em pé, área por árvore) e nove normas alternativas para a sua gestão.

Palvras-chave: normas de gestão; *Pinus nigra* ssp. *laricio*; povoamentos irregulares; simulação; tabela de biomassa; tabela de nutrientes; tabela de produção; povoamentos regulares

SB-CORSICA. Un Logiciel pour l'Aménagement des Peuplements de Pin de Corse

Résumé. L'auteur utilise les résultats de sa recherche théorique pour présenter le logiciel SB-CORSICA, pour les peuplements de pin laricio (*Pinus nigra* ssp. *laricio*). Le logiciel contient deux sous-programmes: SB-CORSO et SB-CORSICANA. Pour les peuplements réguliers auto-éclaircis de pin laricio, le sous-programme SB-CORSO calcule: a) la table de production, b) la table des biomasses, c) les concentrations des éléments nutritifs (N, P, K, Ca, Mg) dans les biomasses. Le sous-programme SB-CORSICANA à partir de l'information sur la struture d'un peuplement régulier auto-éclaircis de pin laricio, calcule la structure irrégulière et propose neuf normes pour son aménagement.

Mots clés: normes pour l'aménagement; peuplements irréguliers; peuplements réguliers; *Pinus nigra* ssp. *laricio*; simulation; table de biomasses; table de production; table de nutritifs

Introduction

This paper introduces program SB-CORSICA, dedicated to the tree, self-thinned even-aged pure stands (SEPS), and self-thinned uneven-aged pure stands (SUPS) of Corsican pine (CP; *Pinus nigra* ssp. *laricio).* The program, written in BASIC, has two subprograms: a) simulator SB-CORSO; b) subprogram SB-CORSICANA.

The article reflects the structure of the program, and evinces two parts. In the first part, I will approach the management of SEPS. Here, I will attempt: a) to establish the allometric equations for the biomasses of the tree; b) to characterise the architecture of the tree; c) to propose Gompertz equations for the biomasses of the tree and SEPS. Finally, I present simulator SB-CORSO (SCO).

In the second part, I will introduce subprogram SB-CORSICANA (PC). This subprogram establishes alternative management guidelines for SUPS of CP.

This paper is a revised and integrated version of BARRETO (1998, 1999)

Simulator SB-CORSO

Introductory remarks

I already proved that the dynamics of density, dbh, height, standing volume and tree volume follow Gompertz equations (BARRETO, 1990b, 1993a). Let me represent, generally, the same forest variables by **y**. At age t(0), when the SEPS enters the 3/2 power law, **y** assumes the value **y(0)**, and in the asymptotic phase the value **y(f).** The Gompertz equation can be written as:

$$y(t) = y(f)Ry^{E} \qquad (1)$$

where Ry=y(0)/y(f) and E=exp(-c(t-t(0))).

Assuming t(0)=20, for the dynamics of the SEPS of CP, the characteristic parameters are:

c=0.051; R(p)=14.042; R(x)=0.267 R(v)=0.019,

being **p** the stand density, **x** the parameters with linear dimension (dbh, height and standing volume), and **v** the tree stem volume.

I already proposed simulator CORSICAN (BARRETO, 1993b) that provides the same output as SCO. It is my understanding that the values provided by simulator CORSICAN are not completely satisfactory, and evince some lack of internal consistency. This evaluation justifies the elaboration of SCO.

A note on simulator CORSICAN

Simulator CORSICAN (BARRETO, 1993b) for CP is equivalent to simulator SANDRIS for *Pinus pinaster* (BARRETO, 1991,1994).

Simulator CORSICAN is supported by my results already presented (BARRETO, 1988, 1990a) and by the information provided by RANGERS (1978, 1981).

For a given self-thinned even-aged pure stand (SEPS) of CP, knowing the age, number of trees per hectare, mean dbh (cm) and the mean height (m), simulator CORSICAN establishes the classical yield table, the biomass table, and the table of the nutrients retained in the biomass (N, P, K, Ca, Mg).

Simulator CORSICAN reproduces the values generated by the equations fitted by RANGERS (1978, table 5, nonfertilised stands).

The allometric equations

To establish SCO, I used the same method I applied to generate the allometric equations in simulator PINASTER (BARRETO, 1994).

Thus, I used simulator CORSICAN to generate the data used in the fitting of the allometric equations where dbh (**d**; cm) is the independent variable.

The fitted equations, for the biomasses of the tree components (kg/tree), are the following ones:

Needles $y(1) = a(1)d^{2.002}$ (2)

Live branches $y(2) = a(2)d^{2.002}$ (3)

Dead branches $y(3) = a(3)d^{2.002}$ (4)

Stem wood $y(4) = a(4)d^{3.000}$ (5)

Stem bark $y(5) = a(5)d^{3.000}$ (6)

Roots $y(6) = a(6)d^{2.948}$ (7)

The values of the constants **a(i)**, in these equations, are density dependent. The equations that express this dependency are included in the listing of the program for SCO. In subroutine Startup, they are preceded by a REM statement ("REM constants and powers of the allometric equations").

The coefficients of determination (cd) of the equations for the constants a(1)-a(6) vary from 0.928 (roots) to 0.969 (crown components). The independent variable is the density at age 20 (**p2**).

For the above-ground and total tree biomasses, I also fitted the two following equations:

Above ground $y(7) = a(7)d^{2.789}$ (8)

$a(7)=0.0284275614+1.542281388E-05\ p2-8.329305969E-09\ p2^2$ (9)

cd=0.965

Total tree $y(8) = a(8)d^{2.798}$ (10)

$a(8)=0.0284358224+1.699312029E-05\ p2-8.904747079E-09\ p2^2$ (11)

cd=0.965

A general and formal approach to the main allometry of trees and SEPS can be found in BARRETO (1995b).

