Forest Research
Technical Report
Coast Forest Region
2100 Labieux Road, Nanaimo, BC, Canada, V9T 6E9, 250-751-7001

TR-031 Ecology March 2004

A modified timber cruise for the inventory of dead wood in Coastal forests: a field trial

by

G. Davis, P. Marshall, P. Ott, A. Orr-Ewing, and A. Nemec

Research Disciplines: Ecology ~ Geology ~ Geomorphology ~ Hydrology ~ Pedology ~ Silviculture ~ Wildlife

Citation:
Davis, G., P. Marshall, P. Ott, A. Orr-Ewing and A. Nemec. 2004. A modified timber cruise for the inventory of dead wood in Coastal forests: a field trial. Res. Sec., Coast For. Reg., B.C. Min. For., Nanaimo, B.C. Tec. Rep. TR-031/2004.

Contacts:

Gerry D. Davis, M.Sc., P.Ag.
Research Ecologist Consultant
1655 Janes Road
Nanaimo, British Columbia V9X 1P3
davismoffat@shaw.ca

Peter L. Marshall, Ph.D., RPF
Professor, Forest Resources Management Dept.
University of British Columbia
2424 Main Mall
Vancouver, British Columbia V6T 1Z4
marshall@interchg.ubc.ca

Peter K. Ott
Biometrician
Research Branch
BC Ministry of Forests
PO Box 9529, Stn Prov Govt
Victoria, British Columbia V8W 9C3
Peter.Ott@gems7.gov.bc.ca

Alec Orr-Ewing
Timber Evaluator
A. Orr-Ewing & Associates
4735 Caulfeild Drive
West Vancouver, British Columbia V7W 1G3
alec@jsthrower.com

Ammanda F. Linnell Nemec
International Statistics and Research Corp.
PO Box 496
Brentwood Bay, British Columbia V8M 1R3
afn@isr.bc.ca

web site: http://www.for.gov.bc.ca/rco/research/index.htm

Cover photo: Cruise plot in an old-growth forest located in the Montane variant of the Very Wet Maritime subzone of the Coastal Western Hemlock biogeoclimatic zone (CWHvm2).

TABLE OF CONTENTS

Tables:

Tables (continued)**:**

Figures:

ABSTRACT

This report details the results of a field trial that explored the feasibility of using a modified version of an industrial timber cruise used in Coastal British Columbia[1] to collect data about dead wood.

The objective of modifying the timber cruise was to explore a means of obtaining reasonable estimates of coarse woody debris (CWD) attributes in Coastal British Columbia forests in a timely and cost-effective manner. The main rule governing the modifications to the industrial timber cruise was that only minor changes could be made to the operational procedures. The modified timber cruise (MIT cruise) used in the field trial therefore differed in four main aspects from other CWD survey methods used in British Columbia:

- variable radius plot sampling was used to survey all standing and downed dead wood above the minimum cruise size limit;
- attributes of all non-merchantable dead wood were estimated by the cruiser;
- attributes of non-merchantable dead wood recorded by the cruiser were limited to species, diameter (dbh), log length, grades, net factors, and original tree height; and,
- compiled estimates of volume and "last log" length were based on taper equations.

The results from the MIT cruise were compared with those of a check survey. The check survey included measuring the estimated attributes and estimating CWD volume using Smalian's formula. Comparisons were made at the individual piece level, and included a comparison of mean differences as well as an indication of overall similarity between the methods.

For the various structures examined, only small average differences occurred between estimated and measured dbh, and between the compiled volumes based on estimated and measured dbh values. However, for each of these attributes the piece-by-piece differences were relatively large, resulting in low overall similarity. For CWD pieces, the estimated lengths were shorter, on average, than the measured lengths. Similarity was also low between the length estimates and the measurements on a piece-by-piece basis. On average, there was little difference between estimates of piece volume made using Smalian's formula and those made using Kozak's taper equation. However, as was the case for all of the measurement procedures compared, the similarity between the volume estimates on a piece-by-piece basis was relatively low.

The results of this field trial illustrate the potential effectiveness of using the MIT cruise as an alternative method of collecting broad-scale data on dead structures. However, if this technique is to be applied more widely, revisions to the MIT cruise procedures are required to address the relatively high variation in the assignment of non-merchantable dead pieces between the MIT cruise and check plots, and to address the apparent underestimation of piece length.

KEY WORDS

coarse woody debris, low-value wood, non-merchantable wood, dead wood, timber cruise, modified industrial timber cruise, Coastal British Columbia

ACKNOWLEDGEMENTS

This project was undertaken under the auspices of the Coast Forest Region's Coarse Woody Debris Working Group. Financial support for this project was provided by TimberWest Forest Corp. (TWF) and International Forest Products Ltd. (Interfor) through the Strengthening Sustainable Forest Management Funding Envelope of Forest Renewal BC (FRBC), and by the BC Ministry of Forests.

The project was initiated due to the far-sighted vision of Alec Orr-Ewing and Tom Jones of TWF. The authors would like to thank operational cruisers Mike Johnston of TWF and John Pitts of Interfor for their interest, advice and dedication to the project. Thanks are also extended to Ron Mecredy of R.C. Mecredy Forest Consulting Ltd. for his advice on the check survey. The assistance of Mark Koepke of Claymore Consulting Ltd. during data compilation is gratefully acknowledged.

The authors would also like to thank the various reviewers who provided many insightful comments on a draft of this paper. These include Katrina Froese, Dr. Valerie LeMay, Norm Shaw, Don Heppner and Nancy Densmore. Fred Dawkins is gratefully acknowledged for the technical editing and layout of this document. Any errors of fact or interpretation which remain are, of course, solely the responsibility of the authors.

1.0 INTRODUCTION

Downed dead wood, also known as coarse woody debris (CWD)[2], is an important component of forests and plays a vital role in biodiversity and ecosystem processes. By providing centres of biological interaction and energy exchange, CWD in many ways symbolizes the complexity of forest ecosystems. The long-term management of this resource is important for maintaining ecosystem integrity[3].

In British Columbia, legislation requires that CWD be managed on private land within a Tree Farm Licence or woodlot licence, and on Crown land other than in a Wilderness Area (see the Forest Practices Code of British Columbia Act and the Forest and Range Practices Act). Current rules governing the management of CWD are tied to the British Columbia Ministry of Forests' timber utilization policy (BCMOF 1997; BCMOF 1999a). Based on the Chief Forester's 1996 impact

[1] An industrial timber cruise is used by several licensees in Coastal British Columbia. As per the Coastal industrial standards, trees/logs were call graded and net factored, with dead wood attributes recorded.

[2] In British Columbia, CWD is commonly defined as non-self-supporting, dead, woody material that is located above the soil and is in various stages of decomposition, including above-ground logs and large fallen branches (BCMOF 2000c). No distinction is made between dead, downed wood with roots (i.e., windthrow), and dead, downed wood without roots. CWD is normally defined as being greater than some minimum diameter. In BC the diameter is commonly 10 cm (BCMOF 2001), but it will vary among jurisdictions and applications.

[3] Nancy Densmore, Chairperson Provincial CWD Management Committee, BC Ministry of Forests, Victoria, BC; personal communication, January 2003.

estimates of stand-level biodiversity[4], CWD management is intended to have no impact on operating costs or timber supply (BCMOF and BCMOE 1996). Under this directive, potential sources of CWD, which can be left in the setting at the time of harvest, are limited to uneconomical wood[5] and economical wood up to the avoidable waste benchmark volumes specified in the timber utilization policy[6].

