A Growth and Yield Projection System (GYPSY) for Natural and Post-harvest Stands in Alberta

Predicting Merchantable Density

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Alberta
SUSTAINABLE RESOURCE DEVELOPMENT

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1. Introduction

This report outlines the sub-models developed to estimate merchantable density for the four species groups modeled by GYPSY. These sub-models were designed to work in concert with the GYPSY sub-models published in May 2009 (Huang et al, 2009). For details on the other sub-models of GYPSY (i.e. top height, total density, basal area increment, and volume), see the May 21, 2009 publication.

2. Steps for Predicting Merchantable Stems/ha

1. Specify a utilization standard, e.g., 15/10 with a 0.2 m stump height;

2. Predict stump03 (i.e., stumpdob at 0.3 m stump ht):

$$\text{Rate} = a \cdot \exp[b \cdot (0.3 - stumpht)^c] + 1$$

Rate = stumpdob /stump03;

Stumpdob = stumpdob at user-specified stumpht (stumpht <= 0.3 m)

Stump03 = stumpdob at 0.3 m stumpht

if stumpht=**0.3** then do; stump03=stumpdob; end;

if stumpht<**0.3** then do; stump03=stumpdob/rate; end;

3. Predict DBH:

DBH =(-k5+sqrt(k5**2-4*k6*(k4-stump03)))/(2*k6);

[this is from the Stump03-DBH relationship, described in taper report #1]

4. Predict the CUM at the DBH, e.g.:

$$\text{CUM} = \frac{b_0}{1 + \exp[b_1 + b_2 \ln(\text{dbh} + 1) + b_3 \ln(\text{bhage} + 1) + b_4 \text{TopHT} + b_5 \ln(N + 1)]}$$

if CUM>**100** then CUM=**100**;

5. Predict the merch stems:

Merch_stem=total density*(**100**-CUM)/**100**;

3. Diameter Prediction Models

Rate = stumpdob /stump03;

Stumpdob = stumpdob at user-specified stumpht (stumpht <= 0.3 m)

Stump03 = stumpdob at 0.3 m stumpht

$$\text{Rate} = a \cdot \exp[b \cdot (0.3 - stumpht)^c] + 1$$

Parameter	AW	SB	SW	PL
A	0.009628	0.030241	0.01939	0.013081
B	10.82514	29.10004	14.58411	13.01001
C	1.068204	1.873577	1.286149	1.213286

```
if stumpht=0.3 then do; stump03=stumpdob;      end;
if stumpht<0.3 then do; stump03=stumpdob/rate; end;
```

```
DBH =(-k5+sqrt(k5**2-4*k6*(k4-stump03)))/(2*k6);
```

[this is from the Stump03-DBH relationship, described in taper report #1]

For example, for AW:

Obs	species	nregion	k4	k5	k6	stumpdob	stumpht	a	b	c	rate	stump03	DBH
1	AW	0	-0.33057	1.10664	.000986	5	0.1	0.009628	10.8251	1.06820	1.06700	4.6861	4.5150
2	AW	0	-0.33057	1.10664	.000986	5	0.2	0.009628	10.8251	1.06820	1.02429	4.8815	4.6902
3	AW	0	-0.33057	1.10664	.000986	5	0.3	0.009628	10.8251	1.06820	1.00963	5.0000	4.7964
4	AW	0	-0.33057	1.10664	.000986	10	0.1	0.009628	10.8251	1.06820	1.06700	9.3721	8.7003
5	AW	0	-0.33057	1.10664	.000986	10	0.2	0.009628	10.8251	1.06820	1.02429	9.7629	9.0479
6	AW	0	-0.33057	1.10664	.000986	10	0.3	0.009628	10.8251	1.06820	1.00963	10.0000	9.2587
7	AW	0	-0.33057	1.10664	.000986	15	0.1	0.009628	10.8251	1.06820	1.06700	14.0582	12.8550
8	AW	0	-0.33057	1.10664	.000986	15	0.2	0.009628	10.8251	1.06820	1.02429	14.6444	13.3726
9	AW	0	-0.33057	1.10664	.000986	15	0.3	0.009628	10.8251	1.06820	1.00963	15.0000	13.6864
10	AW	0	-0.33057	1.10664	.000986	20	0.1	0.009628	10.8251	1.06820	1.06700	18.7442	16.9798
11	AW	0	-0.33057	1.10664	.000986	20	0.2	0.009628	10.8251	1.06820	1.02429	19.5258	17.6649
12	AW	0	-0.33057	1.10664	.000986	20	0.3	0.009628	10.8251	1.06820	1.00963	20.0000	18.0802
13	AW	0	-0.33057	1.10664	.000986	25	0.1	0.009628	10.8251	1.06820	1.06700	23.4303	21.0754
14	AW	0	-0.33057	1.10664	.000986	25	0.2	0.009628	10.8251	1.06820	1.02429	24.4073	21.9257
15	AW	0	-0.33057	1.10664	.000986	25	0.3	0.009628	10.8251	1.06820	1.00963	25.0000	22.4409

