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Method for Estimating Potential Tree-Grade Distributions for Northeastern Forest Species

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Abstract

Generalized logistic regression was used to distribute trees into four potential tree grades for 20 northeastern species groups. Potential tree grade is defined as the tree grade based solely on the length and amount of clear cuttings and defects, disregarding minimum grading diameters. The algorithms described use site index and tree diameter as the predictive variables, allowing the equations to be incorporated into individual-tree growth and yield simulators such as NE-TWIGS.

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An asterisk was inadvertently replaced with a plus sign in an equation of the Methods section on page 6 and in a footnote of Table 3 on page 8. The equation should read:

$$f_i = b_{i0} + b_{i1} * \text{site index} + b_{i2} * \text{d.b.h.} + b_{i3} * \text{site index} * \text{d.b.h.}$$

Use of the equation is properly demonstrated in the Application section.

Introduction

To quantify the value potential of a tree in a simulator, some form of quality must be assigned. Models have been developed that allow the distribution of butt-log grades over diameter at breast height (d.b.h.) (Ernst and Marquis 1979; Myers and others 1986; Dale and Brisbin 1985). This method provides a snapshot of quality and value, but does not indicate the potential of the trees. Lyon and Reed (1987) developed discriminant functions to assign tree grades to northern species, and provided additional discriminant functions which predicted future tree grades based on initial grades. These functions were incorporated into PROQUAL, an uneven-age stand-level simulator based on the SHAF model by Adams and Ek (1974).

Potential grade (Gp) (Yaussy 1991a) is a variable that accounts for the change in tree quality over time. Yaussy (1991b) describes a method to estimate the probability that a tree in an even-aged upland oak stand would be in one of four Gp classes. For this forest type, it was found that species, d.b.h., and stand age were the variables most correlated with Gp. But in expanding this research to different forest types with indeterminate age structures, it was apparent that another stand variable was needed. Using the same upland oak data set, correlations were calculated between Gp and basal area, site index, tree d.b.h. relative to quadratic mean d.b.h., and basal area in trees with larger diameters. Of the variables tested, site index had the highest correlation with Gp. Site index also is useful because it is unaffected by management practices.

This paper describes the use of generalized logistic regression to estimate the probability distribution of Gp as a function of species group, site index, and d.b.h. Equations are presented for 20 species groups found in age-indeterminate stands of the Northeastern United States.

Data Source

Data for this study were collected by the Forest Inventory and Analysis (FIA) unit of the Northeastern Forest Experiment Station as part of the periodic survey of forested lands. Data were collected from 1/5-acre permanent plots in the most recent inventories of Kentucky, Maryland, Pennsylvania, and West Virginia. Table 1 lists the numbers of trees by species and the resulting 20 species groups used by NE-TWIGS. Site index (base age 50 years) was measured on each plot for the dominant species. For other species on the plot, conversion equations were used to assign the appropriate site index to each tree.[1] Table 2 lists the descriptive statistics for the variables of interest by species groups. Roughly 10 percent of the data set was randomly chosen for a validation data set.

[1]Teck, R.M.; Fuller, L.G.; Hilt, D.E. 1988. Untitled report on file at the Northeastern Forest Experiment Station, Delaware, OH.

Table 1.—Number of observations by species and species group

Species group	Code	Species	No. in species	No. in group
Ash	ASH	Black ash	2	2,273
		Green ash	83	
		Pumpkin ash	1	
		White ash	2,187	
Basswood	BAS	American basswood	1,229	1,247
		White basswood	18	
Beech	BEE	American beech	3,897	3,897
Birch	BIR	River birch	67	1,873
		Sweet birch	1,384	
		Paper birch	20	
		Yellow birch	402	
Black cherry	BLC	Black cherry	3,964	4,001
		Cherry/plum spp.	19	
		Pin cherry	18	
Black oak	BLO	Black oak	4,319	4,319
Chestnut oak	CHO	Chestnut oak	7,404	7,736
		Swamp chestnut oak	55	
		Chinkapin oak	74	
		Post oak	200	
Commercial hardwoods	COH	Buckeye spp.	156	4,969
		Catalpa	2	
		Hackberry	42	
		Persimmon	20	
		Butternut	75	
		Black walnut	484	
		Sweetgum	690	
		Magnolia spp.	96	
		Cucumbertree	557	
		Water tupelo	36	
		Blackgum	871	
		Paulownia	9	
		American sycamore	404	
		Eastern cottonwood	14	
		Bigtooth aspen	471	
		Quaking aspen	84	
		Black willow	18	
		Sassafras	293	
		Elm spp.	647	
Hemlock	HEM	Atlantic white-cedar	6	2,912
		Baldcypress	16	
		Balsam fir	4	
		Eastern hemlock	2,681	
		Eastern redcedar	97	
		Red spruce	93	
		Tamarack	13	
		White spruce	2	
Hickory	HIC	Hickory spp.	3,549	3,549
Noncommercial hardwoods	NOH	Ailanthus	8	1,235
		American holly	24	
		American hornbeam	1	
		Apple	29	