In this paper, it can be seen that the powers in eqs. (2)-(4) are equal to 2, in eqs. (5)-(6) to 3, and in eqs. (7), (8), (10) to a value between 2 and 3. Thus, the powers in the allometric equations conform to the theory.

The program for simulator SB-CORSO

The basic input for SCO is the age, density and mean dbh of the SEPS. Optionally, you can input the mean height, dominant height, standing volume and the simulator calculates also the classical yield table, beside the biomasses table, and the table of the nutrients retained in the biomasses of the SEPS components (N, P, K, Ca, Mg).

SCO has four subroutines that I briefly describe as follows:

Startup. This subroutine asks for the input and introduces the equations for the constants of the allometric equations, and their powers. As I already sad, in these equations, the independent variable is the stand density at age 20.

Crown. The biomasses of the crown components and the weights of the nutrient retained in them are calculated and printed in this subroutine. These biomasses are constant during the stand life.

Present. This subroutine calculates the biomasses of the stem and roots and their nutrient contents for the present stand.

Projection. The last subroutine, from the age of the stand till age 90, with the desired periodicity, calculates and prints the biomass table, the yield table (optional), and the table of the nutrients retained in the biomasses of the stem and roots of the SEPS. If the user does not desire the yield table, SCO prints an estimation of the standing volume.

Using the available information to me, and comparing the performances of simulators CORSICAN and SCO, the latter one provides more realistic and coherent estimates of the SEPS biomasses. It is my understanding that the values for the biomasses calculated by simulator CORSICAN are underestimated.

The tree architecture of Corsican pine

In this section, I will use eqs. (2)-(7), (8), (10) to establish some regularities that the architecture of tree of CP abide during its growth, after age **t(0).**

Let C(p)=a(i)/a(j).

Thus, it is expected that the architecture of the tree will satisfy the following equations:

$y(i)/y(j)=C(p)\ d^{-0.998}$ i=1,2,3; j=4,5 (12)
$y(i)/y(j)=C(p)\ d^{-0.946}$ i=1,2,3; j=6 (13)
$y(i)/y(j)=C(p)\ d^{-0.787}$ i=1,2,3; j=7 (14)
$y(i)/y(j)=C(p)\ d^{-0.796}$ i=1,2,3; j=8 (15)
$y(i)/y(j)=C(p)\ d^{0.052}$ i=4,5; j=6 (16)
$y(i)/y(j)=C(p)\ d^{0.211}$ i=4,5; j=7 (17)
$y(i)/y(j)=C(p)\ d^{0.202}$ i=4,5; j=8 (18)
$y(i)/y(j)=C(p)\ d^{0.159}$ i=6; j=7 (19)
$y(i)/y(j)=C(p)\ d^{0.150}$ i=6 j=8 (20)
$y(i)/y(j)=C(p)\ d^{-0.009}$ i=7; j=8 (21)

Gompertz equations for the biomass of the components

Now I will establish the Gompertz models for the biomasses. In these equations, the value of **c** remains the same (0.051) and only **Ry** assume different values.

For the biomasses of the components of the tree, to obtain the values of Ry, I only have to calculate the values of

$$R_x^m = 0.267^m = Rb(i) \qquad (22)$$

being **m** the powers in eqs. (2)-(8), (10).

For the stand components, to obtain the values of **Ry**, I must multiply the values of **Rb(i)** by **Rp** (14.042).

The values obtained are exhibited in table 1. The crown biomasses of the stand are constant, as I already said.

The relative growth rates (RGR) of the biomasses of the components are given by:

$$\text{RGR} = -c \ln(Ry)\,E \qquad (23)$$

The total biomass of self-thinning (TBST), in SEPS of CP, from age t(0) to age w, is given by:

$$TBST = 0.134745\,\text{TBSTf} \sum_{t(0)}^{w} 0.349^{E}\,E \qquad (24)$$

being **TBSTf** the final or asymptotic value of the total standing biomass.

Table 1 - Characteristic parameters of the dynamics of the biomasses of the tree and SEPS of CP. MCAI= maximum current annual increment

Coeficient of Competition, **c**	0.051
TREE	
Crown components	
Ry	0.071
Age of MCAI	39
Stem components	
Ry	0.019
Age of MCAI	47
Root	
Ry	0.020
Age of MCAI	46
Above-ground	
Ry	0.0251
Age of MCAI	45
Total	
Ry	0.0248
Age of MCAI	46
STAND	
Stem	
Ry	0.267
Age of MCAI	25
Roots	
Ry	0.281
Age of MCAI	25
Above-ground	
Ry	0.352
Age of MCAI	21
Total	
Ry	0.349
Age of MCAI	21

Subprogram SB-CORSICANA

Introductory remarks

I already presented management guidelines for SUPS of CP, in BARRETO (1996). These management guidelines have some rigidity, because I only considered two sites, and a typical SUPS in each one.

PC is a more supple management tool. Knowing the age, number of trees, mean dbh and standing volume of a self-thinned even-aged pure stand (SEPS) of CP, the program establishes its age and size-structures and nine alternative management guidelines, homologous of the ones I presented in BARRETO (1996). PC does not require any knowledge about the quality of the site.

