FIA Volume Equation documentation updated on 9-19-2014

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Volume estimation for PNW- Databases -- NIMS and FIADB

Cubic and board foot volumes (in Scribner and International 1/4" log rules) are calculated for softwood and hardwood trees measured on forest land. A variety of volumes are estimated including gross and net volume of the merchantable stem, gross and net volume of both the sawlog portion and the upper stem portion of the bole, gross total stem volume of the entire bole from ground to tip.

All total stem volumes are calculated on all live trees in the inventory that are >= 1” DIA, and on dead trees that are >= 5” DIA.

All other volumes (gross and net growing stock and sawtimber volumes) are calculated on the merchantable stem, originally for the purpose of providing timber information. This is the most common volume most users will see in published reports. Gross volume from these equations has not been adjusted for the presence of cull (rot and defect). Net volume is gross volume minus an estimate of volume lost due to rot, physical defect, and/or other damage.

Growing stock volume is the volume of a tree, from a 1-foot stump to a 4" top, calculated on all trees >= 5” DIA. Board foot volume (sawtimber volume); for softwoods it is the volume of a tree from a 1-foot stump to a 6" top, calculated for softwood species >= 9” DIA; and for hardwoods, it is the volume of a tree from a 1-foot stump to an 8" top, calculated for hardwood species >= 11” DIA.

Note, that the sawlog and upper stem volumes are the cubic volume of sawtimber-sized trees, not to be confused with sawtimber (boardfoot) volume.

The log length for the log rule used in sawtimber (board-foot) calculations differs by species group and location, as follows:

On the west side of Oregon and Washington--
Scribner volume uses a 32-foot log rule for softwoods, and
a 16-foot log rule for hardwoods;
International 1/4" volume uses a 16-foot log rule for softwoods, and
an 8-foot log rule for hardwoods.

On the east side of Oregon and Washington, and all of California--
Scribner volume uses a 16-foot log rule for softwoods, and
a 16-foot log rule for hardwoods;
International 1/4" volume uses a 16-foot log rule for softwoods, and
an 8-foot log rule for hardwoods.

Board foot equations estimate volume of the fractional log up to the specified top diameter. The fractional log is the last log of the tree, which is less than the log rule specification.

The following volume names are used throughout the equations and are defined below:

CUBIC VOLUME (in cubic feet)

Type of Volume	Calculated on trees with a DIA of:	Volume name in equations
All softwoods and hardwoods:		
Volume of the total stem, ground to tip	>= 1”	CVTS
Volume from a 1-foot stump to the tip	>= 1”	CVT
Volume from a 1-foot stump to a 4-inch top	>= 5”	CV4
Softwood sawlog volume:		
Volume from a 1-foot stump to a 6-inch top	>= 9”	CV6
Hardwood sawlog volume:		
Volume from a 1-foot stump to an 8-inch top	>= 11”	CV8

BOARD FOOT VOLUME (square feet)

Type of Volume	Calculated on trees with a DIA of:	Volume name in equations
Softwoods:		
Scribner volume, 16-foot log rule, 1-foot stump to a 6-inch top (Eastern OR; Eastern WA; CA)	>= 9”	SV616
Scribner volume, 32-foot log rule, 1-foot stump to a 6-inch top (Western OR; Western WA)	>= 9”	SV632
International 1/4" volume, 16-foot log rule, 1-foot stump to a 6-inch top (all states)	>= 9”	XINT6
Hardwoods:		
Scribner volume, 16-foot log rule 1-foot stump to an 8-inch top (all states)	>=11”	SV816
International 1/4" volume, 8-foot log rule, 1-foot stump to an 8-inch top (all states)	>= 11”	XINT8

PROCEDURES

The general procedure used to calculate volume is as follows:

a.) estimate cubic volume first to produce CVTS, CVT, CV4, and the TARIF number;
b.) estimate RATIO's from equations that use DBH and TARIF as inputs;
c.) use the RATIO's to convert cubic volume to Scribner and International 1/4" board-foot volumes;
d.) use the RATIO's to convert the Scribner 16-foot log rule to the Scribner 32-foot log rule.

There are three methods to calculate cubic volume, depending on the equation. Each method produces an estimate for CVTS, CVT, CV4, and TARIF. In cases where volume equations do not exist for a given species, a suitable equation has been chosen and assigned to each species.

After cubic volume is calculated, all species use the same set of equations to develop the RATIO's needed to produce the remaining volumes.

CUBIC VOLUME Method 1: The TARIF number is based on CVTS.
Softwood equations 1, 2, 4, 6-15,17, 21, 22, 24
Hardwood equations 25-31

1. Calculate CVTS from published or documented volume equations for the species.
2. Calculate the TARIF number from CVTS, using the equation in DNR report #24.
3. Calculate CV4 from the TARIF number and tree basal area.
4. Calculate CVT from the TARIF number and DIA.

CUBIC VOLUME Method 2: The TARIF number is based on CV4.
Softwood equations 3, 5, 16, 18, 19, 20, 23

5. Calculate CV4 directly from published equations, using a form factor, DIA and height.
6. Calculate the TARIF number from CV4 and tree basal area.
7. If the tree >= 6" DIA then Calculate CVTS from CV4.
8. If the tree < 6" DIA then adjust the TARIF before calculating CVTS.
9. Calculate CVT from the TARIF number and DIA.

CUBIC VOLUME Method 3: The TARIF number is based on CV8.
Hardwood equations 32 to 44

10. Calculate CVTS, CV4, and CV8 directly from published equations;
11. Calculate TARIF from CV8.
12. Calculate CVT from CV8.

