CT – Chip Trees

SLT – Small Log Trees (<=80 ft3)

LLT – Large Log Trees (>80 ft3)

SL – Small Trees (<=80 ft3)

ALT – All Log Trees

Removals, trees/acre

$$RemovalsST = RemovalsCT + RemovalsSLT \quad (1)$$

$$RemovalsALT = RemovalsSLT + RemovalsLLT \quad (2)$$

$$Removals = RemovalsCT + RemovalsSLT + RemovalsLLT \quad (3)$$

Volume Per Acre, ft3/acre

$$VolPerAcreCT = RemovalsCT \times TreeVolCT \quad (4)$$

$$VolPerAcreSLT = RemovalsSLT \times TreeVolSLT \quad (5)$$

$$VolPerAcreLLT = RemovalsLLT \times TreeVolLLT \quad (6)$$

$$VolPerAcreST = VolPerAcreCT \times TreeVolSLT \quad (7)$$

$$VolPerAcreALT = VolPerAcreSLT \times TreeVolLLT \quad (8)$$

$$VolPerAcre = VolPerAcreCT + VolPerAcreSLT \times TreeVolLLT \quad (9)$$

Tree Volume, *ft3/tree*

$$TreeVolST = \frac{VolPerAcreST}{RemovalsST} \quad (10)$$

$$TreeVolALT = \frac{VolPerAcreALT}{RemovalsALT} \quad (11)$$

$$TreeVolST = \frac{VolPerAcre}{Removals} \quad (12)$$

Other Assumptions

$$MaxManualTreeVol, ft3 = 150 \quad (13)$$

$$MaxMechTreeVol, ft3 = 80 \quad (14)$$

$$MoistureContentFraction, wet\ basis = 0.50 \quad (15)$$

$$LogLength, ft = 32 \quad (16)$$

$$LoadWeight, green\ tons\ (logs) = 25 \quad (17)$$

$$LoadWeight, green\ tons\ (chips) = 25 \quad (18)$$

$$CTLTrailSpacing, ft = 50 \quad (19)$$

$$HardwoodCostPremium, fraction = 0.20 \quad (20)$$

$$ResidueRecoveryFraction\ for\ WT\ systems = 0.80 \quad (21)$$

$$ResidueRecoveryFraction\ for\ CTL = 0.50 \quad (22)$$

Calculated Intermediates

DBH

DBH – Diameter at Breast Height, in

$$DBHCT = \sqrt{\frac{TreeVolCT + 3.675}{0.216}} \quad (23)$$

$$DBHSLT = \sqrt{\frac{TreeVolSL + 3.675}{0.216}} \quad (24)$$

$$DBHLLT = \sqrt{\frac{TreeVolLLT + 3.675}{0.216}} \quad (25)$$

$$DBHST = \sqrt{\frac{RemovalsCT \times DBHCT^2 + RemovalsSLT \times DBHSLT^2}{RemovalsST}} \quad (26)$$

$$DBHALT = \sqrt{\frac{RemovalsSLT \times DBHSLT^2 + RemovalsLLT \times DBHLLT^2}{RemovalsALT}} \quad (27)$$

$$DBH = \sqrt{\frac{RemovalsCT \times DBHCT^2 + RemovalsALT \times DBHALT^2}{Removals}} \quad (28)$$

Tree Height

$$HeightCT = -20 + 24 \times \sqrt{DBHCT} \quad (29)$$

$$HeightSLT == -20 + 24 \times \sqrt{DBHSLT} \quad (30)$$

$$HeightLLT == -20 + 24 \times \sqrt{DBHLLT} \quad (31)$$

$$HeightST = \frac{RemovalsCT \times HeightCT + RemovalsSLT \times HeightSLT}{RemovalsST} \quad (32)$$

$$HeightALT = \frac{RemovalsSLT \times HeightSLT + RemovalsLLT \times HeightLLT}{RemovalsALT} \quad (33)$$

$$Height = \frac{RemovalsCT \times HeightCT + RemovalsALT \times HeightALT}{Removals} \quad (34)$$

Wood Density

If the wood density for chip trees, small log trees or large log trees is not specified by users, then it is 50 lb/ft3 by default.