Table 1.—Continued

Species group	Code	Species	No. in species	No. in group
Noncommercial hardwoods	NOH			
		Balsam poplar	17	
		Black locust	992	
		Eastern hophornbeam	22	
		Eastern redbud	2	
		Honeylocust	9	
		Kentucky coffeetree	2	
		Mulberry spp.	7	
		Osage-orange	4	
		Serviceberry	22	
		Sourwood	55	
		Sugarberry	2	
		Unknown spp.	39	
Northern red oak	NRO	Northern red oak	7,609	7,609
Other red oaks	ORO	Blackjack oak	2	3,134
		Cherrybark oak	44	
		Pin oak	108	
		Scarlet oak	2,311	
		Shingle oak	23	
		Shumard oak	3	
		Southern red oak	495	
		Water oak	29	
		Willow oak	119	
Other pines	OTP	Austrian pine	1	2,746
		Loblolly pine	1,425	
		Pitch pine	652	
		Pond pine	7	
		Red pine	275	
		Scotch pine	64	
		Shortleaf pine	262	
		Table Mountain pine	60	
Red maple	REM	Boxelder	62	8,178
		Mountain maple	2	
		Red maple	7,977	
		Silver maple	136	
		Striped maple	1	
Sugar maple	SUM	Black maple	314	4,470
		Sugar maple	4,156	
Virginia pine	VIP	Virginia pine	2,269	2,269
White oak	WHO	Bur oak	3	6,781
		Swamp white oak	72	
		White oak	6,706	
White pine	WHP	Eastern white pine	1,458	1,458
Yellow-poplar	YEP	Yellow-poplar	7,221	7,221

Table 2.—Descriptive statistics for the development and validation data sets

Species group	Variable	Development N	Development Mean	Development Std. Dev.	Validation N	Validation Mean	Validation Std. Dev.
ASH		2,030			243		
	D.b.h.		15.58	4.30		15.21	3.79
	Site index		66.31	16.27		65.73	16.22
	Gp		2.66	1.04		2.69	1.00
BAS		1,135			112		
	D.b.h.		15.46	3.91		15.30	3.91
	Site index		69.07	19.22		63.33	17.34
	Gp		2.70	1.04		2.70	1.03
BEE		3,482			415		
	D.b.h.		18.02	5.88		17.73	5.63
	Site index		62.70	18.53		61.53	18.44
	Gp		3.73	0.57		3.72	0.58
BIR		1,664			209		
	D.b.h.		14.23	3.38		14.09	3.04
	Site index		57.53	16.86		57.23	17.14
	Gp		3.41	0.72		3.40	0.73
BLC		3,619			382		
	D.b.h.		15.70	4.10		15.56	4.23
	Site index		63.76	15.35		63.94	15.78
	Gp		2.73	1.05		2.86	1.01
BLO		3,888			431		
	D.b.h.		16.89	4.94		16.48	5.15
	Site index		63.91	14.99		63.42	14.67
	Gp		2.72	1.02		2.76	1.02
CHO		6,971			765		
	D.b.h.		16.00	4.71		15.72	4.65
	Site index		57.15	14.92		56.77	14.66
	Gp		2.95	0.92		2.95	0.92
COH		4,465			492		
	D.b.h.		15.27	4.31		15.11	3.64
	Site index		68.90	18.02		69.48	18.12
	Gp		3.06	0.96		3.05	0.97
HEM		2,641			269		
	D.b.h.		14.34	4.66		14.37	4.65
	Site index		50.06	13.90		50.01	14.97
	Gp		2.17	1.46		2.04	1.43
HIC		3,191			358		
	D.b.h.		14.67	3.40		14.64	3.50
	Site index		63.80	16.45		62.89	16.14
	Gp		2.93	0.96		2.94	0.92