4. Density Distribution Models

(use bold blue coefficients from mix-3 for this purpose)

Aspen and black spruce fit statistics

Parameter	Local		Population				
	AW	SB	AW	SB	**AW**	SB	**SB**
a0							**104.09**
b0	108.3000	113.2500	110.3810	115.6374	**110.37**	115.58	**3.8437**
b1	14.4012	6.5644	8.9488	3.3942	**8.9504**	3.3965	**0.5145**
b2	-6.1473	-4.7290	-4.2724	-3.1072	**-4.2732**	-3.1095	**-0.1358**
b3	1.0476	0.7098	1.3278	0.6031	**1.328**	0.6035	**0.2201**
b4	0.2584	0.2005	0.1255	0.1432	**0.1255**	0.1433	**-0.01063**
b5	-0.8537	-1.3708	-0.6409	-1.1954	**-0.641**	-1.1969	
c0							**0.5013**
c1							**0.0347**
c2							**0.2354**
$\sigma^2_{u_1}$	59.1992	30.1605					
$\sigma_{u_1u_2}$	-16.9030	-9.9025					
$\sigma^2_{u_2}$	4.9095	3.3228					
σ^2	17.6496	14.4417					
Model	[1]	[2a]	[1]	[2a]	**[1]**	[2a]	**[2b]**
Method	FOCE	FOCE	NLS	NLS	**Mix-3**	Mix-3	**Mix-3**

FOCE – first-order conditional expectation method

NLS – ordinary nonlinear least square method

Mix-3 – marginal structures method, based on FOCE

Distribution models:

[1]

$$CUM = \frac{b_0}{1+\exp[(b_1+u_{1i})+(b_2+u_{2i})\ln(dbh+1\ )+b_3\ln(bhage+1)+b_4 TopHT+b_5\ln(N+1)\ ]}$$

[2a]

$$CUM = \frac{b_0}{1+\exp[(b_1+u_{1i})+(b_2+u_{2i})\ln(dbh+1\ )+b_3\ln(bhage+1)+b_4 TopHT+b_5 N/10000\ ]}$$

[2b]

$$CUM = a_0\left(1-\exp\left[-\left(\frac{DBH}{b_0(H_{top}-1.3)^{b_1}N^{b_2}Bhage^{b_3}+b_4 Bhage}\right)^{c_0\exp[c_1(H_{top}-1.3)]Bhage^{c_2}}\right]\right)$$

[3]

$$CUM = \frac{b_0}{1+\exp[(b_1+u_{1i})+b_2\ln(dbh+1\ )+b_3\ln(bhage+1)+b_4 TopHT+b_5 N/10000\ ]}$$

White spruce fit statistics

Parameter	Local Subregion		Population Subregion				
	1 to 3	Others	1 to 3	Others	All	All	**All**
a0							**102.99**
b0	112.2400	110.8600	119.0212	115.8741	115.7375	115.75	**4.0921**
b1	5.0735	5.3326	5.3555	3.0834	3.5627	3.5624	**0.6369**
b2	-3.5971	-3.5942	-2.5396	-2.3010	-2.3448	-2.3446	**-0.2063**
b3	0.6419	0.8063	0.1883	0.5661	0.5207	0.5207	**0.2555**
b4	0.1382	0.1088	0.0877	0.0757	0.0709	0.07087	**-0.01816**
b5	-6.3446	-5.8827	-6.7295	-4.6189	-5.0717	-5.072	
c0							**0.3233**
c1							**0.02614**
c2							**0.2457**
$\sigma^2_{u_1}$	20.7523	20.9305					
$\sigma_{u_1u_2}$	-6.0954	-5.9386					
$\sigma^2_{u_2}$	1.8238	1.7308					
σ^2	13.6108	16.9004					
Model	[2a]	[2a]	[2a]	[2a]	[2a]	[2a]	**[2b]**
Method	FOCE	FOCE	NLS	NLS	NLS	Mix-3	**Mix-3**