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13. CALCULATE CONVERSION RATIOS:

For all trees:
After CVTS and CV4 have been estimated, use equations to calculate the ratios. These ratios are used to convert cubic to board foot volume, and 16 to 32-foot log rules as follows:

RATIO	Used to convert:
RC6	CV4 to CV6
RC8	CV4 to CV8 (if needed)
RS616	CV6 to SV616
RS816	SV616 to SV816
RS632	SV616 to SV632
RI6	CV6 to XINT6
RI8	XINT6 to XINT8

SOFTWOOD CUBIC VOLUME EQUATIONS

Volume equation numbers

		Halfstate				
Species Code	**Species**	**WOR**	**WWA**	**EOR**	**EWA**	**CA**
11	Pacific silver fir	11	11	10	10	11
14	Bristlecone fir	--	--	--	--	18
15	White fir	23	11	10	10	23
17	Grand fir	11	11	10	10	23
19	Subalpine fir	11	11	10	10	18
20	California red fir	18	--	10	--	18
21	Shasta red fir	18	--	18	--	18
22	Noble fir	11	11	10	10	18
41	Port-Orford-cedar	19	19	19	19	8
42	Alaska-cedar	9	9	8	8	8
50	Cypress	--	--	--	--	19
51	Arizona cypress	--	--	--	--	19
52	Baker cypress	--	--	--	--	19
54	Monterey cypress	--	--	--	--	19
55	Sargent's cypress	--	--	--	--	19
56	McNabb cypress	--	--	--	--	19
62	California juniper	--	--	--	--	14
64	Western juniper	21	21	21	21	21
65	Utah juniper	--	--	--	--	14
66	Rocky mountain juniper	--	--	14.2	--	14.2
72	Subalpine larch	--	22	22	22	--
73	Western larch	22	22	22	22	22
81	Incense cedar	19	19	19	19	19
92	Brewer spruce	13	--	13	13	12
93	Engelmann spruce	13	13	12	12	12
98	Sitka spruce	13	13	13	13	12
101	Whitebark pine	15	15	15	15	20
102	Bristlecone pine	--	--	--	--	16
103	Knobcone pine	15	15	15	--	16
104	Foxtail pine	--	--	--	--	16
108	Lodgepole pine	15	15	15	15	16
109	Coulter pine	--	--	--	--	5
113	Limber pine	--	--	16	--	16
116	Jeffrey pine	5	--	4	--	5
117	Sugar pine	20	--	20	--	20
119	Western white pine	15	15	15	15	20
120	Bishop pine	16	--	16	--	16
122	Ponderosa pine	5	4	4	4	5
124	Monterey pine	--	--	--	--	16
127	Gray pine	--	--	--	--	5
130	Scotch pine	15	--	--	--	--
133	Singleleaf pinyon pine	--	--	--	--	14.1

SOFTWOOD CUBIC VOLUME EQUATIONS

Volume equation numbers
(continued)

		Halfstate				
Species Code	**Species**	**WOR**	**WWA**	**EOR**	**EWA**	**CA**
137	Washoe pine	--	--	--	--	5
142	Great Basin bristlecone pine	--	--	--	--	16
201	Bigcone Douglas-fir	--	--	--	--	3
202	Douglas-fir	1	1	2	2	3
211	Redwood	24	24	24	--	24
212	Giant Sequoia	24	--	24	--	24
231	Pacific yew	9	9	8	8	8
242	Western redcedar	9	9	8	8	8
251	California nutmeg	--	--	--	--	8
263	Western hemlock	6	6	6	6	6
264	Mountain hemlock	17	17	17	17	17
298/299	Unknown Conifer	17	17	17	17	17

There are many equations used to estimate softwood cubic-foot volume. Each equation below has been cross-walked to a particular tree species in the table above.
Click on an equation number to view the actual equation and procedure used to estimate volume.

SOFTWOOD VOLUME EQUATION SOURCES

EQUATION 1	DOUGLAS-FIR	(Brackett, 1973; DNR RPT # 24,1977)
EQUATION 2	DOUGLAS-FIR	(DNR MEMO--SUMMERFIELD,11/7/80)
EQUATION 3	DOUGLAS-FIR	(USDA-FS RES NOTE PNW-266)
EQUATION 4	PONDEROSA PINE	(DNR MEMO--SUMMERFIELD,11/7/80)
EQUATION 5	PONDEROSA PINE	(USDA-FS RES NOTE PNW-266)
EQUATION 6	W.HEMLOCK	(DNR NOTE 27,4/79)
EQUATION 7	W.HEMLOCK	(BROWNE (1962) BC FOREST SERV,P33)
EQUATION 8	REDCEDAR	(REDCEDAR INTERIOR--DNR RPT # 24,1977)
EQUATION 9	REDCEDAR	(REDCEDAR COAST--DNR RPT # 24,1977)
EQUATION 10	TRUE FIRS	(INTERIOR BALSAM--DNR RPT # 24,1977)
EQUATION 11	TRUE FIRS	(COAST BALSAM--DNR RPT # 24,1977)
EQUATION 12	SPRUCE	(SITKA SPRUCE INTERIOR--DNR RPT # 24,1977)
EQUATION 13	SPRUCE	(SITKA SPRUCE MATURE--DNR RPT # 24,1977)
EQUATION 14	Other junipers	(Chojnacky, 1985)
EQUATION 14.1	Singleleaf pinyon	(Chojnacky, 1985)
EQUATION 14.2	Rocky mountain juniper	(Chojnacky, 1985)
EQUATION 15	LODGEPOLE PINE	(LODGEPOLE PINE--DNR RPT # 24,1977)
EQUATION 16	LODGEPOLE PINE	(USDA-FS RES NOTE PNW-266)
EQUATION 17	MTN.HEMLOCK	(BELL, OSU RES.BULL 35)
EQUATION 18	SHASTA RED FIR	(USDA-FS RES NOTE PNW-266)
EQUATION 19	INCENSE CEDAR	(USDA-FS RES NOTE PNW-266)
EQUATION 20	SUGAR PINE	(USDA-FS RES NOTE PNW-266)
EQUATION 21	W.JUNIPER	(CHITTESTER,1984)
EQUATION 22	W.LARCH	(LARCH--DNR RPT # 24,1977)
EQUATION 23	WHITE FIR	(USDA-FS RES NOTE PNW-266)
EQUATION 24	REDWOOD	(Krumland and Wensel 1975; DNR RPT # 24,1977)

Equation 7
Browne, J.E. 1962. Standard cubic-foot volume tables for the commercial tree species of British Columbia. B.C. Forest Service, Victoria. 107 p.

