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Revised Parameter Estimates for CACTOS Growth Models

by

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Abstract

Revised growth coefficients are presented for the California (CA) Conifer Timber Output Simulator (CACTOS). These coefficients, for both tree diameter and height growth, were computed using data from three growth periods for over 600 permanent growth plots maintained by industry members of the Northern California Forest Yield Cooperative. Coefficients are released in computer files that are read directly into the CACTOS program on start up.

Introduction

The previous growth coefficients[1] for CACTOS were built with diameter growth data measured from permanent plots from 1979-1985 and height growth from stem analysis data collected in 1979 and 1980. These coefficients produced overestimates of growth for the second growth period. The differences in the growth rates for the first two periods was a direct result of the higher than average rainfall in the first period and the lower than average rainfall in the second. Subsequently, a rainfall-based adjustment was introduced[2] as a temporary measure until the data from the third remeasurement was available. This paper reports on the results of the fit of a rainfall-based model that was fit to the data for three growth periods. A complete description of the model and coefficients will be presented in a separate paper. This paper announces the availability of the new coefficient files for CACTOS and presents a comparison of the prediction errors for the different coefficient sets.

Growth and climate data

Data used here covered three measurement periods from 1978-1998 for the permanent growth plots managed by the industry members of the Northern California Forest Yield Cooperative.

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[1] The previous growth model coefficients are contained in the computer file cofile.411 distributed with the CACTOS program versions up through 6.4.

[2] This growth comparison was reported in Research Note No. 40 (Wensel and Turnblom, 1994).

These growth plots are distributed across forest industry lands in the central and northern Sierra, the California Cascades, the Shasta-Trinity area, and the area on the ease side of the southern Mendocino range. The initial measurements were during 1978-1983, the first remeasurement from 1984 to 1987, the second remeasurement from 1988 to 1991, and the third remeasurement from 1995 to 1998. The number of growth plots varies by period because some plots were logged or lost due to change in ownership. The balanced data set consists of only the trees on plots that were measured at all 4 points in time[3]. The unbalanced data set include all trees that have growth measurement for any of the three periods. Both data sets were divided into 2 subsets, putting the even-numbered plots into one sample for model fitting, and the odd-numbered plots into the other for testing.

The climate data consists of annual precipitation for the water years (October 1 through September 30) from 1970 through 1998 for 77 northern California weather stations outside the Central Valley. A strong correlation was observed among the precipitation levels at individual stations. The relative amount of precipitation was similar across stations within a similar geographical region (Wensel and Turnblom 1998; Yeh, Wensel and Turnblom *in progress*) and the state was divided into three regions for climate summaries. Black Butte, Klamath, and the sum of the Trinity Alps, Southern Cascade, and Sierra Nevada areas. The climatic variation patterns within each of these regions are statistically the same, meaning that if one station has 30 percent more precipitation or higher temperatures than the average for that station, the other stations in that region will experience the same.

Models and analysis

The form of the growth models developed in earlier papers by Wensel and Koehler (1985) and Wensel, Meerschaert, and Biging (1987) was basically kept for this study. An additional climatic variable, precipitation, was added to the model. Conceptually, the original models express tree growth as a product of two factors, potential growth component and competition component. The first component is intended to reflect the physiological capacity of the tree while the second component is intended to reflect the competition on the site. In this study, a climate adjustment was made on the potential growth based upon the precipitation level present because water stress represented by a precipitation level may limit growth to reach its potential. Also, a complete description of the models will be presented in a subsequent paper.

[3] On the "balanced" plots, there are mortality and ingrowth trees that were not measured every time.

For fitting purposes, only the trees on the "balanced" were used. These plots were divided into two groups with the even-numbered plots being used for fitting and the odd-numbered plots used for testing (except for red fir where number of plots was too small to divide). The model was further tested by applying the model to all trees that were available measured in at least one period, the "unbalanced" plots. This later data set was considerably larger since many of the plots were logged or were lost when ownership changed.

The actual coefficients are presented in the CACTOS coefficient file *cofile.603* which is available directly from the authors or by downloading it from the CACTOS website (http://www.CNR.Berkeley.EDU/~wensel/cactos/cactoss.htm).

Comparisons

The average percentage errors for three coefficient sets are presented in the tables that follow. These coefficients are (1) the set reported by Wensel and Robards (1989)[4], (2) the first set with the adjustments for precipitation reported by Wensel and Turnblom (1998)[5] and (3) the current set fitted to all three measurement periods.