FOCE – first-order conditional expectation method

NLS – ordinary nonlinear least square method

Mix-3 – marginal structures method, based on FOCE

Lodgepole pine fit statistics

Parameter	Local Subregion		Population Subregion				
	Others	11	Others	11	All	All	**All**
a0							**100**
b0	104.2800	105.0000	100.0601	100.5066	100.7262	100.75	**14.4907**
b1	9.8465	10.7167	10.5075	10.5087	9.1578	9.1495	**0.7772**
b2	-6.2000	-6.5823	-5.3443	-5.6421	-5.2021	-5.1993	**-0.237**
b3	1.1060	0.6651	0.6654	0.3889	0.6966	0.6964	**-0.1114**
b4	0.2097	0.3211	0.1462	0.2526	0.1820	0.182	**0.03872**
b5	-4.9845	-7.7793	-5.6316	-8.1692	-5.3221	-5.3109	
c0							**1.5357**
c1							**0.02706**
c2							**0.07775**
$\sigma^2_{u_1}$	0.7939	1.0712					
σ^2	28.3778	28.3046					
Model	[3]	[3]	[3]	[3]	[3]	[3]	**[2b]**
Method	FOCE	FOCE	NLS	NLS	NLS	Mix-3	**Mix-3**

FOCE – first-order conditional expectation method

NLS – ordinary nonlinear least square method

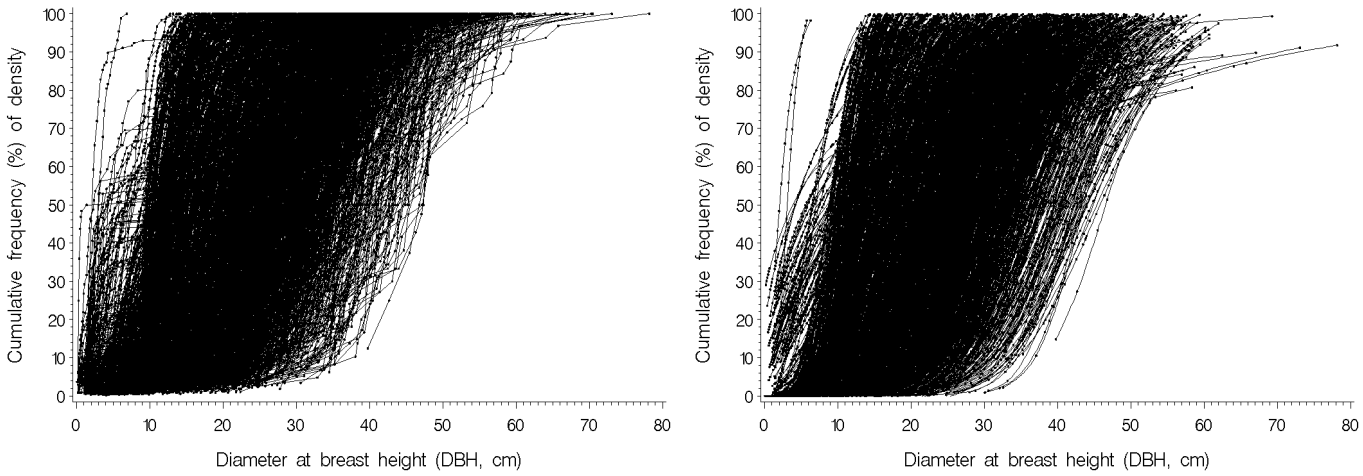
Mix-3 – marginal structures method, based on FOCE

5. Example localized curves from mixed models:

Aspen

$$CUM = \frac{b_0}{1+\exp[(b_1+u_{1i})+(b_2+u_{2i})\ln(dbh+1)+b_3\ln(bhage+1)+b_4 TopHT+b_5\ln(N+1)]}$$

