

Foothills Growth and Yield Association

Technical Note 2010-1

RLPp: A Regeneration Model to Predict the Establishment and Performance of Planted Lodgepole Pine

About RLPp

RLPp is a Microsoft Excel application. It uses results from the Foothills Growth and Yield Association's Regenerated Lodgepole Pine (RLP) trial¹ and inputs provided by the user to predict the development of planted lodgepole pine up to 12 years following harvest and 11 years following planting. The RLP trial on which the projections are based currently has complete measurements only to 7 and 8 growing seasons following planting, for tree size and mortality respectively. Trends in height growth and mortality projected beyond these ages were verified and adjusted against earlier research conducted by Johnstone² and Ives and Rentz.³ Projections beyond the current age of the RLP trial have been made with conservative caution pending their replacement over the next few years as the experimental data become available.

Predicted Variables

The variables named in italics and described below are projected for each year (elapsed growing season) from the second to the twelfth since harvest.

The following height variables are computed from a height distribution function, the parameters of which depend on ecological site class, vegetation management treatment, and years since planting:

- *Average height;*
- *Modal height;*
- *Average height of tallest 100 stems per ha;*
- *Average crop⁴ tree height.*

Top height is usually defined as the average height of the largest-diameter 100 trees per ha. In Alberta regeneration performance surveys it is based on the largest diameter tree per 0.01 ha. This convention has been adopted here to make RLPp consistent with and applicable to regeneration surveys. *Top height* is calculated based on the relationship found in the RLP trial between average crop tree height and height of the largest-diameter tree per 0.01 ha.

Density of planted trees (*total number of trees per ha*) is calculated as the initial planting density specified by the user, less the product of the periodic mean annual mortality rate and the years elapsed since planting. The default mortality rates are 8-year averages by ecological site class from the RLP trial. These may be substituted by user-defined values, or values calculated from the mean annual temperature of the site and its ecological class. *Number of trees per ha >=30cm tall* and *number of trees per ha >=130cm tall* are calculated from the total number of trees per ha and the height distribution function.

¹ Dempster, W.R. 2010. Regenerated lodgepole pine trial, 2009 crop performance report. *Foothills Growth and Yield Association Technical Report*.

² Johnstone, W.D. 1976. Juvenile height growth of white spruce and lodgepole pine following logging and scarification in west-central Alberta. *Canadian Forestry Service Information Report NOR-X-171*.

³ Ives, W.G.B. and C.L. Rentz. 1993. Factors affecting the survival of immature lodgepole pine in the foothills of west-central Alberta. *Forestry Canada Information Report NOR-X-330*.

⁴ A "crop" tree is the tree with the best overall height, diameter and health within a 0.001ha (1.78 m radius) regeneration plot.

Average ground-line diameter is computed from a diameter distribution function. Like the height distribution function, the parameters of this function depend on ecological site class, vegetation management treatment, and years since planting. The following diameter and basal area variables are calculated from the diameter distribution function, additional functions relating stump and breast-height diameter to ground-line diameter, and densities calculated as described above:

- *Modal ground-line diameter;*
- *Average stump diameter;*
- *Average breast-height diameter;*
- *Ground-line basal area per ha;*
- *Breast-height basal area per ha.*

Required and Optional Inputs

The following variables are the minimum inputs required to run the model:

- Ecological site class (see Table 1);
- Vegetation treatment (“Weed” or “Leave”);
- Planting delay: the interval between harvest and planting (must be between 0 and 5 years);
- Planting density: the number of lodgepole pine trees planted per ha.