In BARRETO (1995a), I published a similar program for *Pinus pinaster*. Also, in BARRETO (in press), I established a similar program for *Pinus pinea*, another Mediterranean pine.

The structure of subprogram SB-CORSICANA

The theoretical support of PC is the time-space symmetry between SEPS and SUPS (BARRETO, 1989, 1995a) and the conceptualisation of self-thinned pure stands as self-similar identities (BARRETO, 1995b).

PC has the following subroutines **Initialise**, **Structure**, and **Guides**. The names of the subroutines are self--explanatory. In the previous section, I already mentioned the input required by PC.

In the output of PC, each management guideline (MG) is identified by "diameter-limit/cutting cycle". Each class (I, II,..VI) by "number of trees per ha/cubic meters per ha".

In the same output, VST=volume of self-thinning during the cutting cycle (c.m./ha); MAI=volume of allowable cutting/cutting cycle (c.m./ha/year); APR=average percentual rate of annual increment of standing volume.

The performance of subprogram SB-CORSICANA

The output of PC, exhibited in Appendix, refers to the same SEPS, in site 16, used to establish the management guidelines proposed in BARRETO (1996). As it can be seen, PC virtually reproduces the same management guidelines and the SEPS structure (BARRETO, 1996, table 1).

Thus, I admit that the accuracy of PC is acceptable.

Improving the use of subprogram SB-CORSICANA

The utility of PC is improved if alternatives of SEPS can be easily generated. For this propose, I will suggest the following procedure.

Let **H(40)** be the dominant height, in a given local, and **F** the Wilson's top height ratio.

The index of performance of the stand, **s**, is defined as (BARRETO, 1995b):

$$s=F\,H(40) \qquad (25)$$

At age 10, the stand density **p(10)** is given by (BARRETO, 1995b):

$$p(10) = 314084s^{-2} \qquad (26)$$

At age 10, let the mean tree dbh be **d(10)**, and **v(10)** be its mean volume. For each region, and each site quality, the three following equations must be established:

$$d(10)=f(p(10)) \qquad (27)$$

$$v(10) = ad(10)^3 \qquad (28)$$

$$a= f(p(10)) \qquad (29)$$

With eqs. (25)-(29) several alternative SEPS can be generated, and its parameters can be used as input for PC. This may be relevant when it may be suspected that the SUPS have a density that may affect the regeneration.

Eq. (25) admits that the tree spacing is square. If the triangular spacing is desired, **p(10)** must be multiplied by 1.155 and **d(10)** by 0.93.

Final comments

Although I consider SCO a better simulator than simulator CORSICAN, it evinces theoretical correctness and internal coherence, SCO it is not exempt of a basic shortcoming: I used as data only measurements from trees with age 15 years, from only one site.

On the other hand, I do not have available a time series of biomass data from SEPS of CP, to elaborate an exhaustive evaluation of the performance of SCO.

As in the establishment of simulator PINASTER, SCO illustrates how circumscribed information (the one in Ranger's papers), when integrated in a sound theoretical framework, can be a valuable source for the exploratory expansion of the knowledge about the dynamics of the SEPS of a given species.

My results support the scalling model of geometric similitude.

I hope SCO may reveal some usefulness for those interested in biomass studies and in CP.

The second part of this paper complements BARRETO (1996). Thus, I hope that it may also contribute to the practice of the forestry of uneven-aged stands of CP, when environmental arguments are favouring a permanent forest cover of the soil.

This article also illustrates the benefits, for forest management, that can be obtained from the existence of a unified theory for self-thinned pure stands.