Table 2.—Continued

Species group	Variable	Development N	Development Mean	Development Std. Dev.	Validation N	Validation Mean	Validation Std. Dev.
NOH		1,103			132		
	D.b.h.		14.84	4.00		14.94	3.42
	Site index		55.29	19.37		55.58	19.40
	Gp		3.56	0.70		3.69	0.57
NRO		6,840			769		
	D.b.h.		17.20	5.50		17.29	5.64
	Site index		61.19	15.65		60.30	15.24
	Gp		2.68	1.03		2.67	1.04
ORO		2,817			317		
	D.b.h.		16.14	3.52		15.85	4.30
	Site index		62.27	15.00		62.65	14.50
	Gp		3.26	0.88		3.36	0.82
OTP		2,480			266		
	D.b.h.		12.17	2.64		12.57	3.06
	Site index		67.16	14.74		66.67	14.82
	Gp		2.31	0.89		2.26	0.90
REM		7,365			813		
	D.b.h.		15.20	4.22		15.19	4.06
	Site index		58.96	15.21		58.75	15.05
	Gp		3.39	0.77		3.37	0.80
SUM		3,737			422		
	D.b.h.		15.58	4.64		15.89	4.87
	Site index		60.75	16.39		61.11	16.69
	Gp		3.23	0.87		3.32	0.84
VIP		2,051			218		
	D.b.h.		11.45	2.03		11.48	1.99
	Site index		65.97	12.95		65.98	12.75
	Gp		2.94	0.48		2.93	0.49
WHO		6,054			727		
	D.b.h.		15.95	4.72		15.76	4.53
	Site index		59.34	13.42		59.51	14.27
	Gp		2.86	0.97		2.88	0.99
WHP		1,299			159		
	D.b.h.		15.45	5.37		15.23	4.88
	Site index		61.04	15.61		63.30	16.55
	Gp		2.72	1.05		2.68	1.05
YEP		6,454			767		
	D.b.h.		16.27	4.52		16.02	4.57
	Site index		81.86	18.11		82.47	17.97
	Gp		2.77	1.12		2.80	1.11

Variable Definition

Hardwoods

USDA Forest Service hardwood tree grading standards include d.b.h. restrictions of 16 inches for a grade 1 tree and 13 inches for a grade 2 (Hanks 1976). Gp disregards these d.b.h. restrictions and surface defects that will disapear as the tree grows. Gp is defined as the actual Forest Service tree grade that a tree will attain when it grows into the 16-inch diameter class. When a tree enters the 16-inch class, Gp and actual tree grade will be identical. Gp is a discrete variable with four categories: grade 1, grade 2, grade 3, and below grade. Actual tree grade for hardwoods can be determined directly from Gp and d.b.h. For example, a tree with Gp of 1 and d.b.h. of 12.4 would have an actual grade of 3. As d.b.h. increases beyond the 12.6- and 15.6-inch thresholds, the actual grade would change to 2 and then to 1.

White Pine

The white pine tree grades used by FIA require four full length clear faces for a tree to be considered grade 1 unless the d.b.h. is larger than 16 inches. This restriction would be relaxed for Gp determination. Actual tree grade cannot be determined from white pine Gp since there can be grade 1 trees less than 16 inches d.b.h. if they have four full-length clear faces.

Other Pines

All other pines were graded using the southern pine tree grading system which has no diameter restrictions. Therefore, Gp is identical to actual tree grade and the equations in this study partition the other pines into actual tree grades.

Other Conifers

Minimum merchantability standards were used to sort the spruce, fir, tamarack, and hemlock trees into two classes: merchantable and cull. The only diameter restriction imposed was that 3-inch knots were acceptable if the small end of the grading section was 13 inches or more (inside bark); otherwise, the knots must be 2 inches or less.

Methods

The proportions of trees in each Gp category based on d.b.h. and age were estimated by generalized logistic regression (GLR) as described by the CATMOD procedure of SAS (1985). With a discrete response variable and continuous predictor variables, the maximum likelihood procedure of logistic regression is indicated. Logistic regression is normally used with dichotomous response variables; however, GLR allows responses with more than two levels.