Looking at the following tables one can see the improvements in the overall predictions of tree diameter and height growth. Tables 1 through 4 illustrate the improvements in diameter growth predictions using the three coefficient sets. Tables 1 through 3 present the results for the three coefficient sets as applied to the balanced data set while Table 4 shows the effect of applying the new coefficients to the full permanent plot data set, the unbalanced data set. While there is considerable variation between the species within each table, the final table shows all the percentage errors to be lower than 10% in absolute value except for red fir in the first period.

Table 1. Comparison of observed and predicted basal area growth using the previous growth coefficients (cofile 411) without climatic adjustments for trees on plots measured all 4 times, the "balanced" data set (411_000).

	Number of plots	1st period			2nd period			3rd period		
		Obs.	Pred.	Err %	Obs.	Pred.	Err %	Obs.	Pred.	Err %
PP	233	3.22	3.00	6.83	2.66	3.19	-19.92	3.07	3.39	-10.42
SP	136	2.61	2.34	10.34	2.64	2.52	4.54	3.05	2.79	8.52
IC	210	2.21	1.58	28.51	1.82	1.63	10.44	2.26	1.69	25.22
DF	175	3.98	3.84	3.52	3.75	4.28	-14.13	4.17	4.68	-12.23
WF	255	4.06	3.66	9.85	3.56	3.89	-9.27	4.16	4.40	-5.77
RF	18	2.72	2.79	-2.57	3.01	3.22	-6.98	3.18	3.53	-11.01

[4] This set of coefficients is contained in the CACTOS coefficient file cofile.411.
[5] CJFR

Table 2. Comparison of observed and predicted basal area growth using the previous growth coefficients (cofile 411) with climatic adjustments for trees on plots measured all 4 times, the "balanced" data set (411_011).

	Number of plots	1st period			2nd period			3rd period		
		Obs.	Pred.	Err %	Obs.	Pred.	Err %	Obs.	Pred.	Err %
PP	233	3.22	3.00	6.83	2.66	2.36	11.28	3.07	3.09	-0.65
SP	136	2.61	2.34	10.34	2.64	2.23	15.53	3.05	2.69	11.80
IC	210	2.21	1.58	28.51	1.82	1.21	33.52	2.26	1.55	31.42
DF	175	3.98	3.84	3.52	3.75	3.26	13.07	4.17	4.32	-3.60
WF	255	4.06	3.66	9.85	3.56	3.30	7.30	4.16	4.17	-0.24
RF	18	2.72	2.79	-2.57	3.01	2.91	3.32	3.18	3.42	-7.55

Table 3. Comparison of observed and predicted basal area growth using the new coefficients for both growth and climate adjustment (cofile 603) for trees on plots measured all 4 times, the "balanced" data set. (603_111).

	Number of plots	1st period			2nd period			3rd period		
		Obs.	Pred.	Err %	Obs.	Pred.	Err %	Obs.	Pred.	Err %
PP	233	3.22	3.17	1.55	2.66	2.63	1.13	3.07	3.33	-8.47
SP	136	2.61	2.62	-0.38	2.64	2.57	2.65	3.05	3.12	-2.29
IC	210	2.21	2.08	5.88	1.82	1.82	0	2.26	2.26	0
DF	175	3.98	3.69	7.29	3.75	3.87	-3.2	4.17	4.48	-7.43
WF	255	4.06	3.55	12.56	3.56	3.29	7.58	4.16	4.16	0
RF	18	2.72	2.33	14.34	3.01	2.75	8.64	3.18	3.00	5.66

Table 4. Comparison of observed and predicted basal area growth using the new coefficients for both growth and climate adjustment (cofile 603) for trees with any remeasurements, the "unbalanced" data set. (603_112).

	1st period				2nd period				3rd period			
	Num. of plots	Obs.	Pred.	Err %	Num. of plots	Obs.	Pred.	Err %	Num. of plots	Obs.	Pred.	Err %
PP	336	5.84	5.90	-1.03	302	3.96	3.87	2.27	263	3.74	3.82	-2.14
SP	247	3.92	4.02	-2.55	202	3.2	3.18	0.63	168	3.16	3.17	-0.32
IC	352	3.49	3.49	0.00	297	2.64	2.63	0.38	244	2.82	2.54	9.93
DF	291	5.7	5.22	8.42	243	5.35	5.14	3.93	215	4.83	4.85	-0.41
WF	419	7.56	7.22	4.50	346	5.72	5.4	5.59	307	4.95	4.71	4.85
RF	46	6.69	5.88	12.11	29	4.59	4.25	7.41	23	3.54	3.44	2.82

The comparison of average percentage errors for height predictions is given in Tables 5 through 7[6]. As with the diameter growth predictions, following the results for a given species through the three tables shows some variation in the success. There appears to be considerable room for improvement for the various data sets even though most of the differences are less than 10%. As viewed in Table 6 for the balanced data set, ponderosa pine, Douglas-fir, and red fir are showing almost 14, 13 and 21 percentage errors in the third period while only red fir shows an error larger than ten percent for the third period in Table 7 for the full data set.