Equations 1, 8, 9, 10, 11, 12, 13, 15
Brackett, M. 1973. Notes on TARIF tree volume computation. Res. Management Report 24. WA Dept. of Nat. Resources. Olympia. 26p.

Brackett, Michael. 1977. Notes on TARIF tree-volume computation. DNR report # 24. State of Washington, Department of Natural Resources, Olympia, WA. 132p.
(see Weyerhaeuser Eqn. #4, page 6)

Equations 2, 4
Summerfield, Edward. 1980. In-house memo describing equations for Douglas-fir and ponderosa pine. State of Washington, Department of Natural Resources. On file with the PNW Research Station.

Equations 3, 5,16,18,19,20,23
MacLean, Colin and John M. Berger. 1976. Softwood tree-volume equations for major California species. PNW Research Note, PNW-266. Pacific Northwest Forest and Range Experiment Station, Portland Oregon. 34p. (see page 4)

Equation 6
Chambers, C.J. and Foltz, B. 1979. The TARIF system -- revisions and additions., Resource Management Report # 27. WA Dept. of Nat. Resources. Olympia. (see page 2)

Equations 14, 14.1, 14.2
Chojnacky D.C., 1985. Pinyon-Juniper Volume Equations for the Central Rocky Mountain States.Res. Note INT-339, USDA, Forest Service, Intermountain Res. Station, Ogden, UT 84401.

Equation 17
Bell, J.F., Marshall, D.D. and Johnson G.P. 1981. Tarif tables for mountain hemlock: developed from an equation of total stem cubic-foot volume. Research Bulletin #35. OSU Forest Research Lab, School of Forestry, Oregon State University, Corvallis, OR. (see page 6)

Equation 21
Chittester, Judith and Colin MacLean. 1984. Cubic-foot tree-volume equations and tables for western juniper. Research Note, PNW-420. Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. 8p. (see page 4)

Equation 24
Krumland, B.E. and L.E. Wensel. 1975. Preliminary young growth volume tables for coastal California conifers. Research Note #1. In-house memo. Co-op Redwood Yield Research Project. Department of Forestry and Conservation, College of Natural Resources, U of Cal, Berkeley. On file with the PNW Research Station. (see Table 1, page 4)

Softwood cubic volume equations

Equation 1

$$\mathbf{CVTSL} = -3.21809 + 0.04948 \times \log(HT) \times \log(DBH) - 0.15664 \times (\log(DBH))^2 + 2.02132 \times \log(DBH) + 1.63408 \times \log(HT) - 0.16185 \times (\log(HT))^2 \quad (1)$$

CVTS=10**CVTSL (2)

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 2

$$\mathbf{CVTSL} = -6.110493 + 1.81306 \times ln(DBH) + 1.083884 \times ln(HT) \quad (1)$$

$$\mathbf{CVTS} = exp(CVTSL) \quad (2)$$

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = Natural Log, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 3– (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.248569 + 0.0253524*(HT/DBH) - 0.0000560175*(HT**2/ DBH)
IF(CF4 < 0.3) CF4 =0.3
IF(CF4 > 0.4) CF4 =0.4
CF4_TMP = 0.248569 + 0.0253524*(HT/TMP_DBH) - 0.0000560175*(HT**2/ TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 4

$$\mathbf{CVTSL} = -8.521558 + 1.977243 \times \ln(DBH) - 0.105288 \times (\ln(HT))^2 + \frac{136.0489}{HT} + 1.99546 \times \ln(HT) \quad (1)$$

$$\mathbf{CVTS} = exp(CVTSL) \quad (2)$$

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{((1.033 \times (1.0 + 1.382937 \times exp(-4.015292 \times DBH))) \times (BA + 0.087266) - 0.174533)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = Natural Log (ln), CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 5 (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.402060 - 0.899914 * (1/DBH)
IF(CF4 < 0.3) CF4=0.3
IF(CF4 > 0.4) CF4=0.4
CF4_TMP = 0.402060 - 0.899914 * (1/TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 6

$$\mathrm{CVTSL} = -2.72170 + 2.00857 \times \log\left(DBH\right) + 1.08620 \times \log\left(HT\right) - 0.00568 \times \left(DBH\right) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 7

$$\mathbf{CVTSL} = -2.663834 + 1.79023 \times log(DBH) + 1.124873 \times log(HT) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 8

$$\mathrm{CVTSL} = -2.464614 + 1.701993 \times \log\left(DBH\right) + 1.067038 \times \log\left(HT\right) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 9

$$\mathbf{CVTSL} = -2.379642 + 1.682300 \times log(DBH) + 1.039712 \times log(HT) \quad (1)$$

(2)

CVTS=10**CVTSL

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 10

$$\mathbf{CVTSL} = -2.502332 + 1.864963 \times log(DBH) + 1.004903 \times log(HT) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 11

$$\mathbf{CVTSL} = -2.575642 + 1.806775 \times log(DBH) + 1.094665 \times log(HT) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 12

$$\text{CVTSL} = -2.539944 + 1.841226 \times \log(DBH) + 1.034051 \times \log(HT) \quad (1)$$