Let p_i denote the probability that the response equals i ($i = 1, \ldots, r$). A GLR model is of the form:

$$\ln (p_j/p_r) = f_j \tag{1}$$

where:

$j = 1, \ldots, r\text{-}1$

f_j = a function of predictor variables.

If follows from (1) that:

$$p_j = p_r * \exp(f_j). \tag{2}$$
$$p_j/p_r = \exp(f_j)$$

Note that the p_i's must sum to 1, therefore:

$$1 = \sum_{j=1}^{r-1} p_j + p_r$$
$$= \sum_{j=1}^{r-1} (p_r * \exp(f_j)) + p_r$$
$$= p_r * (1 + \sum_{j=1}^{r-1} \exp(f_j))$$

and

$$p_r = 1/(1 + \sum_{j=1}^{r-1} \exp(f_j)). \tag{3}$$

In the case of Gp being response variable and d.b.h. and site index being the predictor variables:

p_i = the probability that Gp equals i, i = 1, 2, 3, below grade.

$f_j = b_{j0} + b_{j1} * \text{site index} + b_{j2} + \text{d.b.h.} + b_{j3} * \text{site index} * \text{d.b.h.}$

b_{jk} = regression coefficients to be determined.

$j = 1, 2, 3.$

Results and Validation

The coefficients and significance statistics that resulted from fitting the model are listed in Table 3. Site index and its interaction with d.b.h. were significant variables for species classified as intermediate or intolerant in shade tolerance. Moderately tolerant and very tolerant species usually are not dominant or codominant trees throughout their lives, which is a requirement for determining site index. Site index has little significance to these species; an exception is black cherry which is intermediate in tolerance, but the relationship between site index and Gp is insignificant. Many stands of cherry in the Allegheny Plateau of Pennsylvania have experienced extensive stem breakage associated with ice storms (Auchmoody and Rexrode 1984). This type of damage usually results in inaccurate measurements of site index.

Table 3.—Coefficients and chi-square significance statistics for the generalized logistic regressions[a]

Species group	Index j	Intercept 0	Site index 1	D.b.h. 2	D.b.h.* Site index 3
ASH					
	1	-1.6880	0.0145	0.0770	-0.00090
	2	3.0552	-0.0235	-0.1620	0.00102
	3	4.3884	-0.0265	-0.2638	0.00155
	p-value	0.0000	0.0426	0.0000	0.0781
BAS					
	1	-0.6763	-0.0056	0.0702	-0.00054
	2	2.6315	-0.0136	-0.1083	-0.00002
	3	5.6043	-0.0328	-0.2838	0.00101
	p-value	0.0005	0.4528	0.0071	0.7686
BEE					
	1	-3.7807	-0.0229	0.0191	0.00023
	2	-4.0959	0.0167	0.1002	-0.00160
	3	0.7484	-0.0173	-0.0890	0.00028
	p-value	0.0002	0.1522	0.0139	0.3143
BIR					
	1	-7.2202	0.0313	0.2471	-0.00210
	2	-3.5818	0.0285	0.0987	-0.00154
	3	2.9962	-0.0363	-0.2099	0.00205
	p-value	0.0000	0.0136	0.0004	0.0524
BLC					
	1	-0.8194	-0.0163	0.0623	0.00022
	2	0.3603	0.00195	0.0429	-0.00138
	3	2.6043	-0.0070	-0.0947	-0.00069
	p-value	0.0028	0.5305	0.0509	0.2594
BLO					
	1	-3.9969	0.0208	0.2277	-0.00174
	2	-0.7717	0.00308	0.0681	-0.00059
	3	2.0569	-0.0156	-0.0963	0.00070
	p-value	0.0000	0.0330	0.0000	0.0029
CHO					
	1	-4.8895	0.0394	0.1547	-0.00150
	2	-1.2078	0.0239	0.0147	-0.00086
	3	0.9218	0.0105	-0.0605	-0.00047
	p-value	0.0000	0.0001	0.0000	0.0124
COH					
	1	-3.8003	0.0173	0.1148	-0.00073
	2	-1.3358	0.00789	0.0466	-0.00071
	3	1.4717	-0.0024	-0.0985	-0.00006
	p-value	0.0000	0.2377	0.0002	0.3799
HEM					
	1	0.6158	-0.0033	-0.0057	0.00012
	p-value	0.2185	0.7306	0.8657	0.8559
HIC					
	1	-3.6130	0.0060	0.1485	-0.00042
	2	0.1436	-0.0038	-0.0299	0.00012
	3	4.6498	-0.0453	-0.2877	0.00262
	p-value	0.0000	0.0016	0.0000	0.0087
NOH					
	1	-5.6859	0.0092	0.1203	-0.00053
	2	-1.9194	-0.0002	0.0190	-0.00072
	3	0.3254	0.0108	-0.0800	-0.00099
	p-value	0.0318	0.9337	0.4666	0.8322