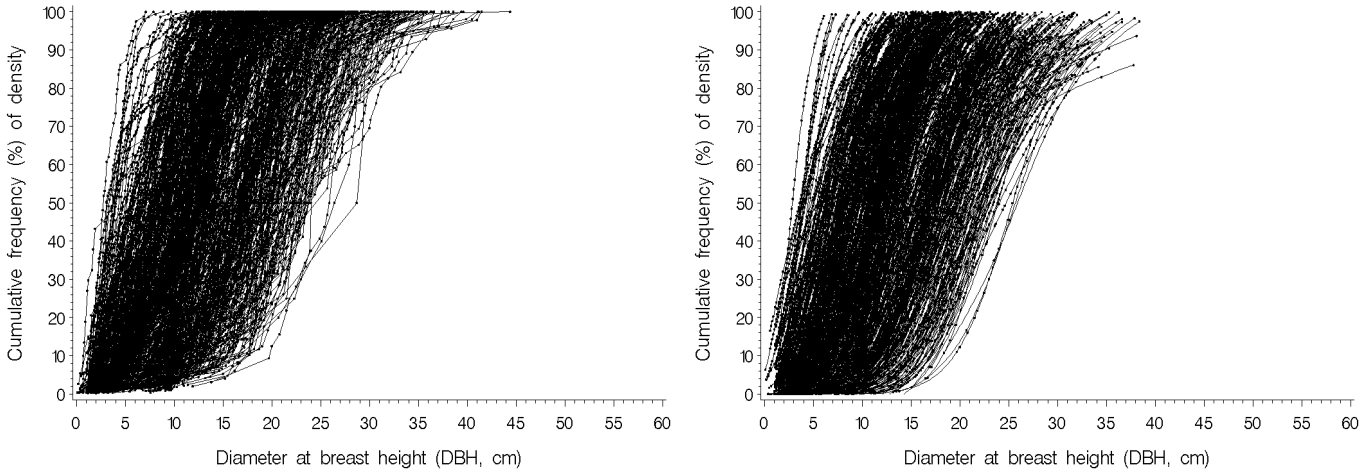
Aspen original data (left) vs fitted curves (right)



Black spruce

$$CUM = \frac{b_0}{1+\exp[(b_1+u_{1i})+(b_2+u_{2i})\ln(dbh+1\ )+b_3\ln(bhage+1)+b_4 TopHT+b_5 N/10000\ ]}$$

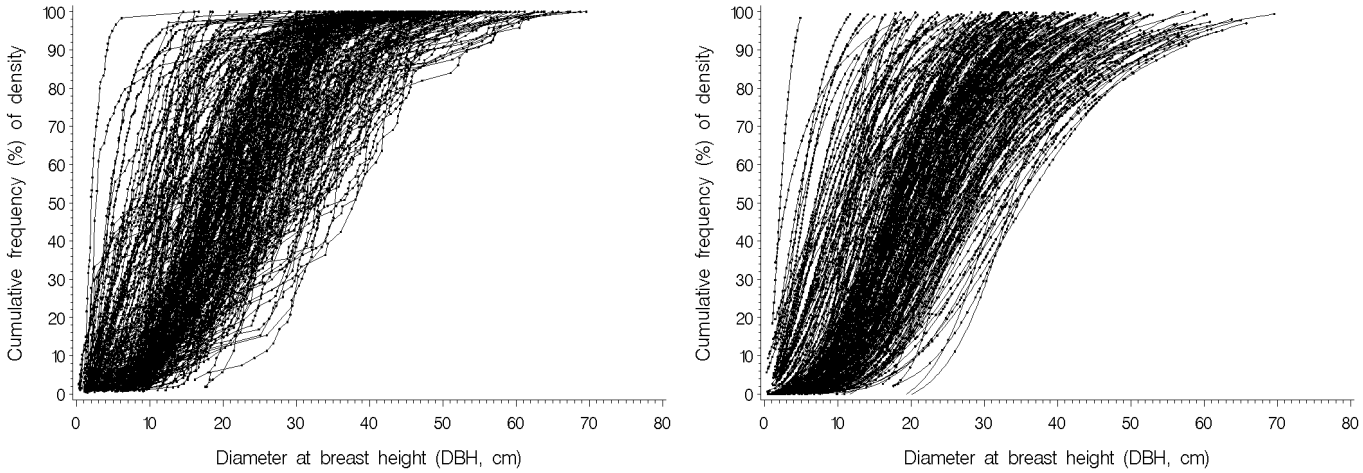
Black spruce original data (left) vs fitted curves (right)