CVTS=10**CVTSL

$$\textbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\textbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 13

$$\mathbf{CVTSL} = -2.700574 + 1.754171 \times log(DBH) + 1.164531 \times log(HT) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 14

IF (DRC >= 3 AND HT > 0) then Factor = DRC *x* DRC *x* HT;

IF STEMS=1 THEN S = 1
IF STEMS>1 THEN S = 0

VOLUME = (-.13386 + (.133726 *x* (Factor $^{1/3}$)) + (.036329 *x* S)) ^{3}

IF VOLUME <=0 then VOLUME = 0.1

WHERE:

VOLUME = cubic foot volume from ground level to a 1.5-inch minimum branch diameter
(includes live wood, dead wood, and bark)

STEMS = number of stems 3 inches and larger within the first foot above DRC. When STEMS=1 it is a single stemmed tree

DRC (inches) = Diameter at the root collar

HT (feet) = Total height of the tree

No boardfoot equation is available

Equation 14.1

IF (DRC >= 3 AND HT > 0) then Factor = DRC *x* DRC *x* HT;

IF STEMS = 1 THEN S = 1
IF STEMS > 1 THEN S = 0

VOLUME = (-0.14240 + (. 148190 x (Factor $^{1/3}$)) - (.016712 x S)) ^{3}

IF VOLUME <=0 then VOLUME = 0.1

WHERE:

VOLUME = cubic foot volume from ground level to a 1.5-inch minimum branch diameter
(includes live wood, dead wood, and bark)

STEMS = number of stems 3 inches and larger within the first foot above DRC. When STEMS=1 it is a single stemmed tree

DRC (inches) = Diameter at the root collar

HT (feet) = Total height of the tree

No boardfoot equation is available

Equation 14.2

IF (DRC >= 3 AND HT > 0) then Factor = DRC *x* DRC *x* HT;

VOLUME = (0.02434 + (0.119106 x (Factor $^{1/3}$))) ^{3}

IF VOLUME <=0 then VOLUME = 0.1

WHERE:

VOLUME = cubic foot volume from ground level to a 1.5-inch minimum branch diameter (includes live wood, dead wood, and bark)

DRC (inches) = Diameter at the root collar

HT (feet) = Total height of the tree

No boardfoot equation is available

Equation 15

$$\mathrm{CVTSL} = -2.615591 + 1.847504 \times \log(DBH) + 1.085772 \times \log(HT) \quad (1)$$

CVTS=10**CVTSL

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 16 (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.422709 - 0.0000612236 * (HT**2/DBH)
IF(CF4 < 0.3) CF4=0.3
IF(CF4 > 0.4) CF4=0.4
CF4_TMP = 0.422709 - 0.0000612236 * (HT**2/TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 17

$$\mathbf{CVTS} = 0.001106485 \times (DBH)^{1.8140497} \times (HT)^{1.2744923} \tag{1}$$

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \tag{2}$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \tag{3}$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \tag{5}$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 18 (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.231237 + 0.028176 * (HT/DBH)
IF(CF4 < 0.3) CF4=0.3
IF(CF4 > 0.4) CF4=0.4
CF4_TMP = 0.231237 + 0.028176 * (HT/TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 19 (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.225786 + 4.44236 * (1/HT)
IF(CF4 < .27) CF4=.27
CF4_TMP = 0.225786 + 4.44236 * (1/HT)
IF(CF4_TMP < .27) CF4_TMP=.27

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # .27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 20 – (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.358550 - 0.488134 * (1/DBH)
IF(CF4 < 0.3) CF4=0.3
IF(CF4 > 0.4) CF4=0.4
CF4_TMP = 0.358550 - 0.488134 * (1/ TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # .27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 21

$$\mathbf{CVTS} = 0.005454154 \times \left[0.30708901 + 0.00086157622 \times HT - 0.0037255243 \times DBH \times \frac{HT}{HT - 4.5} \right] \times DBH^2 \times HT \times \left(\frac{HT}{HT - 4.5} \right)^2 \quad (1)$$

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733 \right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \right)} \quad (2)$$

$$\mathbf{CV4} = \frac{\left(CVTS + 3.48 \right)}{\left(1.18052 + 0.32736 \times exp\left(-0.1 \times DBH \right) \right)} - 2.948 \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \right)}{0.912733} \quad (5)$$

If CVTS < 0 then CVTS = 2
If CV4 < 0 then CV4 = 1

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 22

Use for dbh>2

$$\mathbf{CVTSL} = -2.624325 + 1.847123 \times log(DBH) + 1.044007 \times log(HT) \quad (1)$$

$$\mathrm{CVTS} = 10.0^{CVTSL} \quad (2)$$

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 23 (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.299039 + 1.91272 * (1/HT) + 0.0000367217 * (HT**2/DBH)
IF(CF4 < 0.3) CF4=0.3
IF(CF4 > 0.4) CF4=0.4
CF4_TMP = 0.299039 + 1.91272 * (1/HT) + 0.0000367217 * (HT**2/TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 24

$$\mathbf{CVTS} = exp\left(-6.2597 + 1.9967 \times ln(DBH) + 0.9642 \times ln(HT)\right) \quad (1)$$

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)} \quad (2)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)}{0.912733} \quad (4)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