Guiding principles and management considerations for improving CWD retention within the context of British Columbia Ministry of Forests timber utilization policy (BCMOF 1997) are outlined in the ministry's short-term strategy for managing CWD (BCMOF 2000b). Current quantitative information on CWD attributes in either managed or unmanaged BC forests is sparse, and additional data are required to support ongoing work on developing quantitative CWD management goals.

CWD data currently collected in operational surveys – such as Residue and Waste Surveys and timber cruises – are incomplete because these surveys focus on merchantable wood. While the ground-based component of British Columbia's *Vegetation Resources Inventory* (VRI) (BCMOF 2000c) includes a CWD module in the full measure plots, the high cost of implementing the full measure plots has restricted their use. Research data, while often complete, are limited in scope because study objectives are usually very specific (e.g., Arsenault 1995; Davis 1996; Pollard and Trofymow 1993; Wells 1996). This relegates the collection of CWD data to an independent survey, which is expensive. The alternative to an independent survey is to append the collection of the "missing" dead wood (i.e., non-merchantable[7]) data to an existing operational survey (e.g., Waddell 2001). An industrial timber cruise is a logical choice for collecting background data on the attributes of CWD in forests because a portion of the downed dead wood is already measured in the cruise (i.e., windfalls)[8], and because CWD attributes are closely tied to those of standing live and dead trees. The advantage of using a modified industrial timber (MIT) cruise is that it has the potential to generate, over a very short time period, broad-scale baseline data for the types of forests being surveyed.

1.1 PROPOSED MIT CRUISE

In response to discussions on the merits of an integrated survey, TimberWest Forest Corp. (TWF), a member of the Coast Forest Region CWD Working Group[9], proposed that the industrial timber cruise used by TWF (and other licensees) be modified such that attributes of non-merchantable structures (standing and downed), not routinely included in a timber cruise, would be recorded. The objective of the TWF proposal was to provide a cost-effective, broad-scale inventory for the collection, compilation and reporting of CWD attributes. Two guiding principles governed the design of the modified survey:

1) the collection of data on the non-merchantable structures should increase only minimally the time to complete a cruise plot, and,
2) the additional compilation and reporting must be accommodated within the operational compilation program at minimal cost.

To meet the above principles it was necessary to deviate from the standard survey methods used in British Columbia to inventory CWD (i.e., fixed-area plots and line intersect sampling) (Nemec and Davis 2002; Trowbridge 1986). The resulting CWD survey method differed from the standard CWD surveys in four major aspects:

1) variable radius plot sampling was used to survey all standing and downed dead wood;
2) attributes of all non-merchantable dead structures were estimated by the cruiser;
3) attributes of non-merchantable dead structures recorded by the cruiser were limited to diameter, log length, log grades and net factors, and original tree height; and,
4) total piece volume and length of the last log were compiled estimates based on taper equations.

Because timber cruisers are intimately familiar with variable radius plot sampling[10] for measuring both standing and windfallen trees, it was felt that this survey method could reasonably be extended to chunks of dead wood. The choice of variable radius plot sampling also maintained the field data recording procedures, codes, and compilation formats of the existing

[4] Under the Chief Forester's 1996 impact estimates on stand-level biodiversity, CWD management is to have no impact on operating costs or timber supply. The 1.8% timber reduction allocated to stand-level biodiversity in the 1996 timber supply analysis (BC Ministry of Forests and BC Ministry of Environment Lands and Parks 1995) was assigned to Wildlife Tree Reserves only.

[5] As a general rule, wood is considered uneconomical when the costs of removing and processing it exceed market value. In Coastal British Columbia, uneconomical wood often includes Y and Z Grade wood. However, the definition of uneconomical wood will reflect current market conditions, and harvesting operations and goals, on a site-to-site basis.

[6] In 1999, benchmark avoidable volumes were incorporated into British Columbia's timber utilization policy to mitigate low market value for marginal timber. The benchmark avoidable volumes are voluntary; they are not billed, but are charged to the Cut Control Avoidable Waste benchmark volumes, which are 35 m^3/ha for old-growth stands and 10 m^3/ha for second-growth stands. [References: BCMOF internal memorandum from Janna Kummi (Assistant Deputy Minister, Operations Division) to all Regional and District Managers, re: Timber Utilization Policy; 20 January 1999, and BCMOF internal memorandum from Jim Gowriluk (Assistant Director, Resource Tenures and Engineering Branch) to All Regional Managers and All District Managers, re: Timber Utilization Policy; 22 January 1999.]

[7] For the purpose of this trial, non-merchantable wood included dead useless standing and downed trees (i.e., <50% sound) and chunks of wood. It is acknowledged that higher-value logs are sometimes present, but the gross and net volume of this wood is not tracked in the BCMOF timber cruise (BCMOF 2000a).

[8] The BCMOF timber cruise reports the gross and net volume/ha of dead potential windfalls (i.e., >50% sound), counts dead useless windfalls (i.e., <50% sound), and ignores chunks of wood (BCMOF 2000a).

[9] The Coast Forest Region CWD Working Group was initiated in 2000. It includes representatives from the five major licensees, Small Business Forest Enterprise Program (now BCTS), Forest Engineering Research Institute of Canada, Long Beach Model Forest, Residue Value Enhancement Association, BC Ministry of Forests, and BC Ministry of Environment, Lands and Parks. The terms of reference for the Working Group include testing the main principles outlined in *A Short-term Strategy for Coarse Woody Debris Management in British Columbia's Forests* (BCMOF 2000b), and providing quantitative guidance for managing dead wood on an ecosystem basis.

[10] Variable radius plot sampling is a form of horizontal point sampling (HPS) (de Vries 1986), where an angle gauge (often a prism) is used to select trees into the sample at a given point, with probability proportional to their basal areas.

industrial timber cruise. The decision to estimate rather than measure attributes such as dbh or diameter and length of the non-merchantable structures was a time- and cost-saving choice[11]. It was felt that cruisers could provide reasonable estimates of the basic attributes of these additional structures.

1.2 POTENTIAL APPLICATIONS OF THE MIT CRUISE DATA

From a CWD management perspective, the MIT cruise would provide a unique data set because it would provide an inventory of the attributes of large forest structures, in addition to log grades and net factors called in the field by the cruiser[12]. The former feature would permit different structures to be related to one another, while the latter would provide information about the source (i.e., structure) and volumes of low-value/ non-merchantable wood that could be left during harvesting as CWD. The MIT cruise would provide an opportunity to examine a number of questions related to CWD management options. The interpretation of the results beyond the surveyed blocks, however, would need to take into consideration the non-random selection of the baseline blocks (i.e., harvesting schedules, and market conditions). Following are some examples of questions that might be of interest:

1) **What is the total dead wood volume per hectare and how does it relate to the CWD volume per hectare?**

In a forest, dead wood may be standing or on the ground. The relative proportion of the total dead wood in either structure varies among stands depending on variables such as the dominant form of mortality, the age of the forest, and tree species (Harman and Sexton 1996). Harmon and Sexton (1996) report that it is not unusual to find that this proportion varies widely even within a single forest type; snags can make up as little as 2% or as much as 98% of the dead wood volume. Values for Coastal old-growth forests provided in the literature, while limited, indicate the potential for high stand-to-stand variation in the proportion of standing to downed dead wood volume. For two old-growth forests in the CWHvm2[13] biogeoclimatic subzone variant, total CWD volume/ha ranged from 28 to 62%[14] of the total dead wood volume/ha (Davis and Nemec 2002; Appendix A this report). In the case of three old-growth forests in the CWHwh1[15] biogeoclimatic subzone variant, the total CWD volume/ha represented 51 to 72% of the total dead wood volume/ha[16]. Based on the relative distribution of dead wood reported above, total dead wood may prove to be the more stable index on which to base CWD management goals. The data collected through the MIT cruise would provide information about CWD attributes; but equally important, it would provide further insight into the relative distribution of standing to downed dead wood.