$$WoodDensityST = \frac{WoodDensityCT \times VolPerAcreCT + WoodDensitySLT \times VolPerAcreSLT}{VolPerAcreST} \quad (35)$$

$$WoodDensityALT = \frac{WoodDensitySLT \times VolPerAcreSLT + WoodDensityLLT \times VolPerAcreLLT}{VolPerAcreALT} \quad (36)$$

$$WoodDensity = \frac{WoodDensityCT \times VolPerAcreCT + WoodDensityALT \times VolPerAcreALT}{VolPerAcre} \quad (37)$$

Hardwood Fraction

If the hardwood fraction for chip trees, small log trees or large log trees is not specified by users, then it is 0 by default.

$$HdwdFractionST = \frac{HdwdFractionCT \times VolPerAcreCT + HdwdFractionSLT \times VolPerAcreSLT}{VolPerAcreST} \quad (38)$$

$$HdwdFractionALT = \frac{HdwdFractionSLT \times VolPerAcreSLT + HdwdFractionLLT \times VolPerAcreLLT}{VolPerAcreALT} \quad (39)$$

$$HdwdFraction = \frac{HdwdFractionCT \times VolPerAcreCT + HdwdFractionALT \times VolPerAcreALT}{VolPerAcre} \quad (40)$$

Butt Diameter

$$ButtDiamSLT = DBHSLT + 3 \quad (41)$$

$$ButtDiamST = DBHST + 3 \quad (42)$$

Logs Per Tree

Logs per chip tree was assumed as 1.

$$LogsPerTreeCT = 1 \quad (43)$$

$$LogsPerTreeSLT = -0.43 + 0.678 \times \sqrt{DBHSLT} \quad (44)$$

$$LogsPerTreeLLT = -0.43 + 0.678 \times \sqrt{DBHLLT} \quad (45)$$

$$LogsPerTreeST = \frac{LogsPerTreeCT \times RemovalsCT + LogsPerTreeSLT \times RemovalsSLT}{RemovalsST} \quad (46)$$

$$LogsPerTreeALT = \frac{LogsPerTreeSLT \times RemovalsSLT + LogsPerTreeLLT \times RemovalsLLT}{RemovalsALT} \quad (47)$$

$$LogsPerTree = \frac{LogsPerTreeCT \times RemovalsCT + LogsPerTreeALT \times RemovalsALT}{Removals} \quad (48)$$

Log Volume

$$LogVolST = \frac{TreeVolST}{LogsPerTreeST} \quad (49)$$

$$LogVolALT = \frac{TreeVolALT}{LogsPerTreeALT} \quad (50)$$

$$LogVol = \frac{TreeVol}{LogsPerTree} \tag{51}$$

CTL Logs Per Tree

The minimum for CTLLogsPerTree is 1.

$$CTLLogsPerTreeCT = 2 \times (-0.43 + 0.678 \times \sqrt{DBHCT}) \tag{52}$$

$$CTLLogsPerTree = 2 \times (-0.43 + 0.678 \times \sqrt{DBHST}) \tag{53}$$

CTL Log Volume

$$CTLLogVolCT = \frac{TreeVolCT}{CTLLogPerTreeCT} \tag{54}$$

$$CTLLogVol = \frac{TreeVolST}{CTLLogsPerTree} \tag{55}$$

BFperCF

$$BFperCF = 5 \tag{56}$$

Bole Weight

$$BoleWtCT = \frac{WoodDensityCT \times VolPerAcreCT}{2000} \tag{57}$$

$$BoleWtSLT = \frac{WoodDensitySLT \times VolPerAcreSLT}{2000} \tag{58}$$

$$BoleWtLLT = \frac{WoodDensityLLT \times VolPerAcreLLT}{2000} \tag{59}$$

$$BoleWtST = BoleWtCT + BoleWtSLT \tag{60}$$

$$BoleWtALT = BoleWtSLT + BoleWtLLT \tag{61}$$

$$BoleWt = BoleWtCT + BoleWtALT \tag{62}$$

Residue Weight

RF – Residue Fraction

$$ResidueCT = UserSpecRFCT \times BoleWtCT \tag{63}$$

$$ResidueSLT = UserSpecRFSLT \times BoleWtSLT \tag{64}$$

$$ResidueLLT = UserSpecRFLLT \times BoleWtLLT \tag{65}$$

$$ResidueST = ResidueCT \times ResidueSLT \tag{66}$$

$$ResidueALT = ResidueSLT \times ResidueLLT \tag{67}$$

$$Residue = ResidueCT \times ResidueALT \tag{68}$$

Manual Machine Size

The maximum of ManualMachineSize is 1.

