INCREMENT MODELS FOR SOME PLANTATION GROWN INDIGENOUS MELIACEAE

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ABSTRACT

The periodic annual increments of the stemdiameters from stands of three Meliaceae species, were used to develop predictive increment models. The models considered were of the 'distance independent' type. These models were linear and logarithmic in form. Some sort of a weighting factor (Dmax) was included in the equations, to take account of the differential competition status of individual trees. The r values ranged from o,37 to o, 634. Although the r values were small they were significant at p < o,o5. An age (3o years) was randomly chosen for observed diameters. The corresponding predicted values of diameters for the stands at age 3o years were obtained from a table of predicted diameters. Differences in the observed and predicted diameters were tested, using the Kolmogorov Smirnov two-sample test. They were found not to be significantly different at (p < o,o5 and p > o,o1).

INTRODUCTION

Diameter increment results from the rapid division fo the Cambial cells in the bark of trees. There are variations in the distribution of diameter increment, each year. Some of these variations are related to changes in weather and stand density while others are correlated with size or age (BICKFORD, 1962).The observations made by TOPCUOGHU (194o, quoted by AYHAM, 1978) showed a typical example of the annual progress of radial growth for different species, and the more rapid development of diameter in open grown pine.

The vertical distribution of the increments resulting from Cambial activities varies with stem height (ONAKA, 195o). Depending on the species, age, height growth patterns, tree class, site quality, forest grown trees show minimum diameter growth towards the base of stem, below and above this point, the growth rings increased gradually. The position of minimum diameter increment is not constant but always about 2o,8 % of the height of the tree from its base (total height) and is between 1,3 m and 6,7 m depending on the tree age, site factors, density, height of the tree class (TOPCUOGHU 194o, quoted by AYHAN, 1978).

Young trees with uniform crowns and slender cylindrical boles, have uniform and predictable variations in increment. The Meliaceae usually have cylindrical boles and the point of measurement of diameter and hence increment was fixed at breast height (1,32 m). Increment is expressed in several forms. Diameter increment can be expressed as yearly increases in diameter (annual increment), as a mean increment in diameter up to a certain age (mean annual increment), and as the average increment for a given period (periodic annual increment).

THE MODELS

Many models have been developed for predicting diameter increment (growth). RUDRA and FILMER (197o) used a combinatorial screening of variables in building a model for predicting tree diameters at breast height. They predicted the future diameter of stems by considering current diameter in relation to other readily measurable tree and stand parameters. These included height, stand density, age as well as their transformations. However, most traditional growth models are non-linear (NOKOE, 1974). The models considered in this study, belong to the distance independent single tree group (MUNRO, 1974). They were of the form:

$$\mathrm{Log}\ I \quad a + b \quad 1/D + c\ [\ (\ 1/D\ )\ /\ Dmax\ ] \qquad \text{(i)}$$

$$\mathrm{Log}\ I \quad a + b \quad 1/AGE + c\ [\ (\ 1/D\ )\ /\ Dmax\ ] \qquad \text{(ii)}$$

$$\mathrm{Log}\ I \quad b \quad 1/D + c\ [\ (\ 1/D\ )\ /Dmax\ ]\ \ldots\ldots\ldots\ldots\ldots\ldots \text{(iii)}$$

where Log = logarithm to base 1o of increment.
Increment (I) periodic annual increment,
AGE stand age,
D individual tree diameter (in cm),
Dmax = mean of the 16 largest trees in a given stand.

$[\ (\ 1/D\ )/Dmax\ ) \quad Dmax/D.$

It was realized that competition in stands is a major factor in the development of growth models. There was no information on inter-tree distances, crown depth, crown width and shapes. An index of competition had to be developed for these indigenous Meliaceae stands, and hence the use of (Dmax) as a competition index. The 16 largest trees in each stand represented between 25 to 4o % of the total number of trees. The idea was to ensure that the faster growing portion of the stand was included in the weighting factor (Dmax). It was also reasoned that, on the average, large trees were less affected by competition than small trees. A tree with exactly the same value as (Dmax) had the value of (Dmax/D) 1 as its weighting factor. The weighting factor (Dmax) was included in the increment equations to ensure that individual tree growth was fairly represented.

The reason for using Log I and the reciprocals of stand attributes was to minimize deviations in the observed data. The use of (Dmax) as a weighting factor had the following advantages over the use of tree distance and diameter relationship:-

(a) it showed better relationship between individual trees and dominance.

(b) as a tree gets smaller it 'sinks' more and more into the general crown level. This is expected since smaller trees are more affected by competition as expressed by (Dmax).

