A preliminary trial of alternative methods for treating mortality in the multipurpose forest projection system (MFPS) model[1/]

by

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INTRODUCTION

This report documents a preliminary examination of alternative methods for treating mortality in the Multipurpose Forest Projection System (MFPS). The results are germane to efforts to refine the tree growth projection system (TGPS) model in the U.S. Forest Service's Forest Resource Evaluation Program (FREP) (USDA Forest Service, 1979). In its present form the MFPS model is simply a reduced size tree growth projection model as compared to TGPS. It uses most of the component model forms and coefficients developed for TGPS, but the coding (in FORTRAN) is more efficient and less tied to forest survey requirements.[3/]

Specific analyses conducted here were

a) a comparison of projection accuracy for growth period lengths longer than one year (the current TGPS model allows projections only by one year growth period lengths).

b) a comparison of alternative definitions of tree diameter, a mortality model predictor variable.

c) a comparison of deterministic versus stochastic mortality generation.

3/ The design and implementation of MFPS is due to Alan R. Ek, Dietmar W. Rose, and Michael T. Checky.

ANALYSES AND DISCUSSION

Projections were made for 11 survey plots from northeastern Minnesota, 7 of these having trees (318 total trees in the input list). This is an average of 45.4 trees per plot across the 7 plots. Table 1 attached describes differences in projections for deterministic probability of mortality model forms and varying growth period lengths for 6 of these sample plots.[4/] The six plots cover a range of forest cover types and ages. Projections were made as follows:

- -one 10 year growth period
- -two 5 year growth periods
- -five 2 year growth periods
- -ten 1 year growth periods

The table indicates differences in results for these 10 year projections for numbers of trees, basal area, and biomass. The table also indicates, by model form, three alternative definitions of the diameter term used in Buchman's (1979) mortality model. Results for the individual plots and their sum at the bottom of the table clearly suggests there is little if any loss in accuracy through the use of 1, 2, or 5 year growth period lengths. In fact, there appears to be very little loss from the one year period results by using even 10 year growth period lengths. Five of the six plots show an increase in numbers of trees and basal area as growth period length decreases. However, the third plot listed shows a decrease. An increase or decrease with growth period length apparently depends in part upon the initial stand conditions.

4/ One plot was ommitted due simply to incomplete line printer output.

Table 1. Differences in 10 year projections due to deterministic probability of mortality model form and growth period length for selected sample plots using NFPS.

Plot No.	Cover Type	Projections 1/ Periods (No.)	(Period Length) (Yrs)	Initial Conditions: No. of Trees in Input List	Stand Age	Per Acre No. of Trees	Per Acre Basal Area (ft^2)	Number of Trees, Model 3/ (1)	(2)	(3)	Basal area (ft^2), Model (1)	(2)	(3)	Biomass (dry tons), Model (1)	(2)	(3)
22	Aspen	1	(10)	57	75	1960	210	979	972	964	198	197	196	108.8	108.2	108.2
		2	(5)					988	985	982	201	201	201	110.7	110.5	111.5
		5	(2)					990	989	988	202	202	202	111.2	111.2	111.2
		10	(1)					990	990	990	202	202	202	111.4	111.4	111.4
24	Aspen	1	(10)	33	5	2828	100	1352	1363	1374	114	114	115	44.8	45.1	45.3
		2	(5)					1370	1374	1378	117	117	117	46.0	46.1	46.1
		5	(2)					1375	1376	1377	118	118	118	46.3	46.4	46.4
		10	(1)					1376	1376	1376	118	118	118	46.4	46.4	46.4
37	Black Spruce	1	(10)	35	55	1134	151	969	966	962	154	154	153	55.7	55.5	55.4
		2	(5)					965	963	962	153	153	153	55.3	55.2	55.1
		5	(2)					963	962	962	153	153	153	55.1	55.1	55.1
		10	(1)					962	962	962	152	152	152	55.0	55.0	55.0
38	Northern White Cedar	1	(10)	79	85	1860	324	1107	1107	1107	231	231	231	59.0	59.0	59.0
		2	(5)					1193	1193	1193	255	255	255	65.5	65.5	65.5
		5	(2)					1224	1224	1224	263	263	263	67.6	67.6	67.6
		10	(1)					1232	1232	1232	266	266	266	68.1	68.1	68.1
41	Aspen	1	(10)	22	5	856	51	215	233	232	50	50	50	29.1	29.2	29.2
		2	(5)					230	233	237	51	51	51	29.9	29.9	29.9
		5	(2)					236	237	238	52	52	52	30.3	30.3	30.3
		10	(1)					238	238	238	52	52	52	30.4	30.4	30.4
42	Northern White Cedar	1	(10)	47	45	1700	219	1132	1129	1125	191	191	190	64.7	64.5	64.5
		2	(5)					1153	1152	1150	197	197	196	66.7	66.6	66.6
		5	(2)					1160	1160	1159	199	199	199	67.4	67.4	67.4
		10	(1)					1162	1162	1162	199	199	199	67.6	67.6	67.6
Sum		1	(10)			10338	1055	5754	5770	5764	938	937	935	362.1	361.5	361.6
		2	(5)					5899	5900	5902	974	974	976	374.1	373.8	374.7
		5	(2)					5948	5948	5948	987	987	987	377.9	378.0	378.0
		10	(1)					5960	5960	5960	989	989	989	378.9	378.9	378.9

1/ For projections with growth periods longer than one year, probability of mortality was determined as $1-(1-PM)^L$ where PM is estimated average annual mortality from the model forms described below and L is the length of the growth period in years.