$$ManualMachineSizeALT = \frac{TreeVolALT}{MaxManualTreeVol} \tag{69}$$

$$ManualMachineSize = \frac{TreeVol}{MaxManualTreeVol} \quad (70)$$

Mechanized Machine Size

The maximum of MechMachineSize is 1.

$$MechMachineSize = \frac{TreeVolST}{MaxMechTreeVol} \quad (71)$$

Chipper Size

The maximum of ChipperSize is 1.

$$ChipperSize = \frac{TreeVolCT}{MaxMechTreeVol} \quad (72)$$

NonSelfLevelCabDummy

$$NonSelfLevelCabDummy_{slope<15} = 1 \quad (73)$$

$$NonSelfLevelCabDummy_{15<slope<35} = 1.75 - 0.05 \times Slope \quad (74)$$

$$NonSelfLevelCabDummy_{slope>35} = 0 \quad (75)$$

CSlopeFB&Harv (Mellgren 90)

$$CSlopeFB_{Harv} = 0.00015 \times Slope^2 + 0.00359 \times NonSelfLevelCabDummy \times Slope \quad (76)$$

CRemovalsFB&Harv (Mellgren 90)

$$CRemovalsFB_{Harv} = 0.66 - 0.001193 \times RemovalsST \times 2.47 + 5.357 \times 10^{-7} \times (RemovalsST \times 2.47)^2 \quad (77)$$

CSlopeSkidForwLoadSize (Mellgren 90)

$$CSlopeForwLoadSize = 1 - 0.000127 \times Slope^2 \quad (78)$$

Chardwood

$$CHardwoodCT = 1 + HdwdCostPremium \times HdwdFractionCT \quad (79)$$

$$CHardwoodSLT = 1 + HdwdCostPremium \times HdwdFractionSLT \quad (80)$$

$$CHardwoodLLT = 1 + HdwdCostPremium \times HdwdFractionLLT \quad (81)$$

$$CHardwoodST = 1 + HdwdCostPremium \times HdwdFractionST \quad (82)$$

$$CHardwoodALT = 1 + HdwdCostPremium \times HdwdFractionALT \quad (83)$$

$$CHardwood = 1 + HdwdCostPremium \times HdwdFraction \quad (84)$$

System Product Summary

Amounts Recovered Per Acre

ResidueRecoveredPrimary – WT residue recovered as part of primary product, GT/ac

ResidueRecoveredOptional – Optional residue recovered, GT/ac

$$BoleVolCCF = \frac{VolPerAcre}{100} \quad (85)$$

$$ResidueRecoveredPrimary = ResidueRecovFracWT \times ResidueCT \quad (86)$$

$$PrimaryProduct = BoleWt + ResidueRecoveredPrimary \quad (87)$$

$$ResidueRecoveredOptional = ResidueRecovFracWT \times (ResidueSLT + ResidueLLT) \quad (88)$$

$$TotalPrimaryAndOptional = PrimaryProduct + ResidueRecoveredOptional \quad (89)$$

Amounts Unrecovered and Left within the Stand Per Acre

GroundFuel – Activity fuels (residues) on the ground, GT/ac

$$GroundFuel = ResidueLLT + ResidueST \times (1 - ResidueRecovFracWT) \quad (90)$$

ResidueLLT not times 1-ResidueRecovFracWT?

Amounts Unrecovered and Left at the Landing

PiledFuel – Piled activity fuels (residues), GT/ac

$$PiledFuel = ResidueSLT \times ResidueRecovFracWT \quad (91)$$

No CT and LLT residue Piled? Assume all ResidueLLT left within the stand?