Table 1. Ecological site classes

Class #	Ecosite Names (and Edatope)	Ecosite Codes ⁵	
		WC	SW
1	Bearberry / lichen / hairy wild rye (submesic / subxeric, medium – poor)	b, c	b
2	Labrador tea – mesic (mesic – poor)	d	c
3	Billberry / cranberry / sarsaparilla / rhododendron (mesic / medium)	e	d
4	Honeysuckle / fern (subhygric – rich)	f	e
5	Labrador tea – hygric (hygric – poor)	h	f

Additional variables may be input, from establishment surveys and / or other sources if available, to improve predictions. These are:

- Density (number of surviving planted trees per ha) at a specified survey age (number of years since harvest);
- Average crop tree height at a specified survey age;
- Periodic mean annual mortality rate (total number of trees that have died expressed as a percentage of the total planted, divided by the number of years since planting);
- Periodic mean annual temperature (estimates for any location in Alberta for which latitude and longitude are known may be computed externally to the model using the Alberta version of the public-domain program ClimatePP⁶).

⁵ WC = *Field guide to ecosites of west-central Alberta*, J.D. Beckingham, I.G.W. Corns and J.H. Archibald, Can. For. Serv. Special Report 9, 1996.

SW = *Field guide to ecosites of southwestern Alberta*, J.D. Beckingham, G.D. Klappstein, and I.G.W. Corns, Can. For. Serv.

The current version of RLPp does not support predictions of diameter and basal area from survey data i.e. these predictions are generated only from default data sources.

How to Install

No installation is required. The model may be run on any computer that has Microsoft Excel installed. Simply open the workbook RLPp_v1alpha.xls in Excel. If you are given the choice to disable or enable macros, select “enable macros”.

How to Use

Start at the top of the “Input” worksheet and work your way from top to bottom (see Figure 1). Then proceed to the “Output” worksheet.

1. At the top of the “Input” worksheet you are given a number of run options to choose from. Depending on the options that you select, required inputs will be indicated by red crosses. The run options are:
 - Input data source: choose “Default” or “Survey”. Select “Default” if you wish to rely on data only from the RLP trial e.g. for making broad regional or strategic assessments. Select “Survey” if any survey data are available e.g. to localize predictions for operational or stand-level assessments. (The model will resort to default data sources where the survey data are incomplete.)
 - Mortality calculation method: select “Default”, “User-defined” or “Climatic”.
 - Ecological site class: select one of the classes numbered in the pull-down menu. (See definitions in Table 1 above. If you hold the cursor over the cell to the right of the pull-down, a comment will open to remind you of these.)
 - Vegetation treatment: select “Weed” or “Leave”.
 - If you selected “Survey” as the input data source, you will be asked what survey data you intend to utilize: density, crop tree height, and / or mortality. Answer yes or no for each.
2. Next provide the required information on stand history. You will always be asked for the interval between harvest and planting, and the planting density. If you selected “Survey” as the input data source, you will be prompted for the stand age (years after harvest) at which the survey took place.
3. Enter any requested survey and climate data (i.e. items flagged with a red cross), adhering to the data ranges and formats specified to the right of the input cells.
4. Check that you have provided all required information in the “Input” worksheet, and proceed to the “Output” sheet.
5. Use the keystroke shortcut Ctrl+D to run the model macro i.e. press “Ctrl+D” on your keyboard while in the “Output” sheet. Tabular results will be displayed in, and may be printed from, this worksheet (see Figure 2). Table and chart contents can be cleared by the keystroke Ctrl+Shift+D, though this is not strictly necessary because they are automatically replaced whenever the model is run. Charts illustrating height and density trends with age will be displayed in, and may be printed from, the “Graphs-Height and “Graphs-Density” worksheets (see Figure 3). Do NOT use either of the keystroke shortcuts while in any worksheet except “Output”.

⁶ Wang, T., Hamann, A., Spittlehouse, D., and Aitken, S. N. 2006. Development of scale-free climate data for western Canada for use in resource management. *International Journal of Climatology*, 26(3):383-397.