2/ Projections with probability of mortality model from Buckman (1979). The basic fitted model employes current diameter at breast height (D_c) and past year annual diameter growth (ΔD) as variables. Current diameter D_c is equivalent to initial (at start of growth period) diameter (D_i) + $\Delta D \cdot n$ where n is the growth period length in years.

3/ Model forms considered for projections varied in the definition of variable. The growth variable ΔD, was in all cases defined as average annual growth as estimated from D_c and stand conditions. The diameter variable was alternatively defined as:

Model (1) $D_i + \Delta D$
Model (2) $D_i + \Delta D + D_c)/2$
Model (3) D_c

Note that all three models are equivalent for a growth period length of one year.

Table 2 compares 10 year projections (ten 1 year growth periods) for the deterministic mortality described in Table 2, and three stochastic runs for the same 6 plots. Results for the individual plots and the mean for the deterministic and stochastic trials at the bottom of the table clearly suggest little if any difference in the two treatments of mortality. The deterministic mortality in this case is obtained by reducing the per acre expansion factor for each tree by its survival probability as the run progresses.

Regarding efficiency, projections for the 11 plots for the various growth period lengths rank as follows:

	Central Processor time (Cyber 172)
-one 10 year growth period:	3.47 sec
-two 5 year growth periods:	4.90 sec
-five 2 year growth periods:	9.23 sec
-ten 1 year growth periods:	16.34 sec

Note that all of these times include the initialization of the model involving the reading in of the parameter file. It does not include compilation but it does include printing at the end of each growth period.

The opportunity to use longer growth period lengths and maintain accuracy can be of considerable consequence for handling hundreds if not thousands of projections. Also, it is comforting to note that there appears to be little difference between projections for deterministic and stochastic mortality treatment in terms of basic stand characteristics.

The above results are admittedly from a limited trial. It would be helpful to repeat the analysis for a much larger range of plots. This preliminary analysis, however, does suggest opportunities.

Table 2: Differences in 10 year projections (ten 1 year growth periods) with deterministic and stochastic mortality for selected sample plots using MFPS.

Plot No.	Cover Type	Type of 1/ 2/ Projection	Initial Conditions: No. of Trees in Input List	Initial Conditions: Stand Age	Per Acre: No. of Trees	Per Acre: Basal area (ft^2)	Projection (per acre basis): Number of trees	Projection (per acre basis): Basal area (ft^2)	Projection (per acre basis): Biomass (dry weight tons)
22	Aspen	Deterministic	57	75	1960	210	990	202	111.4
		Stochastic					649	188	107.0
		Stochastic					957	202	114.3
		Stochastic					948	205	108.6
24	Aspen	Deterministic	33	5	2828	100	1376	118	46.4
		Stochastic					1328	110	43.8
		Stochastic					1228	109	43.3
		Stochastic					1128	91	37.5
37	Black Spruce	Deterministic	35	55	1134	151	962	152	55.0
		Stochastic					710	141	50.6
		Stochastic					956	144	52.9
		Stochastic					1104	167	59.4
38	Northern White Cedar	Deterministic	79	85	1860	324	1232	266	68.1
		Stochastic					1403	274	68.8
		Stochastic					1497	285	72.9
		Stochastic					1292	270	69.3
41	Aspen	Deterministic	22	5	856	51	238	52	30.4
		Stochastic					152	38	23.2
		Stochastic					241	51	29.9
		Stochastic					256	55	32.7
42	Northern White Cedar	Deterministic	47	45	1700	219	1162	199	67.6
		Stochastic					953	185	64.5
		Stochastic					1190	206	70.4
		Stochastic					1088	189	62.4
Mean		Deterministic					993	165	63.2
		Stochastic					949	162	61.8

1/ Projections with probability of mortality from Buckman (1979). Deterministic projections reduce per acre tree expansion factors gradually. Stochastic projections remove entire trees from input tree list upon death and reduce the tree expansion factor to zero. The model used is that from table 1. Note that all three deterministic model forms given in Table 1 are identical for one year growth periods.

2/ Stochastic projections are presented for three different random starts.

LITERATURE CITED

Buchman, R.G. 1979. Mortality Functions. In: A generalized forest growth projection system. USDA Forest Service, Gen. Tech. Rep. NC-49, pp 47-55.

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