TotalResidues

$$TotalResidues = ResidueRecoveredPrimary + ResidueRecoveredOptional + ResidueUncutTrees + GroundFuel + PiledFuel \quad (92)$$

System Cost Elements

For Primary Products (boles & WT residues), $/CCF of material treated by the activity

Fell&Bunch: trees <=80 cf	12.70
Manual Fell, Limb, Buck: all trees	
Manual Fell, Limb, Buck: all log trees	
Manual Fell, Limb, Buck: trees >80cf	12.78
Manual Fell: trees <=80 cf	
Manual Fell: chip trees	
Harvest: trees <=80 cf	
Skid Bunched: all trees	35.42
Skid Unbunched: all trees	
Forward: trees <=80 cf	
Yard Unbunched: all trees	
Yard CTL: trees <=80 cf	
Process: log trees <=80 cf	8.18
Load: log trees	7.78
Load CTL: log trees <=80 cf	
Chip: chip whole trees	7.76
Chip: chip tree boles	
Chip CTL: chip tree boles	
Primary Product Move-In Costs, $/CCl	79.06

For Optional Residues, $/GT of additional residue recovered

$$Chip\ Loose\ Residues: from\ logtrees \leq 80\ cf = CostChipLooseRes \times CollectionOption \times InLimits1 \quad (93)$$

$$Residue\ MoveIn\ Costs, \frac{\$}{GT} = 0 \times CalcMoveIn \times CalcResidues \times InLimits1 \quad (94)$$

What is the point of residue move-in costs?

For All Products, $/ac

$$ChipLooseResiduesFromLogTreesLess80cf = CostChipLooseRes \times CalcResidues \times ResidueRecoveredOptional \times InLimits1 \quad (95)$$

$$FellAndBunchTreesLess80cf = \frac{CostFellBunch \times VolPerAcreST \times InLimits1}{100} \quad (96)$$

$$ManualFellLimbBuckTreesLarger80cf = CostManFLBLLT \times VolPerAcreLLT/100 \times InLimits1 \quad (97)$$

$$SkidBunchedAllTrees = CostSkidBun \times VolPerAcre/100 \times InLimits1 \quad (98)$$

$$ProcessLogTreesLess80cf = CostProcess \times VolPerAcreSLT/100 \times InLimits1 \quad (99)$$

$$LoadLogTrees = CostLoad \times VolPerAcreALT/100 \times InLimits1 \quad (100)$$

$$ChipWholeTrees = CostChipWT \times VolPerAcreCT/100 \times InLimits1 \quad (101)$$

$$Stump2TruckPrimaryProductWithoutMovein\ (Mech\ WT) = FellAndBunchTreesLess80cf + ManualFellLimbBuckTreesLarger80cf + SkidBunchedAllTrees + ProcessLogTreesLess80cf + LoadLogTrees + ChipWholeTrees \quad (102)$$

$$Movein4PrimaryProduct = MoveInCosts!G39 \times CalcMoveIn \times BoleVolCCF \times InLimits1 \quad (103)$$

$$OntoTruck4ResiduesWoMovein\ (Mech\ WT) = ChipLooseResiduesFromLogTreesLess80cf \quad (104)$$

$$Movein4Residues = 0 \times CalcMoveIn \times CalcResidues \times ResidueRecoveredOptional \times InLimits1 \quad (105)$$

System Cost Summaries

$$TotalPerAcre = Stump2Truck4PrimaryProductWithoutMovein + Movein4PrimaryProduct + OntoTruck4ResiduesWoMovein + Movein4Residues \quad (106)$$

$$TotalPerBoleCCF = \frac{TotalPerAcre}{BoleVolCCF} \quad (107)$$

$$TotalPerGT = \frac{TotalPerAcre}{TotalPrimaryProductsAndOptionalResidues} \quad (108)$$

Limits

$$MaximumLLTperAcre = none \quad (109)$$

$$MaxLLTasPercentALT = none \quad (110)$$

$$ExceededMaxLLT = 0 \quad (111)$$

$$AvgTreeSizeLimit4Chipping = 80 \quad (112)$$

$$AvgTreeSizeLimit4Processing = 80 \quad (113)$$

$$AvgTreeSizeLimit4ManualFellLimbBuck = 250 \quad (114)$$

$$AvgTreeSizeLimit4loading = 250 \quad (115)$$

$$AvgTreeSize4GrappleSkiddingOfBunchedTrees = 250 \quad (116)$$

$$\begin{aligned} ExceededMaxTreeVol = IF(OR(&TreeVolCT \\ &> AvgTreeSizeLimit4Chipping, TreeVolSLT \\ &> AvgTreeSizeLimit4Processing, TreeVolLLT \\ &> AvgTreeSizeLimit4ManualFellLimbBuck, TreeVolALT \\ &> AvgTreeSizeLimit4loading, TreeVol \\ &> AvgTreeSize4GrappleSkidding),1,0) \end{aligned} \quad (117)$$