SOFTWOOD BOARDFOOT VOLUME EQUATIONS

$$\textbf{RC6} = 0.993\text{-}\left(0.993 \times 0.62^{(DBH-6.0)}\right)$$

$$\textbf{CV6} = RC6 \times CV4$$

IF CV6 > CV4 THEN CV6 =CV4

$$\textbf{CUBUS} = CV4 - CV6$$

$$\textbf{B4} = \frac{TARIF}{0.912733}$$

$$\textbf{RS616L} = 0.174439 + 0.117594 \times log(DBH) \times log(B4) - \frac{8.210585}{DBH^2} + 0.236693 \times log(B4) - 0.00001345 \times (B4)^2 - 0.00001937 \times DBH^2$$

$$\textbf{RS616} = 10.0^{RS616L}$$

$$\textbf{RS632} = 1.001491 - \frac{6.924097}{TARIF} + 0.00001351 \times DBH^2$$

$$\textbf{SV616} = RS616 \times CV6$$

$$\textbf{SV632} = RS632 \times SV616$$

$$\textbf{SCRIB} = SV632$$

note: West-side Scribner conifer volumes are based on 32 foot logs, for areas other than western Oregon and western Washington SCRIB = sv616

$$\textbf{RI6} = -2.904154 + 3.466328 \times log(DBH \times TARIF) - 0.02765985 \times DBH - 0.00008205 \times TARIF^2 + \frac{11.29598}{DBH^2}$$

$$\textbf{XINT6} = RI6 \times CV6$$

Where:

B4 = BINGO FACTOR

CUBUS = CUBIC FOOT VOLUME, UPPER-STEM PORTION

RC6 = RATIO TO CONVERT CUBIC 4-INCH TOP TO CUBIC 6-INCH TOP

CV6 = CUBIC FOOT VOLUME, 6-INCH TOP (SAWLOG)

RS616 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 6-INCH TOP IN 16-FT LOGS

RS632 = RATIO TO CONVERT SCRIB 6-INCH TOP IN 16-FT LOGS TO SCRIB 6-INCH TOP IN 32-FT LOGS (WEST-SIDE ONLY)

SV632 = SCRIBNER VOLUME--6-INCH TOP (IN 32-FT LOGS) (WEST-SIDE ONLY)

SV616 = SCRIBNER VOLUME--6-INCH TOP (IN 16-FT LOGS)

RI6 = RATIO TO CONVERT CUBIC 6-INCH TOP TO INTERNATIONAL ¼ INCH 6-INCH TOP

XINT6 =INTERNATIONAL ¼ INCH VOLUME--6-INCH TOP (IN 16-FT LOGS)

HARDWOOD CUBIC VOLUME EQUATIONS

Volume equation numbers

		Halfstate				
Species Code	**Species**	**WOR**	**WWA**	**EOR**	**EWA**	**CA**
312	Bigleaf maple	37	25	37	25	37
313	Boxelder	37	25	37	25	38
320	Norway maple	37	--	--	--	--
321	Rocky Mountain maple	45	45	45	45	45
322	Bigtooth maple	45	45	45	45	45
333	California buckeye	--	--	--	--	43
341	Tree of heaven	26	--	26	--	--
351	Red alder	25	26	26	26	26
352	White alder	26	26	26	26	26
361	Pacific madrone	40	25	--	--	40
374	Water birch	25	25	25	25	25
375	Paper birch	25	25	25	25	25
431	Golden chinkapin	32	25	32	--	32
475	Curlleaf mountain-mahogany	45	45	45	45	45
492	Pacific dogwood	25	25	25	25	37
500	Hawthorn	25	25	25	25	42
510/511	Eucalyptus	--	--	--	--	31
542	Oregon ash	38	25	38	25	38
547	Velvet ash	--	--	--	--	38
590/591	Holly	25	25	25	25	25
600	Walnut	--	--	--	--	38
603	Northern California black walnut	38	--	--	38	38
604	Southern California black walnut	--	--	--	--	38
611	Sweet gum	--	--	--	--	26
631	Tanoak	34	--	--	--	34
660	Apples	25	25	25	25	42
661	Oregon crabapple	25	25	25	25	42
730	California sycamore	--	--	--	--	42
731	American sycamore	--	--	--	--	42
746	Quaking aspen	25	25	25	25	28
747	Black cottonwood	25	25	25	25	27
748	Fremont poplar	--	--	--	--	27
756	honey mesquite	--	--	--	--	46
758	screwbean mesquite	--	--	--	--	46
760	Cherry	25	25	25	25	26
763	Common chokecherry	25	25	25	25	41
768	Bitter cherry	25	25	25	25	26
771	Sweet cherry	25	--	--	--	--

HARDWOOD CUBIC VOLUME EQUATIONS

Volume equation numbers
(Continued)

		Halfstate				
Species Code	**Species**	**WOR**	**WWA**	**EOR**	**EWA**	**CA**
801	California live oak	--	--	--	--	43
805	Canyon live oak	42	--	--	--	42
807	Blue oak	--	--	--	--	39
811	Englemann oak	--	--	--	--	36
815	Oregon white oak	41	25	41	25	41
818	California black oak	38	--	38	--	38
821	California white oak	35	--	--	--	35
826	Chinkapin oak	--	--	--	--	38
839	Interior live oak	--	--	--	--	44
901	Black locust	37	--	37	25	38
920	Willows	25	25	25	25	40
922	Black willow	40	--	--	--	40
926	Balsam willow	25	--	--	--	--
927	White willow	25	25	--	--	--
929	Weeping willow	--	--	25	--	--
981	California-laurel	33	--	--	--	33
990	Desert ironwood	--	--	46	46	46
997	Russian-olive	37	25	37	25	38
998	Unknown hardwood	25	25	25	25	41
999	Unknown Tree	25	25	25	25	41