ESTIMATING THE MODEL COEFFICIENTS

The data for this study were obtained from the binders of the Forestry Research Institute of Nigeria. The Growth and Yield section of this Institute have carried out diameter measurements, at irregular periodic intervals in the indigenous Meliaceae stands in Sapoba since 1954. Three stands: *E. Cylindricum*, *K. ivorensis* and *L. trichilioides* were selected for this study. Periodical annual increments were obtained from diameter measurements on different dates. After an initial screening only equations (i) and (ii) were investigated further. Accordinq to KOZAK (1974) such condition regression as in equation (iii) require computations for the accompanying statistics like variance, r and standard errors.

To develop the increment models simple relationships were first developed between increment and stand attributes. The scattergrams resulting from them indicated that it was not unreasonable to assume a linear realationship between the increment of diameter and other stand attributes. Having observed this obvious trend logarithmic transformations of periodic annual increments were regressed on the transformed stand attributes [in the form of equations (i) and (ii) above] in multiple regressions, using the CSPSP programme (Oxford University). The resulting (final) models were of the form:

L. trichilioides

(a) $Log_{10}I \quad -o,165 + 5,47 \quad (1/AGE) - o,254 \quad (Dmax/D)$

(r = o,634); D.F. 24o

(b) $Log_{10}I \quad -o,oo176 + 9,24 \quad (1/D) - o,254 \quad (Dmax/D)$

(r = o,63o); D.F. 24o

K. ivorensis

(a) $Log_{10}I \quad -o,39o + 9,12 \quad (1/AGE) -o,266 \quad (Dmax/D)$

$(r = o,633); \quad D.F. \quad 166$

(b) $Log_{10}I \quad -o,127 + o,16 \quad (1/D) - o,266 \quad (Dmax/D)$

$(r = o,636); \quad D.F. \quad 166$

E. cylindricum

(a) $Log_{10}I \quad o,292 + 3,533 \quad (1/Age) -o,1o3 \cdot (Dmax/D)$

$(r = o,373); \quad D.F. \quad 27o$

(b) $Log_{10}{}^{I} \quad -o,178 + 5,38 \quad (1/D) - o,1o66 \cdot (Dmax/D)$

$(r \quad o,37o); \quad D.F. \quad 27o$

Although the r values were small, the regression equations were significant at $p < o,o5$. CLUTTER (1974) reported r values o,1o. He did conclude that it was not unusual to obtain small r values in such regressions involving stand attributes, and that such models were in most cases still good predictive models.

In all cases considered the first models in each stand (containing transformed values of age and diameter) was preferred. The second sets of equations contained only one stand attribute and its transformed values.

TESTING THE MODELS

A program (GROWIT, appendix 1) was written to test the selected models. GROWIT produced tables of predicted diameters (Table 1 - 3), given starting diameters (column 1), starting age and the model coefficients. Excepting the first column, on the tables of predicted diameters, each column was the result of the addition of the predicted yearly increments to previous years diameters.

An age (3o years) was randomly chosen for observed diameters. The corresponding predicted values of diameters for the relevant stands at age 3o years were obtained from tables (1 - 3). Differences in these populations (observed and predicted) were tested, using the KOLMOGOROV SMIRNOV two-sample test. They were found not to be significantly different at (p o,o5 and p o,o1). The predicted and observed diameters for *L. trichilioides* are on table 4.

DISCUSSION AND CONCLUSION

It was recognized that increments were very variable in these stands. In some cases the recorded increments were zero or even minus. Under such situations r values were expected to be small.

However, the r values obtained in these regressions were significant because of the large number of observations and therefore high degrees of freedom. The recorded slow growth rates indicated that year-round growing conditions, warm temperatures and abundant rainfall, did not produce rapid rates of diameter increment in these Meliaceae stands.

It was expected that like in most tropical indigenous species, growth would be slow (KIRA 1969, PRINCE 1973, WHITMORE 1974). However the growth rate was not expected to be that small (1,5 cm/yr) in plantation species. The linear models were to some extent consistent and good predictive models.