$$SkiddingLimit(Slope, \%) = 40 \quad (118)$$

$$ExceededMaxSkidSlope = IF(Slope > SkiddingLimit, 1,0) \quad (119)$$

$$YardingDistLimit = 0 \quad (120)$$

$$ExceededMaxYardingDist = 0 \quad (121)$$

$$\begin{aligned} InLimits1 = IF(OR(&ExceededMaxLLT = 1, ExceededMaxTreeVol \\ &= 1, ExceededMaxSkidSlope = 1, ExceededMaxYardingDist \\ &= 1), NA(),1) \end{aligned} \quad (122)$$

Fell&Bunch

CostFellBunch

$$DistBetweenTrees = \sqrt{\frac{43560}{Max(Removals, 1)}} \quad (123)$$

I. Drive-To-Tree

A) Melroe Bobcat (Johnson, 79)

PMH – Per Productive Machine hour

$$TimePerTreeIA = 0.204 + 0.00822 \times DistBetweenTrees + 0.02002 \times DBHST + 0.00244 \times Slope \quad (124)$$

$$VolPerPMHIA = \frac{TreeVolST \times 60}{TimePerTreeIA} \quad (125)$$

$$CostPerPMHIA = PMH\_DriveToTree \quad (126)$$

$$CostPerCCFIA = \frac{100 \times CostPerPMHIA}{VolPerPMHIA} \quad (127)$$

$$RelevanceIA = IF(DBHST < 10{,}1, IF(DBHST < 15{,}3 - DBHST/5{,}0)) \times IF(Slope < 10{,}1, IF(Slope < 20{,}2 - Slope/10{,}0)) \quad (128)$$

B) Chainsaw Heads (Greene&McNeel, 91)

$$CutsIB = 1.1 \quad (129)$$

$$TimePerTreeIB = (-0.0368 + 0.02914 \times DBHST + 0.00289 \times DistBetweenTrees + 0.2134 \times CutsIB) \times (1 + CSlopeFB_{Harv}) \quad (130)$$

$$VolPerPMHIB = \frac{TreeVolST \times 60}{TimePerTreeIB} \quad (131)$$

$$CostPerPMHIB = PMH\_DriveToTree \quad (132)$$

$$CostPerCCFIB = \frac{100 \times CostPerPMHIB}{VolPerPMHIB} \quad (133)$$

$$RelevanceIB = IF(DBHST < 15{,}1, IF(DBHST < 20{,}4 - DBHST/5{,}0)) * IF(Slope < 10{,}1, IF(Slope < 20{,}2 - Slope/10{,}0)) \quad (134)$$

C) Intermittent Circular Sawheads (Greene&McNeel, 91)

$$CutsIC = 1.01 \quad (135)$$

$$TimePerTreeIC = (-0.4197 + 0.01345 \times DBHST + 0.001245 \times DistBetweenTrees + 0.7271 \times CutsIC) \times (1 + CSlopeFB_{Harv}) \quad (136)$$

$$VolPerPMHIC = \frac{TreeVolST \times 60}{TimePerTreeIC} \quad (137)$$

$$CostPerPMHIC = = PMH\_DriveToTree \quad (138)$$

$$CostPerCCFIC = \frac{100 \times CostPerPMHIC}{VolPerPMHIC} \quad (139)$$

$$RelevanceIC = IF(DBHST < 15{,}1, IF(DBHST < 20{,}4 - DBHST/5{,}0)) \times IF(Slope < 10{,}1, IF(Slope < 20{,}2 - Slope/10{,}0)) \quad (140)$$