HARDWOOD VOLUME EQUATION SOURCES

EQUATION 25	ALDER	(CURTIS/BRUCE, PNW-56 and DNR 24)
EQUATION 26	ALDER	(BC-ALDER--DNR RPT#24,1977)
EQUATION 27	COTTONWOOD	(BC-COTTONWOOD--DNR RPT#24,1977)
EQUATION 28	ASPEN	(BC-ASPEN--DNR RPT#24,1977)
EQUATION 29	BIRCH	(BC-BIRCH--DNR RPT#24,1977)
EQUATION 30	BIGLEAF MAPLE	(BC-MAPLE--DNR RPT#24,1977)
EQUATION 31	EUCALYPTUS	(MEMO,COLIN D. MacLEAN 1/27/83,(REVISED 2/7/83))
EQUATION 32	G.CHINQUAPIN	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION 33	C.LAUREL	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION 34	TANOAK	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION 35	CALIF WHITE OAK	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION 36	ENGELMANN OAK	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION 37	BIGLEAF MAPLE	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 38	CALIF BLACK OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 39	BLUE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 40	PACIFIC MADRONE	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 41	ORE WHITE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 42	CANYON LIVE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 43	COAST LIVE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 44	INT LIVE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 45	MTN. MAHOGANY	(Chojnacky, 1985)
EQUATION 46	MESQUITE	(Chojnacky, 1985)

Equation 25
Curtis, Robert O., Bruce, David, and Caryanne VanCoevering. 1968. Volume and taper tables for red alder. US Forest Serv. Res. Pap. PNW-56. PNW Forest & Range Exp. Sta., Portland, Oregon. 35p.

Equations 26,27,28,29,30
Brackett, Michael. 1977. Notes on TARIF tree-volume computation. DNR report #24. State of Washington, Department of Natural Resources, Olympia, WA. 132p. (see page 5)

Equation 31
Colin MacLean and Tom Farrenkopf. 1983. Eucalyptus volume equation. In-house memo describing the volume equation for CVTS, to be used for all species of Eucalyptus. The equation was developed from 111 trees. On file at the PNW Research Station,Portland,OR

Equations 32 - 44
Pillsbury, Norman H. and Michael L. Kirkley. 1984. Equations for Total, Wood, and Saw-log Volume for Thirteen California Hardwoods. PNW Research Note, PNW-414. Pacific Northwest Research Station, Portland Oregon. 52p.

Equations 45, 46
Chojnacky D.C., 1985. Pinyon-Juniper Volume Equations for the Central Rocky Mountain States. Res. Note INT-339, USDA, Forest Service, Intermountain Res. Station, Ogden, UT 84401.

HARDWOOD CUBIC VOLUME EQUATIONS

EQUATION 25

If HT < 18 then set HT = 18

$$\mathbf{F} = 0.3651 \times Z^{2.5} - 7.9032 \times Z^{2.5} \frac{DBH}{1000.0} + 3.295 \times Z^{2.5} \times \frac{HT}{1000.0}$$
$$- 1.9856 \times Z^{2.5} \times HT \times \frac{DBH}{100000.0} - 2.9668 \times Z^{2.5} \times \frac{HT^2}{1000000.0}$$
$$+ 1.5092 \times Z^{2.5} \times \frac{HT^{0.5}}{1000.0} + 4.9395 \times Z^{4} \times \frac{DBH}{1000.0}$$
$$- 2.05937 \times Z^{4} \times \frac{HT}{1000.0} + 1.5042 \times Z^{33} \times HT \times \frac{DBH}{1000000.0}$$
$$- 1.1433 \times Z^{33} \times \frac{HT^{0.5}}{10000.0} + 1.809 \times Z^{41} \times \frac{HT^2}{10000000.0} \quad (1)$$

Where: $$Z = \frac{\left(HT - 0.5 - \frac{DBH}{24.0} \right)}{HT - 4.5}$$

$$\mathbf{CVT} = 0.00545415 \times \left(DBH\right)^2 \times \left(HT - 4.5\right) \times F \quad (2)$$

$$\mathrm{TARIF} = \frac{\left(CVT \times 0.912733\right)}{\left(\left(0.9679 - 0.1051 \times 0.5523^{\left(DBH - 1.5\right)}\right) \times \left(\left(1.0330 \times \left(1.0 + 1.382937 \times \exp\left(- 4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266\right) - 0.174533 \right) \right)} \quad (3)$$

$$\mathbf{CVTS} = TARIF \times \frac{\left(\left(\left(1.0330 \times \left(1.0 + 1.382937 \times exp\left(- 4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266\right) - 0.174533 \right) \right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983 - \left(0.983 \times 0.65^{\left(DBH - 8.6\right)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE:
DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH2
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 26

$$\mathbf{CVTSL} = -2.672775 + 1.920617 \times log(DBH) + 1.074024 \times log(HT) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983\text{-}\left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 27

$$\mathbf{CVTSL} = -2.945047 + 1.803973 \times log(DBH) + 1.238853 \times log(HT) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983\text{-}\left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 28

$$\mathbf{CVTSL} = -2.635360 + 1.946034 \times log(DBH) + 1.024793 \times log(HT) \quad (1)$$

CVTS=10**CVTSL (2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983\text{-}\left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 29

$$\mathbf{CVTSL} = -2.757813 + 1.911681 \times log(DBH) + 1.105403 \times log(HT) \quad (1)$$

CVTS=10**CVTSL (2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983\text{-}\left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 30

$$\mathbf{CVTSL} = -2.770324 + 1.885813 \times log(DBH) + 1.119043 \times log(HT) \quad (1)$$

CVTS=10**CVTSL (2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983\text{-}\left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 31

$$\mathbf{CVTS} = 0.0016144 \times DBH^2 \times HT \tag{1}$$

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \tag{2}$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \tag{3}$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \tag{4}$$

$$\mathbf{RC8} = 0.983\text{-}\left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \tag{5}$$