2) What are the potential sources of low-value (Y Grade) and/or non-merchantable (Z Grade) wood[17] in the stand, which might be left in the setting during harvesting to provide future CWD?

A number of strategies are being used to provide CWD through the next rotation (e.g., retention and/or acceleration of old-growth structures through the use of variable retention harvesting, wildlife tree patches and reserves) (e.g., de Montigny 2000; Huggard 2000; Lloyd 2002). Retaining the low-value/non-merchantable wood that occurs in large forest structures, is one other strategy for providing future CWD at the time of harvesting. The volumes and sources of low-value/non-merchantable wood will vary among stands, reflecting factors such as stand age, species composition, and local mortality agents. In Coastal old-growth forests, live trees, dead standing trees, and CWD are all potential sources of low-value/non-merchantable wood.

The volume of low-value/non-merchantable wood can be significant in live trees as well as dead standing trees. For three old-growth forests in the CWHwh1 biogeoclimatic subzone variant, live trees represented approximately 20% of the potential total combined volume of Y and Z Grade wood from all large structures, while the dead standing trees represented 30 to 50%[18]. In comparison, in two old-growth forest in the CWHvm2

[11] Operational cruises are based on efficiency, and the 'estimation' of the additional non-merchantable data was deemed crucial to maintain this efficiency.

[12] An industrial timber cruise is not the same as the BC Ministry of Forests' timber cruise. Cruiser call grading and net factoring are a standard component of the industrial timber cruise used by several licensees in Coastal British Columbia. Call grading is the procedure used to assign Coastal log grades to standing and fallen timber. The basic premise is to emulate the faller, who is trying to maximize industrial end-use sorts (not log grades) by preferred log length. The cruiser maximizes the sort, using a preferred log length and then applies the log grade and net factor. Net factoring involves the estimation of the net volume of sound wood (gross volume less decay) per log length. These net factors are based on: (1) direct measurements (includes visual estimates and or physical measurements); or (2) standard, rule-based deductions. Net factoring is for sound wood loss only (decay or missing wood). No additional deductions are made for splits and fractures.

[13] In the Montane variant of the Very Wet Maritime subzone of the Coastal Western Hemlock biogeoclimatic zone.

[14] The studies from which these data are derived used different height criteria for stubs (i.e., 1.3 m vs 3 m). This difference in height would have minimal affect on the relative volume comparisons.

[15] In the Submontane variant of the Wet Hypermaritime subzone of the Coastal Western Hemlock biogeoclimatic zone.

[16] BC Ministry of Forests, Coast Forest Region; unpublished data.

[17] The economic viability of any log varies with current log values, utilization/merchantability standards, yarding chance and transportation distance (Phillips 2003). For the purpose of this report, Y-Grade logs are considered low-value, while Z-Grade wood is considered non-merchantable, even though in some situations it might have some economic value. For the purpose of this trial, the definition of Z-Grade wood is more encompassing than would be the case in an operational cruise or Residue and Waste Survey because it includes all pieces not meeting the definition of a Y Grade log. (A Y Grade piece of wood is either a log or slab cut from trees that were live or recently live and that are lower in grade than a Sawlog (i..e, X-Grade-and-better) but better than Firmwood Reject (i.e., Z Grade). A Z Grade log is referred to as Firmwood Reject. A Z Grade log is generally <50% sound and is considered to have no value, even for commercial chipping. It is a log where (1) heart rot or hole runs the whole length of the log being scaled and the residual collar of the firmwood constitutes <50% of the gross scaled volume of the log, OR (2) slabs or parts of slabs are <10 cm in thickness, OR (3) there is rot and the net length estimated by the scaler is <1.2 m, AND the net length includes the part of the log that is <10 cm thick. More detailed descriptions are available in the *Scaling Manual* (BCMOF 1999b).)

[18] BC Ministry of Forests, Coast Forest Region; unpublished data.

biogeoglimatic subzone variant, live trees represented 30 to 44% of the potential total combined volume of Y and Z Grade wood (all large structures), while the dead standing trees represented 16 to 50% (Davis and Nemec 2002; refer to Appendix A this report). The total combined volume of these lower-value log grades in the live and dead standing trees often exceeded 300 m^3/ha.

The decision – made at the time of harvesting – to leave low-value/non-merchantable wood[19] in the setting for future CWD reflects the operational and harvesting goals and the market conditions. For example, in Coastal British Columbia, modified bucking and yarding practices are used in helicopter harvesting operations to maximize log value and thereby reduce yarding costs.[20] Results from a recent study examining the cost benefits of training for modified bucking and marking (in a loader forwarding and grapple yarding operation) suggest that these modified practices may be economically viable in specific ground-based harvesting operations (Phillips 2003).[21] The benefits could include lower operational costs (e.g., related to remanufacturing at roadside, yarding, hauling and disposal of uneconomical wood) and higher retention of low-value/non-merchantable wood in the harvested setting (Phillips 2003).

The data collected in the MIT cruise would provide an opportunity to identify timber types and/or ecosystems with high volumes of low-value/non-merchantable wood in the standing timber. These stand types might then be viewed as candidates for modified harvesting practices in order to provide future CWD.

3) What are the dimensions of a large piece of CWD and what are the dimensions of the low-value/non-merchantable wood?

In North America, studies about the effects of harvesting on CWD attributes consistently report a shift in the distribution of piece size. Most studies report an increase in total number of pieces/ha of smaller dimension with reductions in larger dimensional pieces (Gore and Patterson III 1985; McCarthey and Baily 1993; Lloyd 2001; Davis and Nemec 2002). Data from the MIT cruise provide an opportunity to define the dimensions (i.e., diameter and length) of a large piece of CWD based on trends in the frequency or volume of these CWD attributes by timber type or ecosystem type. Cruiser-called log grades also provide an opportunity to predict the density and volume of low-value/non-merchantable log grades in standing trees that meet or exceed the dimensions of a large piece of CWD. When these low-value logs meet or exceed the dimensions of a large piece of CWD, the potential exists to replace or augment the existing large CWD in the setting by targeting these logs for retention at the time of harvest – depending on the specifications in the cutting authority[22] and on the harvesting goals.

The word "potential" is used because numerous factors influence not only the number/ha but also the volume/ha of low-value logs in the standing trees that are actually retained, intact, in the setting following harvest. Factors may include the pulp market, susceptibility of trees to shattering (Ruth and Harris 1975), inability to visually assess merchantability until the log is yarded to roadside, concern that the operation will be penalized for leaving merchantable logs in the setting, and bucking to preferred log lengths (Phillips 2003). Broad-scale data collected through the MIT cruise could be used to identify timber types and ecosystems with potential sources of large low-value/non-merchantable logs, which in turn could be targeted for retention in the setting at the time of harvest.