D) Hydro-Ax 211 (Hartsough, 01)

$$TreesPerAccumID = MAX(1, 14.2 - 2.18 \times DBHST + 0.0799 \times DBHST^2) \quad (141)$$

$$TimePerAccumID = 0.114 + 0.266 + 0.073 \times TreesPerAccumID + 0.00999 \times TreesPerAccumID \times DBHST \quad (142)$$

$$TreesPerPMHID = \frac{60 \times TreesPerAccumID}{TimePerAccumID} \quad (143)$$

$$VolPerPMHID = TreeVolST \times TreesPerPMHID \quad (144)$$

$$CostPerPMHID = PMH\_DriveToTree \quad (145)$$

$$CostPerCCFID = \frac{100 \times CostPerPMHID}{VolPerPMHID} \quad (146)$$

$$RelevanceID = IF(DBHST < 10,1, IF(DBHST < 15,3 - DBHST/5,0)) \times IF(Slope < 10,1, IF(Slope < 20,2 - Slope/10,0)) \quad (147)$$

II. Swing Boom

A) Drott (Johnson, 79) not used at present

$$TimePerTreeIIA = 0.388 + 0.0137 \times DistBetweenTrees + 0.0398 \times Slope \quad (148)$$

$$VolPerPMHIIA = \frac{TreeVolST \times 60}{TimePerTreeIIA} \quad (149)$$

$$CostPerPMHIIA = PMH\_SwingBoom \quad (150)$$

$$CostPerCCFIIA = \frac{100 \times CostPerPMHIIA}{VolPerPMHIIA} \quad (151)$$

$$RelevanceIIA = 0 \quad (152)$$

$$(Former\ Relevance\ Weight = IF(DBHST < 12,1, IF(DBHST < 18,3 - DBHST/6,0)) * IF(Slope < 20,1, IF(Slope < 30,3 - Slope/10,0)) \quad (153)$$

B) Timbco 2520&Cat 227 (Johnson, 88)

$$BoomReachIIB = 24 \quad (154)$$

$$TreeInReachIIB = \frac{RemovalsST \times \pi \times BoomReachIIB^2}{43560} \quad (155)$$

$$TreesPerCycleIIB = MAX(1, TreeInReachIIB) \quad (156)$$

$$TimePerCycleIIB = (0.242 + 0.1295 \times TreesPerCycleIIB + 0.0295 \times DBHST \times TreesPerCycleIIB) \times (1 + CSlopeFB_{Harv}) \quad (157)$$

$$TimePerTreeIIB = \frac{TimePerCycleIIB}{TreesPerCycleIIB} \quad (158)$$

$$VolPerPMHIIB = \frac{TreeVolST \times 60}{TimePerTreeIIB} \tag{159}$$

$$\begin{aligned} CostPerPMHIIB &= PMH\_SwingBoom \times NonSelfLevelCabDummy \\ &+ PMH\_SelfLevel \times (1 - NonSelfLevelCabDummy) \end{aligned} \tag{160}$$

$$CostPerCCFIIB = \frac{100 \times CostPerPMHIIB}{VolPerPMHIIB} \tag{161}$$

$$\begin{aligned} RelevanceIIB &= IF(DBHST < 15{,}1, IF(DBHST < 20{,}4 - DBHST/5{,}0)) \times IF(Slope \\ &< 5{,}0, IF(Slope < 20, -1/3 + Slope/15{,}1)) \end{aligned} \tag{162}$$

C) JD 693B&TJ Timbco 2518 (Gingras, 88)

$$UnmerchTreesPerHaIIC = 285 \tag{163}$$

$$UnmerchPerMerchIIC = MIN\left(1.5, \frac{285}{2.47 \times RemovalsST}\right) \tag{164}$$

$$BoomReachIIC = 24 \tag{165}$$

$$TreesInReachIIC = \frac{RemovalsST \times \pi \times BoomReachIIC^2}{43560} \tag{166}$$

$$\begin{aligned} ObsTreesPerCycleIIC &= (4.36 + 9 - (0.12 + 0.34) \times DBHST \\ &+ 0.00084 \times 2.47 \times RemovalsST)/2 \end{aligned} \tag{167}$$

$$TreesPerCycleIIC = MAX(1, MIN(TreesInReachIIC, ObsTreesPerCycleIIC)) \tag{168}$$

$$\begin{aligned} TreesPerPMHIIC &= (127.8 + 21.2 \times TreesPerCycleIIC \\ &- 63.1 \times UnmerchPerMerchIIC \\ &+ 0.033 \times UnmerchTreesPerHaIIC)/(1 + CSlopeFB\_Harv) \end{aligned} \tag{169}$$

