Supplement 1. Applied growth modelling system

1. **Height growth**

$$H_2 = 1.3 + \frac{A_2^{b_1}}{b_2 + 100\, b_3 \frac{\frac{A_1^{b_1}}{H_1 - 1.3} - b_2}{100 b_3 + A_1^{b_1}} + \frac{\frac{A_1^{b_1}}{H_1 - 1.3} - b_2}{100 b_3 + A_1^{b_1}} A_2^{b_1}}, \quad (1)$$

where

H_1 – dominant height of the forest element at the beginning of the period (m);

H_2 – dominant height of the forest element at the end of the period (m);

A_1 –breast-height age at the beginning of the period (years);

A_2 – breast-height age at the end of the period (years);

b_1; b_2; b_3 – empirical coefficients.

$$H = b_1 {H_{dom}}^{b_2} N^{b_3}, \quad (2)$$

H – mean height of the forest element (m);

Hdom – dominant height of the forest element (m);

N – number of trees of the forest element (ha^{-1});

b_1; b_2; b_3 – empirical coefficients.

2. **Algorithm for diameter growth:**

$$N_{max} = c_1 D_1^{c_2} H_1^{c_3}, \quad (2)$$

$$RB = \frac{N}{N_{max}}, \quad (3)$$

$$D_2 = \frac{A_2^{b_1}}{b_2 \frac{N_1}{N_{max}} + 100 b_3 \frac{\frac{A_1^{b_1}}{D_1} - b_2 \frac{N_1}{N_{max}}}{100 b_3 + A_1^{b_1}} + \frac{\frac{A_1^{b_1}}{D_1} - b_2 \frac{N_1}{N_{max}}}{100 b_3 + A_1^{b_1}} A_2^{b_1}}, \quad (4)$$

where

N_{max} – maximum number of trees of the forest element at the beginning of the period (ha^{-1});

N – number of trees of the forest element at the beginning of the period (ha^{-1});

RB – relative density of the forest element;

D_1 – mean diameter at breast height of the forest element at the beginning of the period (m), cm;

D_2 – mean diameter at breast height of the forest element at the end of the period (cm);

A_1 – breast-height age at the beginning of the period (years);

A_2 – breast-height age at the end of the period (years);

b_1; b_2; b_3; c_1; c_2; c_3 – empirical coefficients.

3. Basal area growth:

$$g`_2 = g_1 + g_1\left(b_0 + b_1\frac{t_1}{100} + b_2 t_1^{-2} + b_3\frac{g_1}{t_1} + b_4\frac{G_L}{t_1} + b_5\frac{SI}{t_1}\right)(t_2 - t_1), \quad (5.1)$$

$$g`_2 = g_1 + g_1\left(b_0 + b_1\frac{t_1}{100} + b_2 t_1^{-2}\right)(t_2 - t_1), \quad (5.2)$$

$$g_{max} = \frac{b_1}{1 + \left(\frac{d}{b_2}\right)^{b_3}}, \quad (6)$$

$$g_2 = \min(g`_2; g_{max}), \quad (7)$$

where

$g`_2$ – estimated basal area at the end of the period (m^2ha^{-1});

g_1 – basal area of the forest element at the beginning of the period (m^2ha^{-1});

t_1 – breast-height age at the beginning of the period (years);

t_2 – breast-height age at the end of the period (years);

G_L – sum of basal area at the beginning of the period for forest elements, which are equal or greater than particular forest element (m^2ha^{-1});

SI – site index (m);

g_{max} – maximum basal area of the forest element (m^2ha^{-1});

d – mean diameter at breast height of the forest element (cm);

g_2 – basal area at the end of the period (m^2ha^{-1});

b_0; b_1; b_2; b_3; b_4; b_5 – empirical coefficients.

Volume of the forest element calculated according to single tree stem volume equation by Liepa (1996), taking into account number of trees, mean height and mean quadratic diameter at breast height.

4. Model for mean diameter of the forest element to estimate effect of commercial thinning

Mean diameter estimation steps:

1.Change in mean diameter due to thinning.

$$d_1 = \sqrt{\frac{40000}{\pi}\left(\frac{G_{kop} - G_{kop} rG}{N_{kop} - N_{kop}\ rG\ NG}\right)} \quad (8)$$

where

d_1 – mean diameter after commercial thinning (cm);

G_{kop} – initial basal area (m^2ha^{-1});

rG – thinning intensity (equation 10), 0–1;

N_{kop} – initial number of trees ha^{-1};

NG – type of thinning, (NG = 1.0 if neutral selection; NG > 1.0, if thinning from below; NG < 1.0 if thinning from above).

2.Mean diameter estimation – *equation 4*.

3.Surplus increment of mean diameter due to thinning.

Surplus increment is already estimated, when taking into account reduced relative density and mechanically enlarged mean diameter.

4.Estimation of remaining basal area of the forest element.

$$g_1 = g`_1 - g_{izc} \quad or \quad g_1 = g`_1 - g_{izc}, \tag{9}$$

where

g_1 – basal area of the forest element after thinning (m^2ha^{-1});

$g`_1$ – basal area of the forest element before thinning (m^2ha^{-1});

g_{izc} – removed basal area of the forest element (m^2ha^{-1});

rG – thinning intensity, 0–1.