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 32

$$\text{CVTS} = 0.0120372263 \times DBH^{2.02232} \times HT^{0.68638} \quad (1)$$

$$\textbf{CV4} = 0.0055212937 \times DBH^{2.07202} \times HT^{0.77467} \quad (2)$$

$$\textbf{CV8} = 0.0018985111 \times DBH^{2.38285} \times HT^{0.77105} \quad (3)$$

$$\text{CVT} = CVTS * RTS \quad (4)$$
$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)}$$

$$\textbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\textbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 33

$$\mathbf{CVTS} = 0.0057821322 \times DBH^{1.94553} \times HT^{0.88389} \quad (1)$$

$$\mathbf{CV4} = 0.0016380753 \times DBH^{2.05910} \times HT^{1.05293} \quad (2)$$

$$\mathbf{CV8} = 0.0007741517 \times DBH^{2.23009} \times HT^{1.03700} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$
$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)}$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 34

If HT > 120 feet then set HT = 120 feet

$$\mathbf{CVTS} = 0.0058870024 \times DBH^{1.94165} \times HT^{0.86562} \quad (1)$$

$$\mathbf{CV4} = 0.0005774970 \times DBH^{2.19576} \times HT^{1.14078} \quad (2)$$

$$\mathbf{CV8} = 0.0002526443 \times DBH^{2.30949} \times HT^{1.21069} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$
$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)}$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 35

$$\mathbf{CVTS} = 0.0042870077 \times DBH^{2.33631} \times HT^{0.74872} \quad (1)$$

$$\mathbf{CV4} = 0.0009684363 \times DBH^{2.39565} \times HT^{0.98878} \quad (2)$$

$$\mathrm{CV8} = 0.0001880044 \times DBH^{1.87346} \times HT^{1.62443} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH - 1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH - 8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 36

$$\mathbf{CVTS} = 0.0191453191 \times DBH^{2.40248} \times HT^{0.28060} \quad (1)$$

$$\mathbf{CV4} = 0.0053866353 \times DBH^{2.61268} \times HT^{0.31103} \quad (2)$$

CV8 =CV4 (3)

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH - 1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH - 8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 37

$$\mathbf{CVTS} = 0.0101786350 \times DBH^{2.22462} \times HT^{0.57561} \quad (1)$$

$$\mathrm{CV4} = 0.0034214162 \times DBH^{2.35347} \times HT^{0.69586} \quad (2)$$

$$\mathbf{CV8} = 0.0004236332 \times DBH^{2.10316} \times HT^{1.08584} \times FC^{0.40017} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH - 1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH - 8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC= HARDWOOD FORM CLASS

CVTS= CUBIC FOOT VOLUME, TOP AND STUMP

TARIF= TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 38

$$\mathbf{CVTS} = 0.0070538108 \times DBH^{1.97437} \times HT^{0.85034} \quad (1)$$

$$\mathbf{CV4} = 0.0036795695 \times DBH^{2.12635} \times HT^{0.83339} \quad (2)$$

$$\mathbf{CV8} = 0.0012478663 \times DBH^{2.68099} \times HT^{0.42441} \times FC^{0.28385} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 39

$$\mathbf{CVTS} = 0.0125103008 \times DBH^{2.33089} \times HT^{0.46100} \quad (1)$$

$$\mathbf{CV4} = 0.0042324071 \times DBH^{2.53987} \times HT^{0.50591} \quad (2)$$

$$\mathbf{CV8} = 0.0036912408 \times DBH^{1.79732} \times HT^{0.83884} \times FC^{0.15958} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 40

If HT > 120 feet then set HT = 120 feet

$$\mathbf{CVTS} = 0.0067322665 \times DBH^{1.96628} \times HT^{0.83458} \quad (1)$$

$$\mathbf{CV4} = 0.0025616425 \times DBH^{1.99295} \times HT^{1.01532} \quad (2)$$

$$\mathrm{CV8} = 0.0006181530 \times DBH^{1.72635} \times HT^{1.26462} \times FC^{0.37868} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA= BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 41

$$\mathbf{CVTS} = 0.0072695058 \times DBH^{2.14321} \times HT^{0.74220} \quad (1)$$

$$\mathbf{CV4} = 0.0024277027 \times DBH^{2.25575} \times HT^{0.87108} \quad (2)$$

$$\mathbf{CV8} = 0.0008281647 \times DBH^{2.10651} \times HT^{0.91215} \times FC^{0.32652} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 42

$$\mathbf{CVTS} = 0.0097438611 \times DBH^{2.20527} \times HT^{0.61190} \quad (1)$$

$$\mathbf{CV4} = 0.0031670596 \times DBH^{2.32519} \times HT^{0.74348} \quad (2)$$

$$\mathbf{CV8} = 0.0006540144 \times DBH^{2.24437} \times HT^{0.81358} \times FC^{0.43381} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 43

$$\mathbf{CVTS} = 0.0065261029 \times DBH^{2.31958} \times HT^{0.62528} \quad (1)$$

$$\mathbf{CV4} = 0.0024574847 \times DBH^{2.53284} \times HT^{0.60764} \quad (2)$$

$$\mathbf{CV8} = 0.0006540144 \times DBH^{2.24437} \times HT^{0.81358} \times FC^{0.43381} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 44

$$\mathbf{CVTS} = 0.0136818837 \times DBH^{2.02989} \times HT^{0.63257} \quad (1)$$

$$\mathbf{CV4} = 0.0041192264 \times DBH^{2.14915} \times HT^{0.77843} \quad (2)$$

$$\mathbf{CV8} = 0.0006540144 \times DBH^{2.24437} \times HT^{0.81358} \times FC^{0.43381} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 45