$$VolPerPMHIIC = TreeVolST \times TreesPerPMHIIC \tag{170}$$

$$\begin{aligned} CostPerPMHIIC &= PMH\_SwingBoom \times NonSelfLevelCabDummy \\ &+ PMH\_SelfLevel \times (1 - NonSelfLevelCabDummy) \end{aligned} \tag{171}$$

$$CostPerCCFIIC = 100 \times CostPerPMHIIC/VolPerPMHIIC \tag{172}$$

$$\begin{aligned} RelevanceIIC &= IF(DBHST < 12{,}1, IF(DBHST < 18{,}3 - DBHST/6{,}0)) \times IF(Slope \\ &< 5{,}0, IF(Slope < 20, -1/3 + Slope/15{,}1)) \end{aligned} \tag{173}$$

D) Timbco (Gonsier&Mandzak, 87)

$$TimePerTreeIID = (0.324 + 0.00138 \times DBHST^2) \times (1 + CSlopeFB\_Harv + CRemovalsFB\_Harv) \quad (174)$$

$$VolPerPMHIID = TreeVolST/(TimePerTreeIID/60) \quad (175)$$

$$CostPerPMHIID = PMH\_SelfLevel \quad (176)$$

$$CostPerCCFIID = 100 \times CostPerPMHIID/VolPerPMHIID \quad (177)$$

$$RelevanceIID = IF(DBHST < 15{,}1, IF(DBHST < 20{,}4 - DBHST/5{,}0)) \times IF(Slope < 15{,}0, IF(Slope < 35, -3/4 + Slope/20{,}1)) \quad (178)$$

E) FERIC Generic (Gingras, J.F., 96. The cost of product sorting during harvesting. FERIC Technical Note TN-245)

$$VolPerPMHIIE = (50.338/0.028317 \times (TreeVolST * 0.028317)^{0.3011})/(1 + CSlopeFB\_Harv + CRemovalsFB\_Harv) \quad (179)$$

$$CostPerPMHIIE = PMH\_SwingBoom \times NonSelfLevelCabDummy + PMH\_SelfLevel \times (1 - NonSelfLevelCabDummy) \quad (180)$$

$$CostPerCCFIIE = 100 \times CostPerPMHIIE/VolPerPMHIIE \quad (181)$$

$$RelevanceIIE = IF(Slope < 5{,}0, IF(Slope < 20, -1/3 + Slope/15{,}1)) \quad (182)$$

F) (Plamondon, J. 1998. Trials of mechanized tree-length harvesting in eastern Canada. FERIC Technical Note TN-273)

$$VolPerPMHIIF = (5/0.028317 + 57.7 \times TreeVolST)/(1 + CSlopeFB\_Harv + CRemovalsFB\_Harv) \quad (183)$$

$$CostPerPMHIIF = PMH\_SwingBoom \times NonSelfLevelCabDummy + PMH\_SelfLevel \times (1 - NonSelfLevelCabDummy) \quad (184)$$

$$CostPerCCFIIF = 100 \times CostPerPMHIIF/VolPerPMHIIF \quad (185)$$

$$RelevanceIIF = IF(TreeVolST < 20{,}1, IF(TreeVolST < 50{,}5/3 - TreeVolST/30{,}0)) \times IF(Slope < 5{,}0, IF(Slope < 20, -1/3 + Slope/15{,}1)) \quad (186)$$

G) Timbco 420 (Hartsough, B., E. Drews, J. McNeel, T. Durston and B. Stokes. 97. Comparison of mechanized systems for thinning ponderosa pine and mixed conifer stands. Forest Products Journal 47(11/12):59-68)

$$HybridIIG = 0 \quad (187)$$

$$DeadIIG = 0 \quad (188)$$

$$DelayFracIIG = 0.0963 \quad (189)$$

$$BoomReachIIG = 24 \quad (190)$$

$$TreesInReachIIG = RemovalsST \times \pi \times BoomReachIIG^2/43560 \quad (191)$$

$$TreesPerAccumIIG = MAX(1,1.81 - 0.0664 \times DBHST + 3.64/DBHST - 0.0058 \times 20 - 0.27 * 0 - 0.1 \times 0) \quad (192)$$

$$MoveFracIIG = 0.5/(TRUNC(TreesInReachIIG/TreesPerAccumIIG) + 1) \quad (193)$$

$$MoveIIG = 0.192 + 0.00779 \times (BoomReachIIG + DistBetweenTrees) + 0.35 \times HybridIIG \quad (194)$$