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Appendix A. Listing of program SB-CORSICA

```
CLS
PRINT "                    PROGRAM SB-CORSICA"
PRINT "                © Luís Soares Barreto, 1999"
DEF fna (x) = INT(x * 10 + .5) / 10: DEF fnb (x) = INT(x * 1000 + .5) / 1000
10 CLEAR
PRINT:PRINT "This program is devoted to pure stands of"
PRINT "Corsican pine (Pinus nigra ssp. laricio)"
PRINT "It includes two subprograms:"
PRINT "1 - Simulator  SB-CORSO for sel-thinned even-aged stands"
PRINT "2 - Subprogram SB-CORSICANA for self-thinned uneven-aged stands"
PRINT "3=Close"
INPUT "Enter your choice (1, 2, or 3)"; ch
ON ch GOTO cor, cana, clo
' --------------------------------------------------------' --------------------------------------------------------cor:
REM main
GOSUB startup
GOSUB crown
GOSUB present
GOSUB projection
GOTO 10
'---------------------------------------------------------'
'---------------------------------------------------------'
startup:
PRINT "                    SIMULATOR SB-CORSO"
PRINT "                (c) Luís Soares Barreto, 1997"
PRINT "For self-thinned even-aged pure stands of Corsican pine"
PRINT "(Pinus nigra ssp. laricio) this  program:"
PRINT "   - Simulates the dynamics of biomass"
PRINT "   - Calculates the weights of N,P,K,Ca,Mg retained in the biomass"
PRINT "   - Establishes the yield table of the stand"
DIM np(6), lp(6), dp(6), wp(6), rp(6), nn(6), nl(6), nd(6), nw(6)
DIM nr(6), r$(1)
FOR i = 1 TO 5
READ np(i): READ lp(i): READ wp(i): READ rp(i)
DATA 28.7,2.4,1.1,2.1
DATA 8.1,.2,.6,.1
DATA 12.9,2.2,1.2,1.3
DATA 7.8,2.9,.9,.9
DATA 2.0,0.5,.2,.3
NEXT i
PRINT : PRINT "Input of stand data"
INPUT "Age"; a
INPUT "Density (trees/ha)"; p
INPUT "Mean dbh (cm)"; dh
```

```
j = a - 10: qo = 1 / (.111 ^ EXP(-.051 * j))
pf = p / (81.433 ^ EXP(-.051 * j))
df = dh * qo: p2 = pf * 14.042
PRINT "Do you want the yield table, y(es) or n(o)?": INPUT r$
IF r$ = "n" THEN GOTO 380
INPUT "Mean height (m)"; h
INPUT "Dominant height"; hd
INPUT "Standing volume (c.m./ha)"; v
hf = h * qo: hdf = hd * qo: vf = v * qo
380 INPUT "Output periodicity"; pr
a1 = -3.3822E-04 + 4.24511E-05 * p2 - 1.82497E-08 * p2 ^ 2: b1 = 2.002
a2 = -4.347958E-04 + 5.57777E-05 * p2 - 2.39804E-08 * p2 ^ 2: b2 = 2.002
a3 = -3.795107E-05 + 5.15521E-06 * p2 - 2.21672E-09 * p2 ^ 2: b3 = 2.002
a4 = .0153212758# - 1.84569E-06 * p2 - 2.67077E-10 * p2 ^ 2: b4 = 3!
a5 = 4.03911E-03 - 8.03352E-07 * p2 + 4.8172E-11 * p2 ^ 2: b5 = 3!
a6 = 1.490258E-04 + 1.639465E-06 * p2 - 6.19368E-10 * p2 ^ 2: b6 = 2.948
RETURN
'---------------------------------------------------------'
'---------------------------------------------------------'
crown:
z = p / 1000: n = a1 * dh ^ b1 * z: l = a2 * dh ^ b2 * z
d = a3 * dh ^ b3 * z
LPRINT TAB(37); "PROGRAM SB-CORSICA"
LPRINT TAB(37); "SIMULATOR SB-CORSO"
LPRINT TAB(7); "Crown biomass (t / ha)"
LPRINT TAB(7); "Needles:"; fna(n); "   live branches:"; fna(l); "   dead branches:";
LPRINT fna(d)
br = l + d: tc = n + l + d: LPRINT TAB(7); "Crown:"; fna(tc)
FOR i = 1 TO 5
nn(i) = n * np(i): nl(i) = br * lp(i)
NEXT i
LPRINT TAB(7); "Nutrients in the crown (kg/ha)"
LPRINT TAB(20); "N"; TAB(27); "P"; TAB(35); "K"; TAB(41); "Ca"; TAB(48); "Mg"
LPRINT TAB(7); "Needles:"; TAB(18); fna(nn(1)); TAB(25); fna(nn(2)); TAB(32); fna(nn(3)); TAB(39); fna(nn(4)); TAB(46); fna(nn(5))
LPRINT TAB(7); "Branches :"; TAB(18); fna(nl(1)); TAB(25); fna(nl(2)); TAB(32); fna(nl(3)); TAB(39); fna(nl(4)); TAB(46); fna(nl(5))
FOR i = 1 TO 6: c(i) = nn(i) + nl(i): NEXT i
LPRINT TAB(7); "Crown:"; TAB(18); fna(c(1)); TAB(25); fna(c(2)); TAB(32); fna(c(3)); TAB(39); fna(c(4)); TAB(46); fna(c(5))
LPRINT
RETURN
'---------------------------------------------------------'
'---------------------------------------------------------'
present:
GOSUB s2
GOSUB s3
```

```
GOSUB s4
GOSUB s5
RETURN
'---------------------------------------------------------'
'---------------------------------------------------------'
projection:
FOR q = j + pr TO 90 STEP pr
GOSUB s1
GOSUB s2
GOSUB s3
GOSUB s4
GOSUB s5
NEXT q
RETURN
'---------------------------------------------------------'
'---------------------------------------------------------'
s1:
fa = .111 ^ EXP(-.051 * q): a = q + 10
p = pf * 81.433 ^ EXP(-.051 * q): dh = df * fa: IF r$ = "n" THEN GOTO 920
h = hf * fa: hd = hdf * fa: v = vf * fa
920 RETURN
'---------------------------------------------------------'
s2:
pov = p / 100: w = INT(a4 * dh ^ b4 * pov + .5) / 10
b = INT(a5 * dh ^ b5 * pov + .5) / 10
r = INT(a6 * dh ^ b6 * pov + .5) / 10
t = tc + w + b + r: st = w + b
RETURN
'---------------------------------------------------------'
s3:
FOR i = 1 TO 5: nw(i) = fna(st * wp(i)): nr(i) = fna(r * rp(i)): NEXT i
RETURN
'---------------------------------------------------------'
s4:
LPRINT
LPRINT TAB(7); "Age:"; a; " trees/ha:"; INT(p); "   dbh:"; fna(dh); " cm"
IF r$ = "n" THEN GOTO 1020
LPRINT TAB(7); "Height:"; fna(h); " m dominant height:"; fna(hd); " m standing  volume:"; fna(v); " c.m./ha"
1020 LPRINT TAB(7); "Biomass (t/ha)"
LPRINT TAB(7); "Stem wood:"; w; "  stem bark:"; b; "   roots:"; r;
LPRINT TAB(7); "   Total:"; INT(t + .5)
IF r$ = "y" THEN GOTO 1060
LPRINT TAB(7); "Standing volume:"; INT(w / .4875 + .5); " c.m./ha"
1060 RETURN
'---------------------------------------------------------'
s5:
LPRINT TAB(7); "Nutrients in the stem and roots (kg/ha)"
```

```
LPRINT TAB(20); "N"; TAB(27); "P"; TAB(35); "K"; TAB(41); "Ca"; TAB(48); "Mg"
LPRINT TAB(7); "Stem: "; TAB(18); nw(1); TAB(25); nw(2); TAB(32); nw(3); TAB(39); nw(4); TAB(46); nw(5)
LPRINT TAB(7); "Roots: "; TAB(18); nr(1); TAB(25); nr(2); TAB(32); nr(3); TAB(39); nr(4); TAB(46); nr(5)
tn = nn(1) + nl(1) + nw(1) + nr(1)
tp = nn(2) + nl(2) + nw(2) + nr(2)
tk = nn(3) + nl(3) + nw(3) + nr(3)
tca = nn(4) + nl(4) + nw(4) + nr(4)
tmg = nn(5) + nl(5) + nw(5) + nr(5)
LPRINT TAB(7); "    Total: "; TAB(18); fna(tn); TAB(25); fna(tp); TAB(32); fna(tk); TAB(39); fna(tca); TAB(46);
fna(tmg): PRINT
RETURN
'-------------------------------------------------------------------'-------------------------------------------------------------------cana:
PRINT "                    SUBPROGRAM SB-CORSICANA"
PRINT "                (c)  Luís Soares Barreto, 1997"
PRINT "This program establishes nine management guidelines for the management"
PRINT "of the uneven-aged self-thinned stand of Corsican pine symmetric "
PRINT "to an even-aged stand whose structure is known"
GOSUB initialize
GOSUB structure
GOSUB guides
GOTO 10
'-----------------------------------------------------------'
'-----------------------------------------------------------'
initialize:
PRINT : INPUT "Age of your Corsican pine stand"; a
INPUT "Number of trees per hectare"; p
INPUT "Mean dbh (cm)"; d
INPUT "Standing volume (c.m./ha)"; v
b = a - 10: e = EXP(-.051 * b): pf = p / 81.433 ^ e: df = d / .11081 ^ e: vf = v / .11081 ^ e
q = SQR(d ^ 2 * p * .16)
LPRINT TAB(37); "PROGRAM SB-CORSICA"
LPRINT TAB(35); "SUBPROGRAM SB-CORSICANA"
LPRINT : LPRINT TAB(7); "Your even-aged stand of Corsican pine is "; a; " years old";
LPRINT TAB(7); " has "; p; " trees/ha,  mean dbh="; d; " cm and "; v; " c.m./ha"
RETURN
'-----------------------------------------------------------'
'-----------------------------------------------------------'
structure:
d11 = df * .1051: d12 = d11 * 2.59: d21 = d12 + .1: d22 = d21 * 1.73: d31 = d22 + .1
d32 = d31 * 1.37: d41 = d32 + .1: d42 = d41 * 1.2: d51 = d42 + .1: d52 = d51 * 1.11
d61 = d52 + .1: d62 = d61 * 1.06
LPRINT : LPRINT "                   Structure of the uneven-aged stand"
LPRINT TAB(7); "The symmetric self-thinned uneven-aged stand has trees from age 10"
