

RES-FOR HIGHLIGHT #3

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A Financial Analysis Using Improved White Spruce and Lodgepole Pine Planting Stock in Alberta: Genomic Selection vs. Traditional Breeding

Introduction

Genomics-assisted tree breeding (GATB) is an emerging biotechnology method that has the potential to produce improved planting stock in selected traits, such as greater volume or higher wood quality, more quickly and effectively compared to using traditional breeding (TB) methods. In this study, we conducted an *ex-ante* stand-level financial benefit-cost analysis that is linked to a provincial tree growth and yield projection (GYPSY) model to investigate the potential financial benefits of using improved white spruce (*Picea glauca*) and lodgepole pine (*Pinus contorta* var. *latifolia*) planting stock identified via alternative tree improvement strategies (i.e. GATB vs TB methods) for forest companies in the province of Alberta, Canada.

Goals and Objectives

1. Investigate whether there are additional financial benefits of planting stock derived from selecting parents using the GATB approach compared with selecting parents for planting stock using the traditional field-based tree breeding method for 3rd generation improved white spruce and lodgepole pine programs in Alberta.
2. Develop a decision matrix to help forest managers financially justify the use of the GATB method under varying biophysical and market circumstances, including: (1) various levels of site productivity; (2) higher genetic gain in volume at rotation as a result of higher genomic selection accuracy; (3) a shorter breeding cycle; (4) a change in potential seedling costs for GATB planting stock at the time of planting; and (5) a potential price premium for better- quality logs at harvest.

Financial model, Data and Assumptions

For comparison, a Faustmann formula was used to determine the maximum land expectation value (LEV) generated by each breeding strategy at the optimal economic rotation age.

Table 1. Values of input variables used in the financial model.

| Variable | Values |
|--|--|
| Discount rate | 2% (public sector investment), 4% & 6% (private sector investment) |
| Site Index (top height @ breast height age 50) | 6 (low), 13 (medium), and 18 m (high productivity) |
| Volume gain over wild seed | 30% (TB) and 30-50% (0%-20% additional gain with GATB due to higher selection accuracy, higher survival rates) |
| Seedling cost (including breeding, nursery and planting costs) | \$0.60/stem (TB) and \$0.60-0.92/stem (depending on area (15-100%) planted with improved GATB planting stock.); \$960/ha (TB) and \$960-1,472/ha (GATB) |
| Planting density | 1600 stems/ha |
| Log price @mill-gate | \$60/m ³ (TB) and \$60-200/m ³ (\$0-140/m ³ price premium with GATB) |
| Harvest and hauling costs | \$30/m ³ |
| Breeding cycle time | 33 years (TB) and 18 years (GATB) to produce improved planting stock. |

Results

Table 2. Financial justification for using genomics-assisted tree breeding (GATB) derived planting stock relative to planting stock derived from traditional breeding (TB) method. A red cell represents an additional loss of more than CAD\$-50/ha; a yellow cell represents an additional loss between \$0 and \$-50/ha; and a green cell indicates an additional benefit (greater than \$0) of using GATB seedlings compared with the net present value of using TB seedlings at a 4% discount rate for both white spruce (top) and lodgepole pine (bottom).