$$FellIIG = 0.285 + 0.126 \times TreesPerAccumIIG + 0.0176 \times DBHST \times TreesPerAccumIIG - 0.0394 \times DeadIIG \quad (195)$$

$$TimePerAccumIIG = MoveFracIIG \times MoveIIG + FellIIG \quad (196)$$

$$TimePerTreeIIG = (TimePerAccumIIG \times (1 + DelayFracIIG)/TreesPerAccumIIG) \times (1 + CSlopeFB\_Harv) \quad (197)$$

$$VolPerPMHIIG = TreeVolST/TimePerTreeIIG \times 60 \quad (198)$$

$$CostPerPMHIIG = PMH\_SwingBoom \times NonSelfLevelCabDummy + PMH\_SelfLevel \times (1 - NonSelfLevelCabDummy) \quad (199)$$

$$CostPerCCFIIG = 100 \times CostPerPMHIIG/VolPerPMHIIG \quad (200)$$

$$RelevanceIIG = IF(DBHST < 15,1,IF(DBHST < 20,4 - DBHST/5,0)) \times IF(Slope < 5,0,IF(Slope < 20,-1/3 + Slope/15,1)) \quad (201)$$

III. User-Defined

$$UserDefinedVolPerPMH = 0.001 \quad (202)$$

$$UserDefinedCostPerPMH = null \quad (203)$$

$$UserDefinedCostPerCCF = 100 \times UserDefinedCostPerPMH/UserDefinedVolPerPMH \quad (204)$$

$$UserDefinedRelevance = 0 \quad (205)$$

Felling&Bunching Summary

$$
\begin{aligned}
WeightedAverage\ = IF(&TreeVolST \\
&> 0, CHardwoodST \times 100 \times (CostPerPMHIA \times RelevanceIA \\
&+ CostPerPMHIB \times RelevanceIB + CostPerPMHIC \times RelevanceIC \\
&+ CostPerPMHID \times RelevanceID \\
&+ CostPerPMHIIA \times RelevanceIIA \\
&+ CostPerPMHIIB \times RelevanceIIB \\
&+ CostPerPMHIIC \times RelevanceIIC \\
&+ CostPerPMHIID \times RelevanceIID \\
&+ CostPerPMHIIE \times RelevanceIIE \\
&+ CostPerPMHIIF \times RelevanceIIF \\
&+ CostPerPMHIIG \times RelevanceIIG \\
&+ UserDefinedCostPerPMH \times UserDefinedRelevance) \\
&/(VolPerPMHIA \times RelevanceIA + VolPerPMHIB \times RelevanceIB \\
&+ VolPerPMHIC \times RelevanceIC + VolPerPMHID \times RelevanceID \\
&+ VolPerPMHIIA \times RelevanceIIA + VolPerPMHIIB \times RelevanceIIB \\
&+ VolPerPMHIIC \times RelevanceIIC + VolPerPMHIID \times RelevanceIID \\
&+ VolPerPMHIIE \times RelevanceIIE + VolPerPMHIIF \times RelevanceIIF \\
&+ VolPerPMHIIG \times RelevanceIIG \\
&+ UserDefinedVolPerPMH \times UserDefinedRelevance),0)
\end{aligned}
\tag{206}
$$

RelevanceWeightInputs

A) Melroe Bobcat (Johnson, 79)	0.00
B) Chainsaw Heads (Greene&McNeel, 91)	0.00
C) Intermittent Circular Sawheads (Greene&McNeel, 91)	0.00
D) Hydro-Ax 211 (Hartsough, 01)	0.00
II. Swing Boom	
A) Drott (Johnson, 79) not used at present	0.00
B) Timbco 2520&Cat 227 (Johnson, 88)	1.00
C) JD 693B&TJ Timbco 2518 (Gingras, 88)	0.84
D) Timbco (Gonsier&Mandzak, 87)	0.65
E) FERIC Generic (Gingras, J.F., 96. The cost of product sorting during harv	1.00
F) (Plamondon, J. 1998. Trials of mechanized tree-length harvesting in easte	0.58
G) Timbco 420 (Hartsough, B., E. Drews, J. McNeel, T. Durston and B. Stok	1.00