1.3 REPORT FORMAT

This report presents the results of an operational field trial undertaken by TWF and Interfor in late 2001 to explore the feasibility of the MIT cruise. This field trial included a MIT cruise and a check survey. The objectives of the field trial were to:

1. examine the reliability of the estimated attributes of the non-merchantable dead wood[23];

2. identify implementation issues related to estimating non-merchantable dead wood attributes; and

3. recommend improvements to the survey procedures.

This report is comprised of several sections. The second section describes the field methods, for both the MIT cruise and the check survey, and the data analysis methods employed. The third section presents and discusses the results from the comparison of the MIT cruise and check survey and identifies future research needs. The conclusions are outlined in the final section. Appendix A illustrates how the data collected via the MIT cruise might be used to answer questions related to CWD management. Appendices B to F provide background information, including examples of compilation output formats and summaries of dead wood attributes by timber type, based on the MIT cruise.

This report is intended for forest practitioners who are looking for alternative, effective approaches for collecting the background data on dead wood with which to make sound decisions related to CWD management. Field experience with operational cruising, net factor call grading and CWD sampling,

[19] Z Grade or Grade 5 (dead Y Grade) logs left on site are not measured in the Residue and Waste Survey. These grades are not billed or charged against the Allowable Annual Cut (AAC). Y Grade logs are billed \$0.25/m^3 if the cutting authority specifies their use. Y Grade logs are always charged against the AAC (the cutting authority – i.e., Timber Sale License, License to Cut, Road Permit, or Cutting Permit issued under a Tree Farm License, Forest License, Timber License, or Woodlot License – specifies the timber utilization requirements for each cut block). Residue and Waste Surveys are undertaken following harvesting to provide data and information for the 1) monetary billing of Avoidable Waste as liquidated damages for contract non-compliance, and 2) determination of Residue and Waste volumes for Cut Control (BCMOF 2000d).

[20] Ed Redlin, Azmeth Forest Consulting, Nanaimo; personal communication, January 2001.

[21] "The higher the transportation and disposal costs, the easier it is to receive a net payback from training and marking. The greatest value would therefore be in old-growth stands with a high cull rate, located far from the sort yard or end user." (Phillips 2003)

[22] Refer to footnote 19.

[23] Refer to footnote 7 for a definition of non-merchantable dead wood.

while not required, will be advantageous when reading this paper.

2 METHODS

2.1 STUDY AREAS

TWF and Interfor tested the modified cruise procedures during operational timber cruises conducted between late September and December 2001. The blocks cruised for TWF were located on southern Vancouver Island in the San Juan, Caycuse, Nitinat, and Cowichan drainages. The blocks cruised for Interfor were located on the east and west coast of northern Vancouver Island (west of Tahsish Inlet, north of Pye Lake and east of Stella Lake) and on West Thurlow Island in Johnstone Strait. A subset of the cruise plots was selected for subsequent installation of check plots. The check plots were used in assessing the effectiveness of the MIT cruise design in estimating various aspects of CWD. These plots are more completely described later in this report.

2.2 TRAINING

In September 2001, TWF's Timber Evaluator trained an operational cruiser for each licensee. The training session included a review and field implementation of the MIT cruise. The check cruiser also attended the training session and participated in several debriefing meetings. Both operational cruisers were retained throughout the field trial. Field sampling issues were addressed as they arose.

Table 1. Number of blocks/plots included in MIT cruise conducted by Interfor and TWF.

		Interfor	TWF	Total
Mature	Blocks[a]	2	NA	NA
	Plots	19	114	133
Immature	Blocks	6	NA	NA
	Plots	132	29	161
Total	Blocks	8	NA	NA
	Plots	151	143	294

a. Block information unavailable for the TWF operational survey. (NA=Not Available)

2.3 BLOCK/PLOT SELECTION

2.3.1 MIT CRUISE

For both licensees, site selection was tied to the operational cruising schedule. Because of the time of year, weather also influenced which blocks were sampled. The MIT cruise procedures were used on a total of 133 plots in mature timber (≥120 years of age) and 161 plots in immature timber (<120 years of age) (Table 1). Due to proprietary issues, timber type was

Table 2. Site information for Interfor's blocks.

Age	Block	Location	Tenure	Area (ha)	No. Plots Sampled	Timber Types[a]	Productivity Class	BEC	Site Series[b]
Mature	232	Chamiss Bay	FL-A19232	6.0	5	HB6+; YH4-6	Medium	CWH vm2	01/06
Mature	233	Chamiss Bay	FL-A19232	30.7	14	HB6+; BH6+; HY6+	Medium	CWH vm1/2[c]	01
Immature	119	Bear Lake	FL-A19232	46.1	34	HC4-6; F6+; FH6+; CF6+	Good	CWH xm	01
Immature	WT66	Butterfly Bay	TFL 45	9.2	10	H6+; HC6+	Medium	CWH xm	01
Immature	121	Bear Lake	FL-A19232	15.6	15	DrH2-4; H6+; HF6+; HC6+	Medium	CWH xm	01/05
Immature	WT71	Butterfly Bay	TFL 45	23.9	22	H6+; HC6+	Medium	CWH xm	01/06
Immature	36	Elk Bay	FL A19232	39.4	17	HF6+; HC4-6; CDr6+	Medium	CWH xm	01/06
Immature	109	Elk Bay	FL-A19232	40.9	34	HF6+; HDr6+; FH6+; H6+; HF4-6; FH4-6; FC6+; F6+	Good	CWH xm	01/06

a. Type label codes are as follows: Dr-red alder, H-western hemlock, B-true fir, F-Douglas-fir, C-western redcedar, Y-cypress. 2-4 = 200-400 m3/ha; 4-6 = 400-600m3/ha, 6+ = >600m3/ha. Example - HB6+=Hemlock leading species followed by true fir, >600 m3/ha.

b. Site series refers to the moisture/nutrient regime of the soil. For the subzone variants listed, the following defines the site series reported: an 01 site series has a fresh soil moisture regime and a poor to medium soil nutrient regime; an 06 site series has a moist to very moist soil moisture regime and a very poor to medium soil nutrient regime; an 05 site series has a slightly dry to fresh soil moisture regime and a rich to very rich soil nutrient regime. When more than one site series is listed, the first is the dominant. (Green and Klinka 1994)

c. This block is transitional to the CWH vm1 and the CWH vm2 subzone variants.

available only on a plot basis, where plots were not identified by block. However, Interfor provided additional biogeoclimatic ecosystem classification (BEC) subzone variant (site series) data for its eight blocks (Table 2).

2.3.2 CHECK SURVEY

The check plots were installed on four of the blocks included in the MIT cruise. This translated into a total of 20 plots (three blocks) cruised by TWF and 10 plots (one block) cruised by Interfor. The number of blocks and plots covered by the check plots was less than anticipated due to early snowfall, access difficulties for several blocks, and the need to schedule and undertake the check plots in the presence of the operational cruiser. A check plot was installed in every third or fourth cruise plot location, with either plot 1 or plot 2 randomly chosen as the location of the first check plot. Overall, 35% of the cruise plot locations in the four blocks had check plots installed.

