**Development and comparison of various stand- and tree-level modeling approaches to predict harvest occurrence, intensity, and residual conditions across the mixed forests in Maine, northeastern US**

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# Supplemental Materials

## Magnitude of the random effects in the nonlinear mixed effects PHARVSTAND and PHARVTREE models



Figure S1. Combined effect of the nested random effects structure (county within inventory year) on the intercept of the final *PHARVSTAND* model by inventory year (*INVYR*) for the two contrasting Maine (ME) counties Aroostook (FIA ME county code 3) and Somerset (25).



Figure S2. Effect of the inventory year random effect on the intercept of the final *PHARVTREE* model.



Figure S3. Combined effect of the nested random effects structure (county within inventory year) on the intercept of the final *PHARVTREE* model by inventory year (*INVYR*) for the two contrasting Maine (ME) counties Kennebec (FIA ME county code 11) and Washington (29).

## Overview of response and explanatory variables

Table S1. Tabular summary of all stand-level response and explanatory variables.

|  |  |
| --- | --- |
| Variable | Description |
|  |  |
| *PBAREMALL* | Proportion of stand-level basal area removed in an harvest operation considering all plots |
| *PHARVSTAND* | Stand-level harvest probability |
| *PBAREMHARV* | Proportion of stand-level basal area removed in an harvest operation considering harvested plots only |
|  |  |
| *QMD* (cm) | Quadratic mean diameter |
| *N* (# ha-1) | Tree ha-1 |
| *SDI* (# ha-1) | Stand density index |
| *RD* | Relative density (SDI/maximum SDI) |
| *BATOT* (m2 ha-1) | Total stand-level basal area |
| *BASAW* (m2 ha-1) | Saw timber (live trees ≥ 22.9 and ≥ 28.0 cm DBH for soft- and hardwoods, respectively) basal area |
| *PBAHW* | Percentage of basal area in hardwood species |
| *CCF* (%) | Crown competition factor |
| *NSAP* (# ha-1) | Number of saplings |
| *NSEED* (# ha-1) | Number of seedlings of commercially valuable hard- and softwood species |
| *ELEV* (m) | Plot elevation |
| *SLOPE* (%) | Plot slope |
| *TI* | Topographic index |
| *CSI* (m) | Climate site index |
| *BGI* (kg ha-1 yr-1) | Biomass growth index |
| *RDDIST* | Horizontal distance to nearest improved road class |
| *OWNER* | Ownership (0: private and 1: public) |

Table S2. Tabular summary of all tree-level response and explanatory variables.

|  |  |
| --- | --- |
| Variable | Description |
|  |  |
| *PHARVTREE* | Tree-level harvest probability |
|  |  |
| *DBH* (cm) | Diameter at breast height |
| *CR* | Compacted crown ratio |
| *BAL* (m2 ha-1) | Basal area in larger trees |
| *CCFL* (%) | Crown competition factor in larger trees |
| *AB & PB* | American beech (*AB*), and paper birch (*PB* also including gray birch) |
| *AS & YB* | Ash (*AS* including black, green, and white ash) and yellow birch (*YB* also including sweet birch) |
| *BF & RS* | Balsam fir (*BF*) and red spruce (*RS* also including black, Norway, and white spruce) |
| *EH* | Eastern hemlock |
| *NC* | Non-commercial woody species (*NC,* e.g. striped maple, pin cherry, American mountain ash, and hawthorn) |
| *OS* | Other commercial softwood species (*OS*, mostly red pine and tamarack) |
| *QA* | Quacking aspen also including bigtooth aspen |
| *RM & SM* | Red maple (*RM* also including silver maple) and sugar maple (*SM*) |
| *RO & OH* | Red oak (*RO* also including black oak) and other commercial hardwood species (*OH*, e.g. American basswood, American elm, black cherry) |
| *WC & WP* | Northern white cedar (*WC*) and white pine (*WP*), |