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TABLES of projected diameters (cm) from the increment model

[Examples]*

TABLE 1 *E. cylindricum*

26,o3 years	27,o3 years		31,o3 years		35,o3 years	36,o3 years
5,26	5,31	...	5,51	...	5,71	5,75
6,87	6,96	...	7,34	...	7,72	7,81
5o,13	5o,66	...	52,73	...	54,73	55,22
57,81	58,36	...	6o,5o	...	62,57	63,o8

TABLE 2 *K. ivorensis*

26,o3 years	27,o3 years		31,o3 years		35,o3 years	36,o3 years
8,49	8,51	...	8,57	...	8,63	8,64
8,89	8,91	...	9,99	...	9,o6	9,o7
52,96	53,45	...	55,27	...	56,94	57,34
53,77	54.26	...	56,11	...	57,79	58,19

TABLE 3 *L. trichilioides*

26,o3 years	27,o3 years		31,o3 years		35,o3 years	36,o3 years
6,87	6,89		6,97	...	7,o4	7,o5
6,87	6,89		6,97	...	7,o4	7,o5
44,47	45,o8	...	47,42	...	49,63	5o,17
45,68	46,3o	...	48,67	...	5o,92	51,47

*From table 1, 2 and 3 are only sections published. The original tables may be ordered from Mr. J.A. OKOJIE, University of Ibadan, Nigeria.

TABLE 4: Actual and (Predicted) Diameters (in cm) for *Lovoa trichilioides* (3o Years)

Diameter (in cm)			
Actual	Predicted	Actual	Predicted
6,37	6,95	28,7o	27,85
8,o8	6,95	29,91	29,99
1o,35	9,97	31,53	31,69
11,16	1o,84	32,58	31,69
13,74	13,49	33,8o	33,39
14,55	15,24	34,36	33,39
15,2o	15,68	35,57	33,82
15,6o	16,12	35,57	35,o9
18,19	17,43	36,79	36,78
18,19	18,31	37,43	37,62
19,oo	18,76	33,81	37,62
19,oo	19,63	33,81	38,o4
2o,62	2o,94	39,45	38,46
2o,86	21,37	39,54	38,89
21,o2	21,37	39,62	39,3o
22,48	21,37	39,86	39,73
22,64	21,81	4o,42	4o,56
22,88	22,24	42,o4	41,4o
23,o4	23,54	43,25	41,83
23,28	23,97	43,66	42,66
23,45	23,97	43,66	42,66
23,45	24,4o	43,9o	43,5o
24,26	24,4o	44,47	43,5o
24,26	24,4o	44,87	43,92
25,o6	24,84	44,87	43,92
25,47	24,84	45,11	44,33
26,o3	26,56	46,o8	44,14
26,52	26,99	46,o8	46,84
27,89	27,42	49,32	48,o9

PROGRAM GROWIT   APPENDIX 1

```
      INTEGER ITOT,IMAX(16)
      REAL*4 D(100,11),DD(100),INC(100),T,A,B,C,SIGD,DMAX,MAXD,LGI
      REAL*4 TT(11)
      DATA D/1100*0./,DD/100*0./,INC/100*0./,TT/11*0./
      WRITE(6,601)
601   FORMAT(' ','ENTER AGE OF TREES AT TIME T')
      READ*,T
      WRITE(6,602)
602   FORMAT(' ','ENTER VALUE OF A')
      READ*,A
      WRITE(6,603)
603   FORMAT(' ','ENTER VALUE OF B')
      READ*,B
      WRITE(6,604)
604   FORMAT(' ','ENTER VALUE OF C')
      READ*,C
      DO1 K=1,100
      READ(4,*)D(K,1)
      ITOT=K-1
      IF(D(K,1).LT.0)GOTO8
1     CONTINUE
8     DO2 J=1,10
      SIGD=0.
      DO3 N=1,16
      MAXD=0.
      IF(J.GT.1.1)GOTO5
      DO4 I=1,ITOT
      DD(I)=D(I,J)
      IF(DD(I).LT.MAXD)GOTO4
      MAXD=DD(I)
      IMAX(N)=I
4     CONTINUE
      SIGD=SIGD+DD(IMAX(N))
      DD(IMAX(N))=0.
      GOTO3
5     SIGD=SIGD+D(IMAX(N),J)
3     CONTINUE
      DMAX=SIGD/16.
      DO6 I=1,ITOT
      TT(J)=T+(J-1)*1.
      LGI=A+B/TT(J)+C*DMAX/D(I,J)
      INC(I)=10.**LGI
6     D(I,(J+1))=D(I,J)+INC(I)
2     CONTINUE
      TT(11)=TT(10)+1.
      WRITE(6,605)
605   FORMAT(////' ',32X,'TABLE OF PROJECTED DIAMETERS(CM) FROM THE INCR
     *EMENT MODEL'/)
      WRITE(6,607)(TT(M),M=1,11)
607   FORMAT(' ',11(5X,F6.2)/' ',11(6X,'YEARS')/)
      DO7 I=1,ITOT
7     WRITE(6,606)(D(I,J),J=1,11)
606   FORMAT(' ',11(4X,F7.2))
      STOP
      END
```