IF (DRC >= 3 AND HT > 0) then Factor = DRC *x* DRC *x* HT;

IF STEMS =1 then

VOLUME = (-0.13363 + (0.128222 *x* (Factor $^{1/3}$)) + 0 .080208) ^{3}

ELSE IF STEMS > 1 THEN

VOLUME = (-0.13363 + (0.128222 *x* (Factor $^{1/3}$))) ^{3}

IF VOLUME <=0 then VOLUME = 0.1

WHERE:

VOLUME = cubic foot volume from ground level to a 1.5-inch minimum branch diameter (includes live wood, dead wood, and bark)

STEMS = number of stems 3 inches and larger within the first foot above DRC. When STEMS=1 it is a single stemmed tree

DRC (inches) = Diameter at the root collar
HT (feet) = Total height of the tree

No boardfoot equation is available

Equation 46

IF (DRC >= 3 AND HT > 0) then Factor = DRC *x* DRC *x* HT;

```
IF STEMS > 1 then
      if DRC**2 * HT/1000 <=2 then
         VOLUME = 0.020 + 1.8972 * DRC**2*HT/1000 + 0.5756 * (DRC**2*HT/1000)**2
       Else
         VOLUME = 6.927 + 1.8972 * DRC**2*HT/1000 - 9.210 / (DRC**2*HT/1000)

IF STEMS =1 then
      if DRC**2 * HT/1000 <=2 then
         VOLUME = -0.043 + 2.3378 * DRC**2*HT/1000 + 0.8024 * (DRC**2*HT/1000)**2
       Else
         VOLUME =  9.586 + 2.3378 * DRC**2*HT/1000 - 12.839 / (DRC**2*HT/1000)

IF VOLUME <=0  then VOLUME = 0.1
```

WHERE:

VOLUME = cubic foot volume from ground level to a 1.5-inch minimum branch diameter (includes live wood, dead wood, and bark)

STEMS = number of stems 3 inches and larger within the first foot above DRC. When STEMS=1 it is a single stemmed tree.

DRC (inches) = Diameter at the root collar
HT (feet) = Total height of the tree

HARDWOOD BOARDFOOT VOLUME RATIOS and EQUATIONS

$$\mathbf{CUBUS} = CV4 - CV8 \quad (1)$$

$$\mathbf{RC6} = 0.993 - 0.993 \times 0.62^{(DBH-6.0)} \quad (2)$$

IF Hardwood Equation Number is 25 to 31 THEN set
CV4X = CVT
TARIFX = TARIF (note that TARIF was calculated in the cubic volume equation)

Otherwise, for all other hardwood equation numbers, calculate CV4X and TARIFX as follows:

$$\text{CV4X} = \text{CVT} \times 0.99875 - \frac{43.336}{\text{DBH}^3} - \frac{124.717}{\text{DBH}^4} + \frac{0.193437 \times \text{HT}}{\text{DBH}^3} + \frac{479.83}{\text{DBH}^3 \times \text{HT}}$$

$$\text{TARIFX} = \frac{\text{CV8} \times 0.912733}{0.983 - 0.983 \times 0.65^{\text{DBH}-8.6} \times \text{BA} - 0.087266}$$

If TARIF or TARIFX are <0 then set them to .01

$$\text{CV6} = RC6 \times CV4X \quad (3)$$

$$\text{B4} = \frac{TARIFX}{0.912733}$$

$$\text{RS616L} = 0.174439 + 0.117594 \times \log(DBH) \times \log(B4) - \frac{8.210585}{DBH^2} + 0.236693 \times \log(B4) - 0.00001345 \times (B4)^2 - 0.00001937 \times DBH^2 \quad (4)$$

$$\text{RS616} = 10.0^{RS616L} \quad (5)$$

$$\text{SV616} = RS616 \times CV6$$

$$\text{RI6} = -2.904154 + 3.466328 \times \log(DBH \times TARIFX) - 0.02765985 \times DBH - 0.00008205 \times TARIFX^2 + \frac{11.29598}{DBH^2} \quad (6)$$

$$\text{XINT6} = RI6 \times CV6 \quad (7)$$

$$RS616 = 0.990 - 0.58 \times (0.484^{DBH-9.5}) \quad (8)$$

$$SV816 = RS816 \times SV616 \quad (9)$$

Calculated on hardwood species only:

$$RI8 = 0.990 - 0.55 \times (0.485^{DBH-9.5}) \quad (10)$$

$$XINT8 = XINT6 \times RI8 \quad (11)$$

WHERE:
B4 = BINGO FACTOR
CUBUS = CUBIC FOOT VOLUME, UPPER-STEM PORTION
RC6 = RATIO TO CONVERT CUBIC 4-INCH TOP TO CUBIC 6-INCH TOP
CV6 = CUBIC FOOT VOLUME, 6-INCH TOP (SAWLOG)
RS616 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 6-INCH TOP IN 16-FT LOGS
SV616 = SCRIBNER VOLUME--6-INCH TOP (IN 16-FT LOGS)
RS816 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 8-INCH TOP IN 16-FT LOGS
SV816 = SCRIBNER VOLUME--8-INCH TOP (IN 16-FT LOGS)
XINT6 = INTERNATIONAL ¼ INCH VOLUME--6-INCH TOP (IN 16-FT LOGS)
RI8 =RATIO TO CONVERT INTERNATIONAL ¼ INCH 6-INCH TOP TO INTERNATIONAL ¼ INCH 8-INCH TOP
XINT8 = INTERNATIONAL ¼ INCH VOLUME--8-INCH TOP (IN 8-FT LOGS)