LPRINT TAB(7); "to 75 years, allocated to six age classes, each one with 11 years."
y1 = CINT(pf * 6.154): y2 = CINT(y1 * .203): y3 = CINT(y2 * .412): y4 = CINT(y3 * .612)
y5 = CINT(y4 * .767): y6 = CINT(y5 * .826)
v1 = fnb(vf * .0308): v2 = fnb(v1 * 2.0458): v3 = fnb(v2 * 1.5136): v4 = fnb(v3 * 1.2694)
```

```
v5 = fnb(v4 * 1.1466): v6 = fnb(v5 * 1.0814)
dd1 = fna(q / SQR(y1)): dd2 = fna(q / SQR(y2)): dd3 = fna(q / SQR(y3)): dd4 = fna(q / SQR(y4))
dd5 = fna(q / SQR(y5)): dd6 = fna(q / SQR(y6))
vv1 = fnb(v1 / y1): vv2 = fnb(v2 / y2): vv3 = fnb(v3 / y3): vv4 = fnb(v4 / y4)
vv5 = fnb(v5 / y5): vv6 = fnb(v6 / y6)
c = 1666.7: a1 = fnb(c / y1): a2 = fnb(c / y2): a3 = fnb(c / y3): a4 = fnb(c / y4)
a5 = fnb(c / y5): a6 = fnb(c / y6)
d11 = fna(d11): d12 = fna(d12): d21 = fna(d21): d22 = fna(d22): d31 = fna(d31): d32 = fna(d32)
d41 = fna(d41): d42 = fna(d42): d51 = fna(d51): d52 = fna(d52): d61 = fna(d61): d62 = fna(d62)
LPRINT
LPRINT TAB(7); "Cl."; TAB(14); "f"; TAB(20); "V"; TAB(31); "dd"; TAB(41); "v"; TAB(49); "d"; TAB(58); "A"
LPRINT TAB(7); "I"; TAB(12); y1; TAB(17); v1; TAB(26); d11; "-"; d12; TAB(39); vv1; TAB(48); dd1; TAB(55); a1
LPRINT TAB(7); "II"; TAB(12); y2; TAB(17); v2; TAB(26); d21; "-"; d22; TAB(39); vv2; TAB(48); dd2; TAB(55); a2
LPRINT TAB(7); "III"; TAB(12); y3; TAB(17); v3; TAB(26); d31; "-"; d32; TAB(39); vv3; TAB(48); dd3; TAB(55);
a3
LPRINT TAB(7); "IV"; TAB(12); y4; TAB(17); v4; TAB(26); d41; "-"; d42; TAB(39); vv4; TAB(48); dd4; TAB(55);
a4
LPRINT TAB(7); "V"; TAB(12); y5; TAB(17); v5; TAB(26); d51; "-"; d52; TAB(39); vv5; TAB(48); dd5; TAB(55); a5
LPRINT TAB(7); "VI"; TAB(12); y6; TAB(17); v6; TAB(26); d61; "-"; d62; TAB(39); vv6; TAB(48); dd6; TAB(55);
a6
LPRINT TAB(7); "------------------------------------------------------"
LPRINT TAB(7); "Cl.=classes;f=trees/ha,V=standing volume, c.m./ha;dd=limits of the"
LPRINT TAB(7); "dbh of the class, cm;v=mean tree stem volume, c.m.;d=mean tree dbh, cm"
LPRINT TAB(7); "A=mean area occupied by a tree, s.m./tree."
RETURN
'--------------------------------------------------------'
'--------------------------------------------------------'
guides:
LPRINT : LPRINT "                    Management guidelines"
'1
y1 = CINT(pf * 10.48387): v1 = fnb(vv1 * y1)
y2 = CINT(y1 * .203): y3 = CINT(y2 * .412): v2 = fnb(vv2 * y2): v3 = fnb(vv3 * y3)
y4 = CINT(y3 * .327103): v4 = fnb(y4 * (vv3 + vv4) / 2)
LPRINT : LPRINT TAB(7); "MG: "; d41; "/5"
LPRINT TAB(7); "Residual stocking"
LPRINT TAB(7); "I:"; y1; "/"; v1; "   II:"; y2; "/"; v2; "   III:"; y3; "/"; v3
LPRINT TAB(7); "Allowable cutting"
LPRINT TAB(7); "IV:"; y4; "/"; v4
LPRINT TAB(7); "VST:"; fnb(vf * .137982); "    MAI:"; fnb(v4 / 5); "    APR:"; 4.6
'2
y1 = CINT(pf * 9.08064): v1 = fnb(vv1 * y1)
y2 = CINT(y1 * .203): y3 = CINT(y2 * .412): v2 = fnb(vv2 * y2): v3 = fnb(vv3 * y3)
y4 = CINT(y3 * .666667): v4 = fnb(vv4 * y4)
LPRINT : LPRINT TAB(7); "MG: "; d41; "/10"
LPRINT TAB(7); "Residual stocking"
LPRINT TAB(7); "I:"; y1; "/"; v1; "   II:"; y2; "/"; v2; "   III:"; y3; "/"; v3
LPRINT TAB(7); "Allowable cutting"
```

```
LPRINT TAB(7); "IV:"; y4; "/"; v4
LPRINT TAB(7); "VST:"; fnb(vf * .255193); "    MAI:"; fnb(v4 / 10); "    APR:"; 5.4
'3
y1 = CINT(pf * 8.53684): v1 = fnb(vv1 * y1)
y2 = CINT(y1 * .203): y3 = CINT(y2 * .412): v2 = fnb(vv2 * y2): v3 = fnb(vv3 * y3)
y4 = CINT(y3 * .551724): v4 = fnb(vv4 * y4): y5 = CINT(y4 * .375)
v5 = fnb(y5 * (vv5 + vv4) / 2)
LPRINT : LPRINT TAB(7); "MG: "; d41; "/15"
LPRINT TAB(7); "Residual stocking"
LPRINT TAB(7); "I:"; y1; "/"; v1; "   II:"; y2; "/"; v2; "   III:"; y3; "/"; v3
LPRINT TAB(7); "Allowable cutting"
LPRINT TAB(7); "IV:"; y4; "/"; v4; "   V:"; y5; "/"; v5
LPRINT TAB(7); "VST:"; fnb(vf * .392435); "    MAI:"; fnb((v4 + v5) / 15); "    APR:"; 4.2
'4
y1 = CINT(pf * 6.68568): v1 = fnb(vv1 * y1)
y2 = CINT(y1 * .203): y3 = CINT(y2 * .412): v2 = fnb(vv2 * y2): v3 = fnb(vv3 * y3)
y4 = CINT(y3 * .588235): v4 = fnb(vv4 * y4): y5 = CINT(y4 * 1.275)
v5 = fnb(vv5 * y5)
LPRINT : LPRINT TAB(7); "MG: "; d41; "/20"
LPRINT TAB(7); "Residual stocking"
LPRINT TAB(7); "I:"; y1; "/"; v1; "   II:"; y2; "/"; v2; "   III:"; y3; "/"; v3
LPRINT TAB(7); "Allowable cutting"
LPRINT TAB(7); "IV:"; y4; "/"; v4; "   V:"; y5; "/"; v5
LPRINT TAB(7); "VST:"; fnb(vf * .430267); "    MAI:"; fnb((v4 + v5) / 20); "    APR:"; 5.2
'5
y1 = CINT(pf * 8.258): v1 = fnb(vv1 * y1)
y2 = CINT(y1 * .203): y3 = CINT(y2 * .412): v2 = fnb(vv2 * y2): v3 = fnb(vv3 * y3)
y4 = CINT(y3 * .612): v4 = fnb(vv4 * y4): y5 = CINT(y4 * .365)
v5 = fnb(y5 * (vv5 + vv4) / 2)
LPRINT : LPRINT TAB(7); "MG: "; d51; "/5"
LPRINT TAB(7); "Residual stocking"
LPRINT TAB(7); "I:"; y1; "/"; v1; "   II:"; y2; "/"; v2; "   III:"; y3; "/"; v3
LPRINT TAB(7); "IV:"; y4; "/"; v4
LPRINT TAB(7); "Allowable cutting"
LPRINT TAB(7); "V:"; y5; "/"; v5
LPRINT TAB(7); "VST:"; fnb(vf * .12908); "    MAI:"; fnb(v5 / 5); "    APR:"; 3.4
'6
y1 = CINT(pf * 7.4274): v1 = fnb(vv1 * y1)
y2 = CINT(y1 * .203): y3 = CINT(y2 * .412): v2 = fnb(vv2 * y2): v3 = fnb(vv3 * y3)
y4 = CINT(y3 * .612): v4 = fnb(vv4 * y4): y5 = CINT(y4 * .760869)
v5 = fnb(y5 * vv5)
LPRINT : LPRINT TAB(7); "MG: "; d51; "/10"
LPRINT TAB(7); "Residual stocking"
LPRINT TAB(7); "I:"; y1; "/"; v1; "   II:"; y2; "/"; v2; "   III:"; y3; "/"; v3
LPRINT TAB(7); "IV:"; y4; "/"; v4
LPRINT TAB(7); "Allowable cutting"
LPRINT TAB(7); "V:"; y5; "/"; v5
```

```
LPRINT TAB(7); "VST:"; fnb(vf * .246291); "    MAI:"; fnb(v5 / 10); "    APR:"; 3.7
'7
y1 = CINT(pf * 6.90322): v1 = fnb(vv1 * y1)
y2 = CINT(y1 * .203): y3 = CINT(y2 * .412): v2 = fnb(vv2 * y2): v3 = fnb(vv3 * y3)
y4 = CINT(y3 * .612): v4 = fnb(vv4 * y4): y5 = CINT(y4 * .697674)
v5 = fnb(vv5 * y5): y6 = CINT(y5 * .4): v6 = fnb(y6 * (vv6 + vv5) / 2)
LPRINT : LPRINT TAB(7); "MG: "; d51; "/15"
LPRINT TAB(7); "Residual stocking"
LPRINT TAB(7); "I:"; y1; "/"; v1; "   II:"; y2; "/"; v2; "   III:"; y3; "/"; v3
LPRINT TAB(7); "IV:"; y4; "/"; v4
LPRINT TAB(7); "Allowable cutting"
LPRINT TAB(7); "V:"; y5; "/"; v5; "   VI:;"; y6; "/"; v6
LPRINT TAB(7); "VST:"; fnb(vf * .350148); "    MAI:"; fnb((v5 + v6) / 15); "    APR:"; 3!
'8
y1 = CINT(pf * 6.57258): v1 = fnb(vv1 * y1)
y2 = CINT(y1 * .203): y3 = CINT(y2 * .412): v2 = fnb(vv2 * y2): v3 = fnb(vv3 * y3)
y4 = CINT(y3 * .612): v4 = fnb(vv4 * y4): y5 = CINT(y4 * .767)
v5 = fnb(vv5 * y5): y6 = CINT(y5 * .4): v6 = fnb(y6 * (vv6 + vv5) / 2)
LPRINT : LPRINT TAB(7); "MG: "; d61; "/5"
LPRINT TAB(7); "Residual stocking"
LPRINT TAB(7); "I:"; y1; "/"; v1; "   II:"; y2; "/"; v2; "   III:"; y3; "/"; v3
LPRINT TAB(7); "IV:"; y4; "/"; v4; "   V:"; y5; "/"; v5
LPRINT TAB(7); "Allowable cutting"
LPRINT TAB(7); "VI:"; y6; "/"; v6
LPRINT TAB(7); "VST:"; fnb(vf * .121662); "    MAI:"; fnb(v6 / 5); "    APR:"; 2.7
'9
y1 = CINT(pf * 6!): v1 = fnb(vv1 * y1)
y2 = CINT(y1 * .203): y3 = CINT(y2 * .412): v2 = fnb(vv2 * y2): v3 = fnb(vv3 * y3)
y4 = CINT(y3 * .612): v4 = fnb(vv4 * y4): y5 = CINT(y4 * .767)
v5 = fnb(vv5 * y5): y6 = CINT(y5 * .8125): v6 = fnb(vv6 * y6)
LPRINT : LPRINT TAB(7); "MG: "; d61; "/10"
LPRINT TAB(7); "Residual stocking"
LPRINT TAB(7); "I:"; y1; "/"; v1; "   II:"; y2; "/"; v2; "   III:"; y3; "/"; v3
LPRINT TAB(7); "IV:"; y4; "/"; v4; "   V:"; y5; "/"; v5
LPRINT TAB(7); "Allowable cutting"
LPRINT TAB(7); "VI:"; y6; "/"; v6
LPRINT TAB(7); "VST:"; fnb(vf * .22252); "    MAI:"; fnb(v6 / 10); "    APR:"; 2.9
RETURN
'-----------------------------------------------------------'-----------------------------------------------------------clo:
END
'-----------------------------------------------------------'-----------------------------------------------------------
```