| 4% discount rate | | | | White Spruce | | | | | | | | | | | | |
|---|---|------|------|--------------|---|------|---|------|---|------|--|------|--|------|------|------|
| \$0.92/item for GATB (15% area planted with improved seedlings) | \$60/m ³ log price (No price premium for GATB seedlings) | | | | \$90/m ³ log price for GATB seedlings (\$30/m ³ price premium) | | \$120/m ³ log price for GATB seedlings (\$60/m ³ price premium) | | \$150/m ³ log price for GATB seedlings (\$90/m ³ price premium) | | \$180/m ³ log price for GATB seedlings (\$120/m ³ price premium) | | \$200/m ³ log price for GATB seedlings (\$140/m ³ price premium) | | | |
| | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | | | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | | |
| | Site Index | 0% | 10% | 20% | Site Index | 0% | 10% | 20% | Site Index | 0% | 10% | 20% | Site Index | 0% | 10% | 20% |
| | SI 6 | -292 | -292 | -292 | SI 6 | -290 | -289 | -289 | SI 6 | -286 | -285 | -284 | SI 6 | -282 | -281 | -281 |
| | SI 13 | -295 | -294 | -294 | SI 13 | -223 | -212 | -210 | SI 13 | -148 | -141 | -139 | SI 13 | 3 | 32 | 62 |
| | SI 18 | -294 | -278 | -269 | SI 18 | -117 | -84 | -58 | SI 18 | 61 | 101 | 143 | SI 18 | 418 | 486 | 555 |
| | SI 6 | -139 | -138 | -138 | SI 6 | -139 | -138 | -138 | SI 6 | -135 | -134 | -133 | SI 6 | -128 | -124 | -122 |
| | SI 13 | -66 | -56 | -43 | SI 13 | 9 | 27 | 44 | SI 13 | 85 | 109 | 132 | SI 13 | 161 | 190 | 220 |
| | SI 18 | -133 | -119 | -93 | SI 18 | 44 | 71 | 98 | SI 18 | 222 | 263 | 304 | SI 18 | 580 | 649 | 717 |
| | SI 6 | -78 | -78 | -78 | SI 6 | -75 | -75 | -75 | SI 6 | -68 | -65 | -64 | SI 6 | -62 | -61 | -58 |
| | SI 13 | -34 | -68 | -83 | SI 13 | 0 | 12 | 23 | SI 13 | 76 | 93 | 111 | SI 13 | 228 | 257 | 286 |
| | SI 18 | -65 | -52 | -38 | SI 18 | 112 | 139 | 166 | SI 18 | 290 | 331 | 373 | SI 18 | 648 | 717 | 786 |
| | SI 6 | -54 | -54 | -54 | SI 6 | -51 | -51 | -51 | SI 6 | -42 | -41 | -41 | SI 6 | -38 | -36 | -34 |
| | SI 13 | -48 | -44 | -38 | SI 13 | 25 | 37 | 48 | SI 13 | 101 | 118 | 136 | SI 13 | 253 | 284 | 311 |
| | SI 18 | -41 | -27 | -13 | SI 18 | 137 | 164 | 192 | SI 18 | 316 | 357 | 398 | SI 18 | 674 | 743 | 811 |
| | SI 6 | -35 | -35 | -34 | SI 6 | -31 | -30 | -29 | SI 6 | -26 | -25 | -24 | SI 6 | -22 | -20 | -18 |
| | SI 13 | -33 | -27 | -22 | SI 13 | 42 | 53 | 65 | SI 13 | 117 | 135 | 152 | SI 13 | 269 | 299 | 329 |
| | SI 18 | -22 | -10 | 4 | SI 18 | 154 | 182 | 209 | SI 18 | 333 | 374 | 415 | SI 18 | 691 | 761 | 829 |