Table 3.—Continued

Species group	Index j	Intercept 0	Site index 1	D.b.h. 2	D.b.h.* Site index 3
NRO					
	1	-2.7720	0.0194	0.1115	-0.00085
	2	-0.0144	0.0011	0.0140	-0.00026
	3	1.9383	-0.0071	-0.1002	0.00034
	p-value	0.0000	0.0091	0.0000	0.0317
ORO					
	1	-4.3659	-0.0086	0.1482	-0.00002
	2	-2.5847	0.0039	0.0889	-0.00035
	3	1.4839	-0.0307	-0.0916	0.0014
	p-value	0.0000	0.0314	0.0008	0.1199
OTP					
	1	-3.2416	0.0697	0.3413	-0.00441
	2	-0.9328	0.0500	0.1581	-0.00301
	3	3.1008	0.0212	-0.1018	-0.00074
	p-value	0.0000	0.0170	0.0001	0.0400
REM					
	1	-4.8396	0.0096	0.1327	-0.00113
	2	-2.2768	0.0144	0.0932	-0.00176
	3	1.9865	-0.0206	-0.1169	0.00052
	p-value	0.0000	0.0046	0.0000	0.0115
SUM					
	1	-4.1101	0.0141	0.1198	-0.00104
	2	-1.1156	0.0062	0.0164	-0.00073
	3	1.7617	-0.0056	-0.0902	-0.00042
	p-value	0.0000	0.6241	0.0046	0.4386
VIP					
	1	-5.1864	0.0917	0.4989	-0.00969
	2	2.7574	-0.0405	-0.1028	0.00148
	3	-1.4009	0.0956	0.2363	-0.00637
	p-value	0.1949	0.0017	0.1845	0.0246
WHO					
	1	-2.4304	0.0077	0.0695	-0.00028
	2	1.4338	-0.0239	-0.0690	0.00085
	3	3.9248	-0.0396	-0.2030	0.00185
	p-value	0.0000	0.0000	0.0000	0.0022
WHP					
	1	-1.5897	0.0122	0.0912	-0.00126
	2	4.1031	-0.0444	-0.2235	0.00205
	3	2.3886	-0.0098	-0.1421	0.00047
	p-value	0.0000	0.0115	0.0000	0.0285
YEP					
	1	-0.8811	-0.0253	0.1212	0.00020
	2	1.6087	-0.0365	-0.0359	0.00110
	3	1.8402	-0.0261	-0.073	0.00089
	p-value	0.0000	0.0000	0.0000	0.0455

[a]Model is of the form:

$$p_{below\ grade} = 1/(1 + \sum_{j=1}^{3} \exp(f_j))$$

$$p_j = p_r * \exp(f_j).$$

where:

f_j = b_{j0} + b_{j1} *d.b.h. + b_{j2} + d.b.h. + b_{j3} * site index * d.b.h.

p_j = the probability that Gp equals j, j = 1, 2, 3.

Potential grade probabilities were calculated for each tree in the validation data set. A uniform random number was generated and a predicted Gp was assigned to each tree. Since these equations are to be used in simulators, I was not interested in how well they worked for individual trees, but on the resulting distribution of Gp's. Table 4 shows the actual and predicted totals for each species group and the level attained in a χ^2 test of goodness of fit (the larger the p-value, the better the fit). The equations performed adequately for most of the species groups in which stem quality is a concern. Surprisingly, the white oak and yellow poplar groups did not test as well as would have been expected from the significance of the coefficients shown in Table 3. Figures 1a-b compare the Gp distributions for the development and validation data sets and the predicted Gp distribution for the validation set for white oak and yellow-poplar. Although the differences between the actual and predicted distributions of the validation set are not large or unreasonable, the large number of observations in the divisor of the χ^2 statistic determines these differences to be important.