Appendix B. Sample of the output of simulator SB-CORSO

```
                        PROGRAM SB-CORSICA
                        SIMULATOR SB-CORSO

Crown biomass (t/ha)
Needles: 5.3    live branches: 7    dead branches: .6
Crown: 13
Nutrients in the crown (kg/ha)

              N      P      K     Ca     Mg
Needles:    153.3   43.3   66.9   41.7   10.7
Branches:    18.4    1.5   16.9   22.2    3.8
Crown:      171.7   44.8   85.8   63.9   14.5


Age: 15     trees/ha: 2890     dbh: 8.8 cm
Height: 5.7 m     dominant height: 6.7 m     standing volume: 56 c.m./ha
Biomass (t/ha)
Stem wood: 24.4     stem bark: 6     roots: 2.2
Total: 46
Nutrients in the stem and roots (kg/ha)

              N      P       K      Ca     Mg
Stem:        33.4   18.2    38,5   27.4    6.1
Roots:        4.6     .2     2.9      2     .7
Total:      209.7   63.2   125.2   93.7   21.3


Age: 20     trees/ha: 1341     dbh: 12.9 cm
Height: 8.4 m     dominant height: 9.8 m     standing volume: 82.2  c.m./ha
Biomass (t/ha)
Stem wood: 35.7     stem bark: 8.8     roots: 3.1
Total: 61
Nutrients in the stem and roots (kg/ha)

              N      P       K      Ca      Mg
Stem:          49   26.7    53.4    40.1    8.9
Roots:        6.5     .3       4     2.8     .9
Total       227.2   71.8   143.2   106.8   24.3


Age: 25     trees/ha: 740      dbh: 17.4 cm
Height: 11.3  m     dominant height: 13.2 m        standing volume: 110.6 c.m./ha
Biomass (t/ha)
Stem wood: 48     stem bark: 11.8     roots: 4.1
Total: 77
```

```
Nutrients in the stem and roots (kg/ha)

               N     P      K      Ca    Mg
Needles:     65.8  35.9   71.8   53.8    12
Branches:     8.6    .4    5.3    3.7   1.2
Crown       246.1  81.1  162.9  121.4  27.7
```