[6] Wensel and Turnblom (1998) did not compute climate adjustments for height growth so there is no height table equivalent to Table 2 for basal area.

Table 5. Comparison of observed and predicted height growth using the previous growth coefficients (cofile 411) without climatic adjustments for trees on plots measured all 4 times, the "balanced" data set (411_000).

	Number of trees	1st period			2nd period			3rd period		
		Obs.	Pred.	Err %	Obs.	Pred.	Err %	Obs.	Pred.	Err %
PP	969	4.99	5.58	-11.82	3.88	5.46	-40.72	3.63	5.36	-47.66
SP	282	5.21	5.37	-3.07	4.77	5.16	-8.18	4.90	5.01	-2.24
IC	613	3.54	2.92	17.51	2.86	2.79	2.45	2.81	2.68	4.63
DF	716	5.41	5.41	0	4.42	5.33	-20.59	4.34	5.17	-19.12
WF	1025	5.84	5.42	7.19	4.76	5.27	-10.71	4.27	5.22	-22.25
RF	53	5.45	4.80	11.93	4.83	4.90	-1.45	3.66	4.93	-34.70

Table 6. Comparison of observed and predicted ~~basal area~~ height growth using the new coefficients for both growth and climate adjustment (cofile 603) for trees on plots measured all 4 times, the "balanced" data set. (603_111).

	Number of trees	1st period			2nd period			3rd period		
		Obs.	Pred.	Err %	Obs.	Pred.	Err %	Obs.	Pred.	Err %
PP	969	4.99	4.63	7.21	3.88	3.51	9.54	3.63	4.14	-14.05
SP	282	5.21	5.79	-11.13	4.77	4.86	-1.89	4.90	5.34	-8.98
IC	613	3.54	3.33	5.93	2.86	2.55	10.84	2.81	2.91	-3.56
DF	716	5.41	5.33	1.48	4.42	4.39	0.68	4.34	4.89	-12.67
WF	1025	5.84	5.23	10.44	4.76	4.19	11.97	4.27	4.66	-9.13
RF	53	5.45	4.61	15.41	4.83	4.67	3.31	3.66	4.46	-21.86

Table 7. Comparison of observed and predicted height growth using the new coefficients for both growth and climate adjustment (cofile 603) for trees with any remeasurements, the "unbalanced" data set. (603_112).

	1st period				2nd period				3rd period			
	Num. of trees	Obs.	Pred.	Err %	Num. of trees	Obs.	Pred.	Err %	Num. of trees	Obs.	Pred.	Err %
PP	2812	5.14	4.48	12.84	1988	3.99	3.50	12.28	1355	3.77	4.13	-9.55
SP	772	5.43	5.59	-2.95	573	4.64	4.66	-0.43	402	4.81	5.19	-7.90
IC	1810	3.66	3.15	13.93	1367	2.87	2.42	15.68	885	2.81	2.86	-1.78
DF	1654	5.32	5.33	-0.19	1458	4.82	4.33	10.17	1092	4.63	4.95	-6.91
WF	3313	5.46	5.05	7.51	2449	4.50	4.05	10.00	1594	4.37	4.61	-5.49
RF	249	5.05	4.79	5.15	121	5.01	4.62	7.78	82	4.14	4.62	-11.59

Using the new coefficient files

After obtaining the new coefficient file either from the authors or directly from the CACTOS web site, you must then delete the binary file "*cofbin*" from the CACTOS directory on your computer. This file contains the binary version of the coefficients used to set up CACTOS each time the program is run. With *cofbin* missing, the program will prompt you to identify the coefficient files you want to use. You should specify *cofile.603* in place of the previous *cofile.411*. Later version of CACTOS will also ask for the climate file (specify *cofile.103*) and the volume equation file (specify *cofile.500*).

Please contact Lee Wensel (wensel@nature.berkeley.edu) if you have any problems getting CACTOS to run with the new coefficient file.

Literature Cited

Wensel, L. C. and Turnblom, E. C. 1994. A comparison of CACTOS short- term growth projections with observed growth, Research Note No. 40. Northern Calif. Forest Yield Cooperative. Dept. of Forestry and Resource Mgmt., Univ. of Calif., Berkeley. 8 pp.

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