2.4 FIELD PROCEDURES

2.4.1 THE MIT CRUISE

The MIT cruise procedures were the same as the Coastal industrial timber cruise procedures for live and dead potential trees (Table 3). The MIT cruise varied from a Coastal industrial timber cruise because it involved the collection of data on all remaining dead wood structures meeting the minimum cruise size criteria. The additional dead wood structures included all standing and downed dead useless (i.e., <50% sound wood) stems (i.e., with intact roots) and all chunks of dead wood (i.e., without root attached) irrespective of the amount of rot. The guiding principle for the inclusion of all downed dead wood was that it was included in the sample if it met the definition of a linear structure and minimum size criteria.

Table 4. Minimum merchantable limits (BCMOF 2000a).

Attribute	**Mature** (120 yrs)	**Immature**(<120 yrs)
DBH (cm)	17.5	12.0
Top Inside Bark Diameter (cm)	15.0	10.0
Stump Height (cm)	30	30

Because call grading and net factoring were applied to all structures, the application of a Y Grade log was extended to include pieces not normally recorded in an industrial cruise. Further, in the absence of a default grade, the Z Grade was applied to all pieces not meeting the criteria of a Y Grade log. The Z Grade was therefore a bit of a "catch all". Often the chunks and even the downed dead useless stems retained little sound wood, and in some cases the pieces were beginning to lose their shape.

In each block, plots were systematically established on a 100 x 100 m grid commencing from a random starting corner. All plots were full measure plots. Prism sampling was used to de-

Table 3. Structures and associated tree class codes

General Definition of Structures	BCMOF Tree Class Codes	MoF Windfall Field Codes	Merch / Non Merch
Live Standing	1 - Living trees with none of the eight external pathological indicators (Residual). 2 - Living trees with one or more of eight pathological indicators of decay: conks, blind conks, scars, fork and/or pronounced crook, frost crack, mistletoe (truck infection), rotten branches, dead or broken top (Suspect). 5 - A veteran is defined as a mature living tree (121 years or older for all species except deciduous >40 years or cottonwood and aspen >80 years) in a main stand which has been classified as immature (<121 years) (Veteran). 6 - Living trees that have only one or two live limbs. 8 - An immature stem is defined as an immature tree (<121 years) within a mature stand.	none	M
Live Windfall	1 - Living trees with none of the eight external pathological indicators (Residual). 2 - Living trees with one or more of eight pathological indicators of decay: conks, blind conks, scars, fork and/or pronounced crook, frost crack, mistletoe (truck infection), rotten branches, dead or broken top (Suspect). 5 - A veteran is defined as a mature living tree (121 years or older for all species except deciduous >40 years or cottonwood and aspen >80 years) in a main stand which has been classified as immature (<121 years) (Veteran). 6 - Living trees that have only one or two live limbs. 8 - An immature stem is defined as an immature tree (<121 years) within a mature stand.	E/G damage code	M
Dead Potential Standing	3 - Dead standing timber which is estimated to contain at least 50% of its original gross volume in sound wood content. 7 - This class combines the definition of Tree Classes 5 and 3 and is referred to as a Veteran Dead Potential. 9 - This class combines the definition of Tree Classes 8 and 3 and is referred to as Immature Dead Potential.	none	M
Dead Potential Windfall	3 - Dead, fallen trees with at least 50% of its original gross volume in sound-wood content. 7, 9 - As above.	E/G damage code	M
Dead Useless Standing	4 - Dead standing trees that have <50% of their original gross volume in firm-wood content or otherwise fail to meet the criteria of Tree Class 3 (Dead Useless).	none	NM
Dead Useless Windfall	4 - Dead standing trees that have <50% of their original gross volume in firm-wood content or otherwise fail to meet the criteria of Tree Class 3 (Dead Useless).	E/G damage code	NM
Dead Down Wood without roots attached	4 - Dead down wood without roots attached: % sound wood variable, but generally <50% of their original gross volume in firm-wood content or otherwise fail to meet the criteria of Tree Class 3 (Dead Useless).	E/G damage code (Extra field code: first log coded as R 1 0)	NM

Table 5. Attributes recorded in the MIT cruise and in the check plots.

Data type	Attributes Recorded in MIT Cruise[a]	Attributes Recorded in Check Plots[b]
Live and dead potential standing and downed trees (Tree Classes 1-3, 5-9)	· Species · DBH (cm) · Actual or projected original total tree height (m) (measured or estimated in the case of broken tops) · Log: grade length and net factor	N/A
Dead useless standing trees (Tree Classes 4)	· Species · DBH (cm) · Actual or projected original tree height (m) (measured or estimated in the case of broken tops) · Log: grade, length, net factor	· Species · DBH (cm)
Dead useless fallen trees (Tree Class 4)	· Species · DBH (cm) · Actual or projected original total tree height (m) (measured or estimated in the case of broken tops) · Log: grade, length, net factor	· Species · DBH (cm) · Total length (m) to a 10 cm inside bark top diameter · Inside bark butt diameter (cm) · Inside bark top diameter (cm) (>10 cm) · Number of breaks · Ecological decay class
Chunks $\geq$1.3m in length (Tree Class 4)	· Species · DBH (1.3 m above butt) · Actual or projected original total tree height (m) (measured or estimated in the case of broken tops) · Log: grade, length, net factor	· Species · DBH (cm) · Total length (m) to a 10 cm inside bark top diameter · Inside bark butt diameter (cm) · Inside bark top diameter (cm) (>10 cm) · Number of breaks · Ecological decay class

a. Attributes measured or estimated in MIT cruise. b. Attributes measured in check survey.

termine which merchantable trees (i.e., live and dead potential) and additional non-merchantable dead pieces were included in each plot. The prism size (basal area factor – BAF) was chosen to provide, on average, four to six live and dead potential trees per plot. Non-vertical structures were envisioned to be upright, at the location of the equivalent of breast height (i.e., 1.3 m above the butt end of a chunk or above the point of germination of a windfall). Live and dead potential trees that were borderline were measured to assess “in or out” status[24]. As a general rule, decisions on whether the additional non-merchantable dead pieces were in the plot were based on estimated values.

The minimum diameter limits for merchantable stems are given in Table 4. These minimums were applied to all stems and chunks of wood. All stems and chunks tallied were at least 1.3 m in height; stems and chunks less than these minimums were not recorded.

Table 3 summarizes the BCMOF tree class and damage codes used in the MIT cruise (BCMOF 2000a). The following attributes were either measured or estimated for all live and dead potential trees: species, tree height or projected height if the top was broken (m), dbh (cm), tree class and preferred length, log grade and net factors (% sound) (Table 5 and Appendix B). These same attributes were estimated for all additional non-merchantable dead pieces (i.e., dead useless stems and chunks). For chunks, the location of dbh was assigned to be 1.3 m above the large end. Estimating the location of breast height and estimating dbh were particularly challenging on well-decomposed pieces. Bark may or may not have been present on dead pieces.

Call grading[25] and net factoring[26] were used to assess timber quality and net tree volume. The criteria used in call grading and net factoring were similar to the criteria used in the Vegetation Resources Inventory (BCMOF 2000c)[27]. Net factors were recorded in units of 10%, for percentage sound remaining.