Appendix C. Sample of the output of subprogram SB-CORSICANA

```
                    PROGRAM SB-CORSICA
                  SUBPROGRAM SB-CORSICANA

Your even-aged stand of Corsican pine is 10 years old
has 10097     trees/ha,    mean dbh= 5.76   cm and    74.686 c.m./ha.

Structure of the uneven-aged stand
The symmetric self-thinned uneven-aged stand has trees from age 10 to 75 years, allocated to six age classes,
each one with 11 years.

  Cl        f        V          Dd          v        d        A
I         763    20.759      5.5-14.     .027      8.4     2.184
II        155    42.469    14.2-24.7     .272     18.6    1.0753
III        64    64.281    24.8-33.9    1.004     28.9    26.042
IV         39    81.598      34-40.8    2.092     37.1    42.736
V          30     93.56    40.9-45.4    3.119     42.3    55.557
VI         25   101.176    45.5-48.2    4.047     46.3    66.668

Cl.=classes;f=trees/ha,V=standing volume, c.m./ha;dd=limits of the dbh of the class, cm;v=mean tree stem
volume, c.m.;d=mean tree dbh, cm
A=mean area occupied by a tree, s.m./tree.

                          Management guidelines

MG:  34 /5
Residual stocking
I: 1300 / 35.1        II: 264 / 72.336       III: 109 / 109.436
Allowable cutting
IV: 36 / 55.728
VST: 93      MAI: 11.146      APR: 4.6

MG:  34 /10
Residual stocking
I: 1126 / 30.402      II: 229 / 62.746       III: 94 / 94.376
Allowable cutting
IV: 63 / 131.796
VST: 172     MAI: 13.18       APR: 5.4
```