| 4% discount rate | | | | Lodgepole Pine | | | | | | | | | | | | |
|---|---|------|------|----------------|---|------|---|------|---|------|--|------|--|-------|-------|-------|
| \$0.93/item for GATB (15% area planted with improved seeds) | \$60/m ³ log price (No price premium for GATB seedlings) | | | | \$90/m ³ log price for GATB seedlings (\$30/m ³ price premium) | | \$120/m ³ log price for GATB seedlings (\$60/m ³ price premium) | | \$150/m ³ log price for GATB seedlings (\$90/m ³ price premium) | | \$180/m ³ log price for GATB seedlings (\$120/m ³ price premium) | | \$200/m ³ log price for GATB seedlings (\$140/m ³ price premium) | | | |
| | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | | | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | Expected additional volume gain (%) with GATB compared to the volume gain (30% of TB) | | | |
| | Site Index | 0% | 10% | 20% | Site Index | 0% | 10% | 20% | Site Index | 0% | 10% | 20% | Site Index | 0% | 10% | 20% |
| | SI 6 | -301 | -301 | -301 | SI 6 | -291 | -289 | -287 | SI 6 | -277 | -274 | -270 | SI 6 | -262 | -258 | -253 |
| | SI 13 | -207 | -296 | -325 | SI 13 | -162 | -139 | -117 | SI 13 | -13 | 21 | 56 | SI 13 | 137 | 183 | 229 |
| | SI 18 | -301 | -271 | -241 | SI 18 | 21 | 71 | 123 | SI 18 | 347 | 422 | 497 | SI 18 | 674 | 775 | 875 |
| | SI 6 | -150 | -149 | -148 | SI 6 | -138 | -138 | -134 | SI 6 | -123 | -120 | -117 | SI 6 | -109 | -104 | -99 |
| | SI 13 | -146 | -135 | -124 | SI 13 | 1 | 24 | 47 | SI 13 | 151 | 185 | 220 | SI 13 | 301 | 348 | 394 |
| | SI 18 | -134 | -109 | -85 | SI 18 | 190 | 240 | 291 | SI 18 | 517 | 592 | 668 | SI 18 | 1,172 | 1,298 | 1,424 |
| | SI 6 | -85 | -85 | -84 | SI 6 | -78 | -71 | -65 | SI 6 | -59 | -55 | -52 | SI 6 | -45 | -38 | -34 |
| | SI 13 | -70 | -67 | -58 | SI 13 | 70 | 93 | 116 | SI 13 | 220 | 255 | 288 | SI 13 | 522 | 580 | 638 |
| | SI 18 | -63 | -38 | -14 | SI 18 | 262 | 312 | 362 | SI 18 | 589 | 664 | 740 | SI 18 | 1,244 | 1,370 | 1,496 |
| | SI 6 | -62 | -61 | -58 | SI 6 | -48 | -47 | -45 | SI 6 | -34 | -31 | -27 | SI 6 | -19 | -14 | -8 |
| | SI 13 | -27 | -41 | -31 | SI 13 | 96 | 119 | 142 | SI 13 | 246 | 281 | 315 | SI 13 | 548 | 604 | 664 |
| | SI 18 | -37 | -12 | 13 | SI 18 | 288 | 339 | 389 | SI 18 | 616 | 691 | 767 | SI 18 | 1,271 | 1,397 | 1,523 |
| | SI 6 | -46 | -45 | -44 | SI 6 | -38 | -31 | -29 | SI 6 | -18 | -15 | -11 | SI 6 | 13 | 19 | 25 |
| | SI 13 | 113 | 136 | 159 | SI 13 | 263 | 298 | 333 | SI 13 | 414 | 460 | 507 | SI 13 | 565 | 623 | 681 |
| | SI 18 | 19 | 6 | 31 | SI 18 | 306 | 356 | 407 | SI 18 | 634 | 709 | 785 | SI 18 | 1,288 | 1,415 | 1,541 |

Conclusions

- The use of GATB-selected 3rd generation planting stock was difficult to justify on economic grounds alone compared with TB-selected planting stock under the current sawlog market value and the current planting rate (~15%) with improved stock in Alberta for both white spruce and lodgepole pine.
- The stand-level financial performance of lodgepole pine GATB planting stock consistently outperformed that of the white spruce GATB stock. Thus, if budgets are limited, investing in lodgepole pine improvement programs would generate more revenue per hectare than investing in white spruce in Alberta.
- Results from the sensitivity analysis revealed that the GATB method is:
 - more financially supported at lower discount rates;
 - strongly supported through decreased seedling costs with increased areas planted with improved stock;
 - strongly supported through an increase in log price premiums at harvest resulting from potentially better wood quality and higher volume production relative to TB-selected stock.

Reference

Chang, W.-Y., Gaston, C., Cool, J., & Thomas, B.R. 2019. A financial analysis of using improved planting stocks of white spruce and lodgepole pine in Alberta, Canada: Genomic selection *versus* traditional breeding. *Forestry* doi:10.1093/forestry/cpz011

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