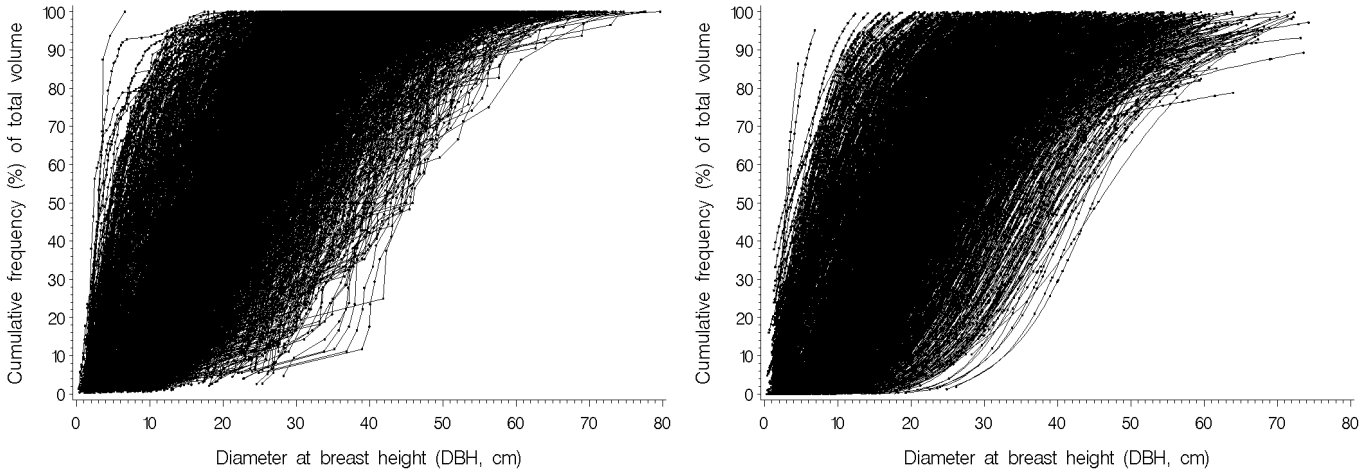
White spruce

$$CUM = \frac{b_0}{1+\exp[(b_1+u_{1i})+(b_2+u_{2i})\ln(dbh+1)+b_3\ln(bhage+1)+b_4 TopHT+b_5 N/10000]}$$

White spruce original data (left) vs fitted curves (right) – subregions 1 to 3



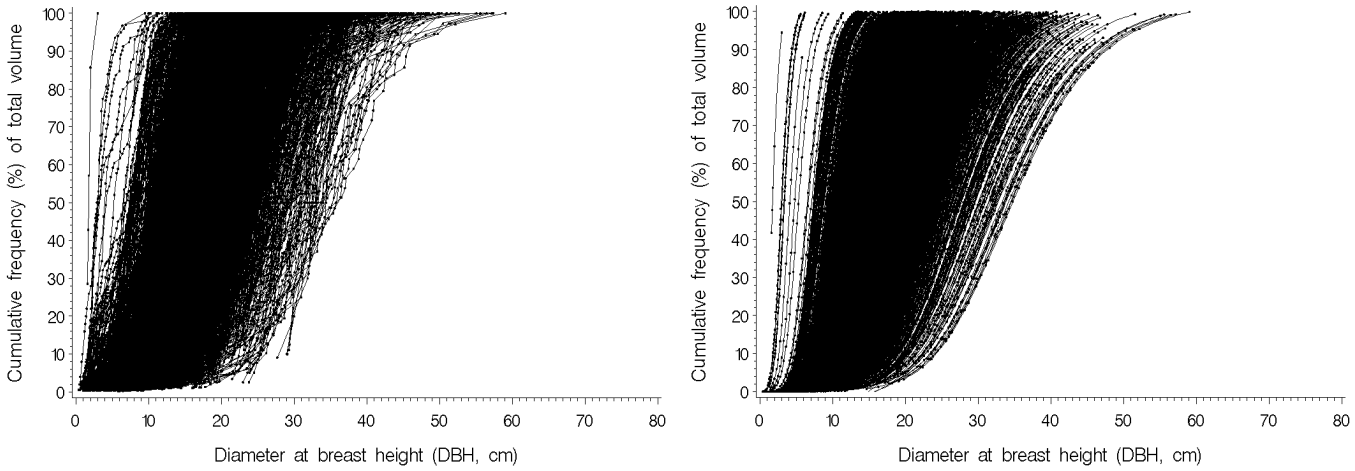
White spruce original data (left) vs fitted curves (right) – subregions 4 to 20 (y-axis should be density, not volume)



Lodgepole pine

$$CUM = \frac{b_0}{1+\exp[(b_1+u_{1i})+b_2\ln(dbh+1)+b_3\ln(bhage+1)+b_4 TopHT+b_5 N/10000]}$$

PL original data (left) vs fitted curves (right) – subregions 1 to 10, 12 to 20 (y-axis should be density, not volume)



PL original data (left) vs fitted curves (right) – subregion 11 (y-axis should be density, not volume)