MG: 34 /15
Residual stocking
I: 1058 / 28.566   II: 215 / 58.91   III: 89 / 89.356
Allowable cutting
IV: 49 / 102.508   V: 18 / 46.899
VST: 264.502   MAI: 9.96   APR: 4.2

MG: 34 /20
Residual stocking
I: 829 / 22.383   II: 168 / 46.032   III: 69 / 69.276
Allowable cutting
IV: 41 / 85.772   V: 52 / 162.188
VST: 290   MAI: 12.398   APR: 5.2

MG: 40.9 /5
Residual stocking
I: 1024 / 27.648   II: 208 / 56.992   III: 86 / 86.344
IV: 53 / 110.876
Allowable cutting

MG: 40.9 /10
Residual stocking
I: 921 / 24.867   II: 187 / 51.238   III: 77 / 77.308
IV: 47 / 98.324
Allowable cutting
V: 36 / 112.284
VST: 166   MAI: 11.228   APR: 3.7

MG: 40.9 /15
Residual stocking
I: 856 / 23.112   II: 174 / 47.676   III: 72 / 72.288
IV: 44 / 92.048
Allowable cutting
V: 31 / 96.689   VI:; 12 / 42.996
VST: 236   MAI: 9.312   APR: 3

MG: 45.5 /5
Residual stocking
I: 815 / 22.005   II: 165 / 45.21   III: 68 / 68.272
IV: 42 / 87.864   V: 32 / 99.808
Allowable cutting
VI: 13 / 46.579
VST: 82   MAI: 9.316   APR: 2.7

MG: 45.5 /10
Residual stocking
I: 744 / 20.088   II: 151 / 41.374   III: 62 / 62.248
IV: 38 / 79.496   V: 29 / 90.451
Allowable cutting
VI: 24 / 97.128
VST: 149.979   MAI: 9.713   APR: 2.9