The existing industrial field card was used for the MIT cruise with only a few changes required to the coding to track the types of non-merchantable dead structures for the compilation program. Dead useless standing trees were coded as Tree Class 4. Dead useless windfalls were coded as Tree Class 4 with a windfall code of G or E[28], and chunks were coded as Tree Class 4 with a cruise windfall code of G or E. Chunks were also recorded with a first phantom "log" with Grade R, length 1 m, and net volume factor 0% (i.e., "R 1 0"). The compilation program was thence modified to read the "R 1 0" code as a marker and not as an actual log.

As in an industrial timber cruise, tree height was recorded as either the actual tree height, or the projected original tree height in the case of a broken top. In the latter case, it was necessary

[24] This is based on dbh, the plot radius factors and horizontal distance from the plot centre to the tree (or point at which dbh was measured if the tree was downed.

[25] Refer to footnote 12.

[26] Refer to footnote 12.

[27] Further detail is provided in Appendix B.

[28] Windfall codes: E: the tree may have one clean break in the merchantable portion of the stem; the compilation program will assign the risk group by tree class and pathological indicators; G: the tree must have two or more clean breaks or one or more shattered breaks within the merchantable portion of the stem. The compilation program will downgrade these trees to the highest risk group.

to identify the missing piece in order to discount the missing volume and length of the last log.

In order to differentiate between the last log of a tree with a dead (0% net volume) versus a broken top, the MIT cruise[29] introduced a slight variation to the cruise net factors applied to Z Grade logs. For trees with 0% net volume in the last log, a net volume of 10% was arbitrarily assigned to that log. Hence the compiled length of the last log (to the minimum top diameter) and gross volume of the last log were incorporated into the total tree gross volume and height to the minimum top diameter[30]. As in an operational industrial timber cruise, broken tops (i.e., missing tops) were graded as "Z 99 0" (i.e., Grade Z, length code 99, to indicate that the grade applies to the minimum top diameter, and 0% net volume). For these logs, the compilation treated the last log as "missing". The total tree gross volume and actual height were calculated to the top of the last actual log, or to the minimum top diameter, whichever was the smaller.

2.4.2 CHECK SURVEY

In most cases, the check survey was undertaken in the presence of the operational cruiser. The cruise plot centre was re-established and the same BAF prism was used as in the operational cruise.

The check plots included measurements on:

1) **Specific attributes estimated in the MIT cruise on non-merchantable dead structures.** The species was recorded and dbh measured on all non-merchantable dead structures included in the main prism sweep. Projected tree height, log grades, and net factors were not re-estimated.

2) **Chunk and windfall attributes required to calculate volume using Smalian's equation.** To permit a comparison of volume estimates based on Kozak's (1988) taper equation and the conventional approach to estimating CWD volume based on Smalian's equation, the following attributes were measured on all windfalls and chunks (all tree classes): inside bark diameter at the large and small ends (minimum 10 cm inside bark diameter); total length to a 10 cm top inside bark diameter[31]; decay class (BCMOF 2000c); and number of breaks to a 10 cm inside bark diameter top.

3) **Attributes of all dead standing and downed stems and chunks with a dbh between 17.5 and 12.0 cm.** In mature stands, a second, smaller BAF prism ("2P plot") was used to identify all "in" live and dead stems and chunks with a dbh between 12.0 and 17.5 cm and with heights greater than or equal to 1.3 m. This step allowed the documentation of the relative contribution of these smaller dead wood pieces to the total dead wood volume, and therefore, an evaluation of the difference in volume due to different minimum size criteria used in cruising for immature and mature forests. For the second prism sweep, all attributes measured in the cruise and check survey for standing and downed stems and chunks were measured and recorded (Table 5).

4) **"Missed" and incorrect stem counts.** All non-merchantable dead stems and chunks were re-assessed in the check survey and recorded as correct, incorrectly included, or incorrectly excluded. In the case of borderline chunks or windfalls, the assessment was based on the measured horizontal distance from the plot centre to the dbh point on the piece, plot radius factor, and the measured dbh.

2.5 COMPILATION AND ANALYSES

2.5.1 COMPILATION & OUTPUT FILES

Claymore Consulting Group Limited compiled both the MIT cruise and the check survey data. The output files included the cruise and/or check field data and the compiled attributes on an individual tree or piece basis. There were four output files:

1. a combined file with cruise and check field data and compiled attributes for plots included in both surveys. Pieces were identified by plot number;
2. a file with field and compiled data for the Interfor cruise plots, with pieces identified by plot number and biogeoclimatic subzone variant;
3. a file with field and compiled data for Interfor and TWF cruise plots with pieces identified by timber type only; and
4. a summary of volume by piece type, grade, length, and large-end diameter.

The attributes of individual pieces calculated using Kozak's taper equations included: total volume and length/height to minimum inside bark top diameter, log volume, log length, and large- and small-end inside bark diameters. These attributes were compiled twice – once using the cruise dbh, and once using the check dbh. In both instances the total, or original, tree height and log lengths and grades recorded during the cruise were used. The combined output file (i.e., including both cruise and check data) also included piece volumes for chunks and windfalls based on Smalian's formula. Appendix C provides an example of the output fields.

The gross volume and total tree height/length for all stems/chunks were compiled to the cruise minimum dbh and minimum top inside bark diameter, based on the stand age (i.e., 12.0 cm dbh and 10 cm top for immature, and 17.5 cm dbh and 15 cm top for mature stands). In the case of mature stands, stem/chunk gross volume and height/length were additionally calculated to the immature minimum top inside bark diameter (i.e., 10 cm). Because the length measurement recorded in the check survey was to a 10 cm minimum top inside bark diam-

[29] In an industrial cruise compilation, logs with zero net volume are treated as if the log is missing because the attribute of interest is net rather than gross volume.

[30] See footnote 29.

[31] In mature forests, different minimum top diameters were used in the check survey and MIT cruise. In the check survey, the top diameter and length of downed dead wood were recorded to a minimum inside bark top diameter of 10 cm. This minimum was used in both immature and mature forests. In the MIT cruise, the minimum top inside bark diameter was 10 and 15 cm, respectively, for immature and mature forests. Reconciliation of this discrepancy required separate compilations using each of the two minimum top diameters. In the future, the MIT cruise minimum top diameter should be adopted for the check survey.

eter, this latter step permitted rough comparisons between: 1) the compiled cruise height/length and the check field length measurement, and 2) the compiled volumes based on Kozak's taper equation and Smalian's equation (windfalls and chunks only).

2.5.2 ANALYSES

Summaries from the combined and Interfor-only output files are presented in this report. A summary of stand attributes by timber type is provided for reference in Appendix D.

Check Plot Analyses:

Comparisons were made between estimates of dbh, length, and gross volume based on cruise measurements and estimates based on the check plot measurements for all non-merchantable dead structures. Only structures common to both surveys were included in the comparisons.[32] For dbh, an estimate made during the cruise was compared with a measured value of dbh from the check survey. For standing dead trees, a compiled length based on Kozak's taper equations (using cruiser-called original tree "height", estimated dbh, and estimated log lengths) was compared with a compiled length based on Kozak's taper equations (using cruiser-called original tree "height", measured dbh, and log lengths). For windfalls and chunks, the compiled lengths from the MIT cruise were compared with measured lengths from the check plots. Volumes produced by the compilation program using Kozak's taper equation, based on estimated dbh and compiled length, were compared with volumes based on measured dbh and compiled length. Finally, a comparison was made between chunk and windfall volumes based on Smalian's formula and volumes from the taper equations employed in the MIT cruise.