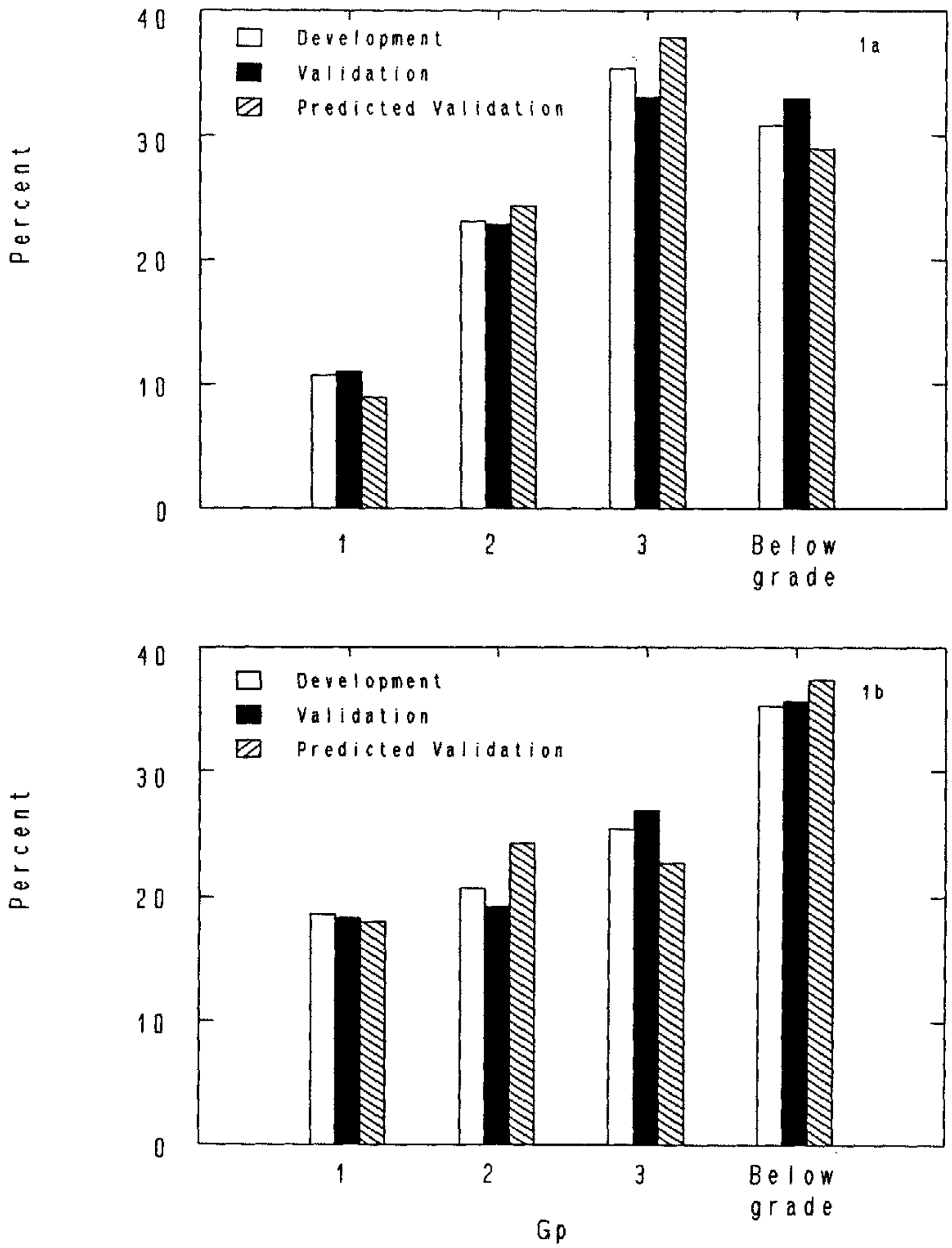

Figure 1.— Percentages of trees for the development and validation data sets and for those predicted for the validation data set by the models for white oak (1a) and yellow-poplar (1b).