## Simplified PHARVSTAND and PHARVTREE equations for wider application after inclusion in growth and yield simulators

Table S3. Annual stand-level harvest probability (*PHARVSTAND*) fixed effects model parameter estimates and statistics for simplified *PHARVSTAND* equation with forest type group treated as random (cf. Table 5). *AUC* and *OCP* of the simplified equation were 0.6413 and 0.1421, respectively. See Supplemental Materials Table S1 for explanation of variables.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Estimate | SE | t-value | P-value |
|  |  |  |  |  |
| Intercept | -12.9297 | 3.0341 | -4.2614 | <0.0001 |
| *QMD* | -0.3171 | 0.1155 | -2.7451 | 0.0061 |
| ln(*QMD*+0.1) | 4.2629 | 1.6710 | 2.5511 | 0.0108 |
| ln(*RD*+0.01) | 2.1810 | 0.3236 | 6.7398 | <0.0001 |
| ln(*PBAHW*+0.01) | 0.3823 | 0.1624 | 2.3545 | 0.0186 |

Table S4. Annual stand-level harvest probability (*PHARVSTAND*) forest type specific random effects model parameter estimates for simplified *PHARVSTAND* equation with forest type treated as random.

|  |  |
| --- | --- |
| Forest type | Intercept |
|  |  |
| Aspen / birch | -0.39920 |
| Elm / ash / cottonwood | -1.86339 |
| Exotic hardwoods | -0.01962 |
| Exotic softwoods | 0.52445 |
| Maple / beech / birch | 1.45772 |
| Oak / hickory | -1.29677 |
| Oak / pine | 0.47274 |
| Other softwoods | 0 |
| White / red / jack pine | 1.23585 |
| Spruce / fir | -0.11178 |

Table S5. Annual individual tree harvest probability (*PHARVTREE*) fixed effects model parameter estimates and statistics for simplified *PHARVTREE* equation with species treated as random (cf. Table 7). *AUC* and *OCP* of the simplified equation were 0.7142 and 0.2373, respectively. See Supplemental Materials Table S2 for explanation of variables.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Estimate | SE | t-value | P-value |
|  |  |  |  |  |
| Intercept | -29.5255 | 0.9745 | -30.2971 | <0.0001 |
| *DBH* | -0.3369 | 0.0241 | -13.9641 | <0.0001 |
| ln(*DBH*) | 10.685 | 0.3636 | 29.3844 | <0.0001 |
| *BAL* | -0.0783 | 0.0186 | -4.2009 | <0.0001 |

Table S6. Annual individual tree harvest probability (*PHARVTREE*) species specific random effects model parameter estimates for simplified *PHARVTREE* equation with species treated as random.

|  |  |  |  |
| --- | --- | --- | --- |
| Species | Intercept | *DBH* | *BAL* |
|  |  |  |  |
| American beech | 2.13329 | -0.02419 | -0.00590 |
| Black, green, & white ash | 0.44374 | 0.00740 | -0.09155 |
| Balsam fir | -0.65805 | 0.08164 | 0.09870 |
| Gray & paper birch | 1.29902 | -0.01099 | 0.00280 |
| Eastern hemlock | 0.23769 | -0.00396 | -0.05139 |
| Non-commercial species | -1.48628 | 0.02682 | 0.04896 |
| Red & black oak | 2.36305 | -0.13374 | -0.13259 |
| Other hardwoods | -1.70438 | -0.01292 | -0.04080 |
| Other softwoods | 3.16380 | -0.16693 | 0.11952 |
| Quacking & bigtooth aspen, balsam poplar | 2.31511 | 0.00223 | -0.00694 |
| Red maple | -0.16152 | 0.01959 | -0.00695 |
| Sugar maple | -0.23992 | 0.05085 | -0.03990 |
| Black, Norway, red, & white spruce | -0.00310 | 0.04928 | 0.07434 |
| White cedar | -2.80652 | 0.01918 | 0.03401 |
| White pine | -4.53950 | 0.07404 | 0.02797 |
| Yellow & sweet birch | -0.35642 | 0.02169 | -0.03027 |