All structures were weighted by the number of pieces per ha represented by that structure, determined from the basal area factor (BAF) of the prism used for selecting the piece and the measured dbh of the piece. A paired t-test (Zar 1984) was used to examine differences between the mean cruised and check estimates of the structures. A modification of Freese's (1960) accuracy test was used to provide an indication of the similarity of the measurements on a piece-to-piece basis. The index calculated (called E) represented the lowest accuracy standards at which the two methods could be considered interchangeable, assuming a significance level of 0.05. The higher the value of E is for a particular attribute, the less similar the two estimation methods being compared. E is affected by the variability in the compared estimates, as well as by overall mean differences.

Cruise Compilation:

Using the Interfor cruise data, plot volumes (m^3/ha) and densities (number of pieces/ha) were calculated for live and dead stems, CWD, total dead wood, and low-value/non-merchantable wood (i.e., Y and Z Grades). The density and volume of CWD and Y and Z Grade wood were further subdivided by large-end diameter (inside bark) and length classes.

In order to classify the CWD pieces by size (diameter and length), empirical cumulative distribution functions (CDFs) were calculated based on large-end diameters and lengths. The CDFs provide an estimate of the proportion of CWD pieces (per hectare) that have diameters (or lengths) less than or equal to an arbitrary diameter (length). Estimates of the diameters (lengths) that correspond to the upper 20, 10, 5, 2 and 1% of the diameter (or length) distribution were determined by (numerically) inverting the CDF. Pieces with diameters (lengths) corresponding to the upper 10% were classified as "large". Diameter and length classes used by Lloyd (2001) were also calculated to permit future comparisons.

Basic statistics (i.e., size of sample (n), sample mean, standard error of the mean (SE), and coefficient of variation (CV)) were compiled for all attributes of interest, and tabulated by Biogeoclimatic subzone variant and broad moisture grouping (Green and Klinka 1994).

Sensitivity of the Plot-Level Results:

A simple Monte Carlo experiment was run to assess the impacts of systematic differences between the cruise and check measurements, and sampling variability (due to natural variation among plots), on plot-level estimates of standing and downed wood attributes (i.e., plot totals expressed on a per hectare basis). For this analysis, all blocks were given equal weight (i.e., differences between blocks, age classes, subzones, etc. were ignored). The 30 check plots were pooled and were randomly divided into five groups of six plots apiece. Five (overlapping) subsets, each comprising 24 plots, were formed by dropping each group of six plots, one at a time. A number of plot-level parameters were estimated for the five subsets and for the original sample of 30 plots. In each case, two separate estimates were calculated using the cruise and check plot data: 1) trees and pieces of CWD common to both data sets and 2) all trees and pieces of CWD.

3 RESULTS AND DISCUSSION

3.1 ASSUMPTIONS AND LIMITATIONS

Interpretation of the results of this field trial is subject to a number of underlying assumptions and limitations of the sampling design.

Assumptions:

- The contribution of structures below the minimum cruise dbh (<12 cm) and length limits (<1.3 m) to the plot total volume is negligible;
- The measurement errors associated with the check plots are negligible.

Limitations:

- The number of check plots was small; therefore the results from the check plots should not be extrapolated beyond the blocks sampled, without further verification of the results over a broader range of timber types and stand ages;

[32] The cruise included structures incorrectly counted in the plot; the check plots did not include these structures, but did include structures missed in the cruise. Only the check plots included the 2P data.

Table 6. Number of Tree Class 4 pieces correctly counted, missed, or incorrectly counted.

Block	Misclassification Matrix					Summary	
	No. of Pieces		Cruise				
			in	out	total		
119	Check Plots	in	32	1	33	Error of omission	1/33 = 0.033
		out	4	?	4+?	Error of commission	4/36 = 0.111
		total	36	1+?	37+?	Overall accuracy	(32+?)[a]/(37+?) ≥ 0.865
769	Check Plots	in	25	3	28	Error of omission	3/28 = 0.107
		out	1	?	1+?	Error of commission	1/26 = 0.038
		total	26	3+?	29+?	Overall accuracy	(25+?)/(29+?) ≥ 0.862
7130	Check Plots	in	20	4	24	Error of omission	4/24 = 0.167
		out	1	?	1+?	Error of commission	1/21 = 0.048
		total	21	4+?	25+?	Overall accuracy	(20+?)/(25+?) ≥ 0.800
8445	Check Plots	in	17	1	18	Error of omission	1/18 = 0.056
		out	0	?	0+?	Error of commission	0/17 = 0.000
		total	17	1+?	18+?	Overall accuracy	(17+?)/(18+?) ≥ 0.944

a. The check survey did not record attributes of pieces which were out of the plot but which were recorded in the cruise; the check survey recorded attributes of pieces which were in the plot but missed in the cruise. In both instances one of the data sets was missing.

- The blocks included in the MIT cruise were not randomly selected from a well-defined population. The licensee's harvesting schedule governed block selection. As a result, the sampled blocks may or may not accurately reflect the attributes of the larger populations on a timber type and/or BEC subzone variant basis;
- The blocks where the check plots were installed were not a random sub-sample of MIT cruise blocks. Access and availability governed the choice of blocks;
- Gross volumes were not adjusted for missing volume, i.e., hollow logs.

Table 7. Dead wood volume (m^3/ha) for immature stands by plot type.

Block	Plot	Main Plot (m^3/ha)	2P Plot (m^3/ha)	Combined Plots (m^3/ha)	2P Volume as % of Total Vol.
769	10	581.3	0.0	581.3	0.0%
769	14	354.0	0.0	354.0	0.0%
769	22	122.5	5.5	128.0	4.3%
769	26	570.8	40.4	611.2	6.6%
769	30	104.3	36.4	140.7	25.8%
769	34	599.6	13.3	612.9	2.2%
769	38	776.8	0.0	776.8	0.0%
769	42	38.4	0.0	38.4	0.0%
7130	1	2649.6	0.0	2649.6	0.0%
7130	11	1294.4	0.0	1294.4	0.0%
7130	3	367.2	19.1	386.3	4.9%
7130	5	261.0	0.0	261.0	0.0%
7130	7	42.0	3.5	45.4	7.6%
7130	9	475.5	39.6	515.0	7.7%
8445	11	355.6	0.0	355.6	0.0%
8445	13	481.3	42.3	523.7	8.1%
8445	3	293.8	19.4	313.2	6.2%
8445	5	195.9	13.4	209.3	6.4%
8445	7	378.8	0.0	378.8	0.0%
8445	9	393.8	21.3	415.0	5.1%
Mean		**516.8**	**12.7**	**529.5**	**4.3%**

3.2 COMPARISON OF THE MIT CRUISE DATA WITH THE CHECK SURVEY DATA

3.2.1 VARIATION IN DEAD WOOD COUNTS

Table 6 summarizes by block the total number of pieces correctly estimated as "in", missed or incorrectly included. Of the 109 non-merchantable dead pieces included in the check plots, 15 were estimated either as" in" when they should have been "out" or vice versa. Nine of the 15 were errors of omission (i.e., pieces that were not included in the plot but should have been) while the remaining six were errors of commission (i.e., pieces that were included in the plot but should not have been). Eight of the errors of omission were chunks and one was a windfall, while four of the errors of commission were chunks and two were standing stems.