Table 4.—Actual and predicted distributions of the validation data set and significance level attained by a χ^2 test of goodness of fit[a]

Species group	p-value[a]	Gp	Actual	Predicted
ASH	0.183	1	38	44
		2	58	66
		3	89	74
		Below grade	58	59
BAS	0.056	1	18	30
		2	27	27
		3	38	30
		Below grade	30	26
Bee	0.737	1	3	2
		2	18	15
		3	71	69
		Below grade	323	329
BIR	0.111	1	3	1
		2	21	16
		3	76	82
		Below grade	111	112
BLC	0.348	1	50	60
		2	79	82
		3	136	136
		Below grade	124	111
BLO	0.783	1	65	69
		2	95	96
		3	152	156
		Below grade	120	111
CHO	0.778	1	55	58
		2	175	178
		3	288	295
		Below grade	247	234
COH	0.064	1	45	34
		3	92	79
		3	158	171
		Below grade	204	215
HEM	0.005	1	175	152
		Below grade	94	117
HIC	0.364	1	26	36
		2	85	83
		3	133	131
		Below grade	117	111
NOH	0.425	1	1	1
		2	4	2
		3	31	36
		Below grade	97	94

Table 4.—Continued

Species group	p-value[a]	Gp	Actual	Predicted
NRO	0.712	1	128	122
		2	195	186
		3	247	251
		Below grade	199	210
ORO	0.009	1	13	17
		2	30	50
		3	105	92
		Below grade	169	158
OTP	0.282	1	75	83
		2	55	62
		3	129	116
		Below grade	7	5
REM	0.483	1	25	22
		2	93	103
		3	256	241
		Below grade	441	449
SUM	0.211	1	17	15
		2	52	54
		3	132	151
		Below grade	221	202
VIP	0.265	1	6	6
		2	17	22
		3	186	194
		Below grade	13	11
WHO	0.078	1	80	67
		2	166	180
		3	241	260
		Below grade	240	220
WHP	0.691	1	27	29
		2	41	35
		3	50	54
		Below grade	43	43
YEP	0.003	1	142	135
		2	153	185
		3	211	175
		Below grade	279	290

[a]The form of the statistic is: $\chi^2 = \sum_{i=1}^{k} \frac{(actual\text{-}predicted)^2}{predicted}$

[b]The larger the p-value, the more likely that the actual distribution of Gp is the same as the predicted distribution.

Application

The proportion of trees that will be in one of the four potential tree-grade classes is determined from equations (2) and (3). An example of the use of the equations for northern red oaks with a d.b.h. (D) of 14 inches and site index (S) 70 feet is:

$$\exp(f_1) = \exp(-2.772 + 0.0194 * S + 0.1115 * D - 0.00085 * S * D) = .5036$$
$$\exp(f_2) = 1.0045$$
$$\exp(f_3) = 1.4518$$
$$\Sigma \exp(f_j) = 2.9599$$

The proportion of trees of this species, d.b.h., and site index with a potential tree grade of below grade is (from equation (3)):

$$p_{\text{below grade}} = (1 + 2.9599)^{-1} = 0.2525$$

From equation (2), the proportion of trees of this species, d.b.h., and site index with the other three potential tree-grades is:

$$p_1 = 0.2525 * 0.5036 = 0.1272$$
$$p_2 = 0.2537$$
$$p_3 = 0.3666$$

In a growth and yield simulator such as NE-TWIGS, a uniform random number would be generated and potential tree grade would be assigned based on cumulative proportions. For example, if the random number fell between zero and 0.1272, the tree would be assigned a grade 1; between 0.1272 and 0.3809 (p_1+p_2), a grade 2; between 0.3809 and 0.7475 ($p_1+p_2+p_3$), a grade 3; and between 0.7475 and 1 below grade.

Summary

This study used FIA data on 20 species groups to develop a method to distribute trees into quality classes. This method relies on species, d.b.h., site index, and generalized logistic regression techniques to assign probabilities of being in one of four potential tree grade classes (two for nonpine conifers). The equations fit well for all but the shade-tolerant species for which site index has little meaning. Validation of the equations was performed using an independent data set also from FIA data.

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Generalized logistic regression was used to distribute trees into four potential tree grades for 20 northeastern species groups. The potential tree grade is defined as the tree grade based on the length and amount of clear cuttings and defects only, disregarding minimum grading diameter. The algorithms described use site index and tree diameter as the predictive variables, allowing the equations to be incorporated into individual-tree growth and yield simulators such as NE-TWIGS.

Keywords: Generalized logistic regression; NE-TWIGS; growth and yield simulators

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