Figure 1. Example of a completed run input worksheet

Run Options		
<input checked="" type="checkbox"/> Input data source	<input type="text" value="Survey"/>	Select from drop-down
<input checked="" type="checkbox"/> Mortality calculation method	<input type="text" value="Default"/>	Select from drop-down
<input checked="" type="checkbox"/> Ecological site class	<input type="text" value="4"/>	Select from drop-down
<input checked="" type="checkbox"/> Vegetation treatment	<input type="text" value="Weed"/>	Select from drop-down
<input checked="" type="checkbox"/> Survey data to be utilized:		
Density (live trees per ha)?	<input type="text" value="No"/>	(optional)
Average crop tree height?	<input type="text" value="Yes"/>	(optional)
Percent periodic mean annual mortality?	<input type="text" value="No"/>	(optional)
Stand History		
<input checked="" type="checkbox"/> Interval between harvest and planting (years)	<input type="text" value="1"/>	Integer between 0 and 5
<input checked="" type="checkbox"/> Planting density (trees per ha)	<input type="text" value="1600"/>	Integer between 816 and 4444
<input checked="" type="checkbox"/> Survey age (years after harvest)	<input type="text" value="6"/>	Integer between 5 and 12
Survey Data Inputs		
Density (live trees per ha)	<input type="text" value=""/>	Integer between 1 and 4444
<input checked="" type="checkbox"/> Average crop tree height	<input type="text" value="110"/>	Decimal >10cm
Percent periodic mean annual mortality	<input type="text" value=""/>	Decimal between 0 and 8
Climate Data		
Mean annual temperature (°C)	<input type="text" value=""/>	(not enabled in this version)

Figure 2. Example of tabular output

Regenerated Lodgepole Pine - Planted											
Input data source	Default										
Ecological site class	4										
Interval between harvest and planting (years)	1										
Planting density (trees per ha)	1600										
Vegetation treatment	Weed										
Mortality calculation method	Default										
Percent mean annual mortality	2.78										
Age (years since harvest)	2	3	4	5	6	7	8	9	10	11	12
Years since planting	1	2	3	4	5	6	7	8	9	10	11
Average height (cm)	26.8	41.5	56.1	90.9	125.8	172.5	219.4	266.6	313.9	361.5	409.2
Average crop tree height (cm)	25.2	41.0	56.8	94.1	131.3	180.7	230.0	279.4	328.7	378.1	427.4
Modal height (cm)	27.0	41.0	57.0	90.0	131.0	174.0	219.0	267.0	307.0	338.0	397.0
Average height of tallest 100 stems per ha (cm)	37.4	59.0	81.5	130.4	178.5	239.9	299.9	358.5	416.0	472.6	528.1
Top height (cm)	37.4	59.0	81.5	130.4	177.3	223.4	269.5	315.6	361.7	407.8	453.9
Total number of trees per ha	1556	1511	1467	1422	1378	1333	1289	1244	1200	1155	1111
Number of trees per ha >=30cm tall	483	1319	1411	1417	1377	1333	1289	1244	1200	1155	1111
Number of trees per ha >=130cm tall	0	0	0	42	640	1143	1240	1231	1196	1154	1110
Average ground-line diameter (cm)	0.59	1.07	1.54	2.50	3.47	4.52	5.57	6.64	7.71	8.79	9.87
Modal ground-line diameter (cm)	0.60	1.10	1.60	2.50	3.40	4.50	5.50	6.90	8.10	8.90	10.10
Average stump diameter (cm)	0.44	0.79	1.16	1.95	2.77	3.70	4.64	5.58	6.53	7.48	8.44
Average breast-height diameter (cm)	-	-	-	0.90	1.20	1.76	2.54	3.42	4.33	5.26	6.20
Ground-line basal area per ha (m ²)	0.04	0.14	0.29	0.75	1.40	2.27	3.31	4.50	5.82	7.25	8.76
Breast-height basal area per ha (m ²)	0.00	0.00	0.00	0.00	0.08	0.32	0.71	1.24	1.91	2.68	3.54

Figure 3. Examples of graphical output