Factors that may have contributed to the variation in dead wood counts include:

1. restricted visibility, due to underbrush and local terrain;
2. limited checking of borderline dead stems and chunks; and
3. irregularly-shaped dead stems and chunks, which make the location of "breast height" and estimate of dbh subjective.

3.2.2 2P PLOT VOLUMES

Table 7 presents the dead wood volume/ha in the main and 2P plots (i.e., pieces with dbh between 12-17.5 cm; volume calculated to a 10 cm top) for check plots in mature stands. The

Table 8. Comparison of estimated and measured values by attribute and structure.

Attribute	Structure	n[b]	Mean1[c]	Mean2[c]	Mean Diff.[d]	St. Error of the Mean Diff.	P[e]	E[f]
Diameter (cm)	All	97	33.3	32.5	0.751	0.544	0.171	9.45
	Standing Dead	29	48.6	48.5	0.086	0.978	0.931	8.37
	Windfall	17	44.2	43.6	0.609	1.307	0.648	8.09
	Chunks	51	29.1	28.2	0.890	0.669	0.190	8.13
	CWD[a]	68	30.8	29.9	0.859	0.612	0.165	8.74
Length (m)	All	92	5.49	6.18	-0.689	0.224	0.003	3.92
	Standing Dead	29	7.87	9.07	-1.195	0.382	0.004	3.80
	Windfall	15	13.20	14.26	-1.058	0.574	0.087	3.64
	Chunks	48	4.12	4.66	-0.544	0.278	0.057	3.34
	CWD[a]	63	5.05	5.65	-0.596	0.256	0.023	3.60
Volume (m^3)	All	97	0.576	0.568	0.008	0.015	0.567	0.251
	Standing Dead	29	1.243	1.315	-0.072	0.047	0.132	0.415
	Windfall	17	1.740	1.726	0.015	0.077	0.854	0.476
	Chunks	51	0.308	0.286	0.022	0.014	0.111	0.169
	CWD[a]	68	0.468	0.446	0.021	0.015	0.154	0.213

a. CWD (coarse woody debris) is the combination of the windfall and chunk categories.

b. Sample size is the number of observations made for a particular attribute and structure.

c. Mean1 is the weighted mean estimated diameter, compiled length, or Kozak's taper function volume based on the estimated diameter and compiled length. Mean2 is the weighted mean measured diameter, measured length, or Kozak's taper function volume based on measured diameter and the compiled length. Each observation was weighted by the stems per ha the particular piece represents to reflect the fact that selection was made with probability proportional to the square of the diameter of the piece at a specific reference point. Stems per ha was calculated as: $\frac{40000 \times BAF_i}{p \cdot D_i^2}$ where *BAFi* is the basal area factor of the device used to select the *i*th piece, and *Di* is the measured diameter of the piece, in cm, at the appropriate reference point.

d. The mean difference is the average of the differences between the estimated and measured value of the attribute, weighted by the number of stems per ha a particular piece represents.

e. The probability associated with the result of a paired t-test on the weighted differences.

f. E is an indicator of the "accuracy" of estimated value. It represents the value at which the weighted differences would "just meet" a set accuracy level with α = 0.05, based on Freese's (1960) accuracy test.

$E = \sqrt{\frac{\sum_{i=1}^{n} (W_i \times diff_i)^2}{c^2_{(n)df}} \times Z^2_{0.05/2}}$, where W_i is the weighting applied to the *i*th observation $\left(W_i = \frac{pieces_i}{\sum_{i=1}^{n} pieces_i} \times n \right)$, $pieces_i$ is the number of stems per ha represented by the *i*th piece, $diff_i$ is the difference between the two values obtained for the *i*th piece, $X^2_{(n)df}$ is the chi-square value for *n* degrees of freedom, and $Z^2_{0.05/2}$ is the square of the standard normal deviate for a two-tailed test at a significance level of 0.05.

total dead wood volume in the 2P plot represented, on average, 4.3% of the total dead wood in the combined plots.

3.2.3 COMPARISON OF NON-MERCHANTABLE DEAD STRUCTURES: CRUISE AND CHECK PLOTS

The estimated sample mean for dbh (cruise plots) did not differ significantly from the measured sample mean (check plots) for individual or combined structures (Table 8). However, accuracy levels were low, ranging from just over 8 cm for windfalls to almost 9.5 cm for all structures combined. This reflects the high piece-to-piece variability of the differences between the means. See Appendix E, Figures 12 to 15, for graphical comparisons of estimated versus measured values of dbh.

The compiled lengths, on average, underestimated the measured lengths (windfalls, chunks) and the compiled lengths based on measured dbh (standing dead) (Table 8). The mean differences ranged from -0.54 m for chunks to -1.20 m for standing dead trees. Not surprisingly, accuracy levels were low, ranging from 3.3 m for chunks to 3.9 m for all structures together.

The underestimation of length, particularly for pieces greater than 10 m in length, is illustrated in Appendix E, Figures 16 through 18. For standing dead stems, dbh was the only factor that differed in the calculation of the "estimated" and "measured" (compiled) lengths. In the case of CWD (i.e., chunks and windfalls), where the compiled length was directly compared with the field measured length, other influencing factors may include[33]:

1. different rounding procedures (log lengths were rounded to 1 m during the cruise, while piece length was rounded to 1 cm on the check plots);
2. increased difficulty in estimating original tree height and/or log lengths on longer pieces due to reduced visibility (e.g., thick underbrush or undulating terrain); and
3. inexperience with the new survey method.

In the case of chunks, the subjective choice of dbh and its estimation, particularly on short, decomposed pieces, may additionally compromise the compiled cruise length.

The compiled volumes based on the cruise (estimated dbh) and the check plots (measured dbh) were not significantly different for individual or combined structures, on average (Table 8). This was not surprising given the small mean difference between estimated and measured dbh. However, as was the case for dbh, the two approaches differed on a piece-by-piece basis, as evidenced by the relatively high values of E, ranging from about 0.21 m^3 for CWD (windfall and chunks together) to 0.48 m^3 for windfalls. If the piece lengths for the check plots used in the comparison of the lengths were used for computing the volumes for the pieces in the check plots, the check plot volumes would have undoubtedly been larger, on average, than the cruise plot volumes, and the accuracy would have been considerably lower than reported for the volume comparison in Table 8.

The similarity of the average estimates of dbh and volume is reassuring. However, the relatively large differences (low similarity) on a piece-by-piece basis means that relatively large mean differences between the two survey methods could exist if there are only a small number of pieces being compared. The underestimation of piece length by the MIT cruise warrants addressing if this approach is to be used operationally.

3.2.4 COMPARISON OF PIECE VOLUMES BASED ON SMALIAN'S AND KOZAK'S TAPER EQUATIONS

In order to assess possible differences between volume estimates based on Smalian's equation and volume estimates based on Kozak's taper function for windfalls, chunks, and total CWD (windfalls and chunks together), a comparison similar to that described in the previous section was made. Method 1 is the estimate of volume based on Kozak's taper equation, and method 2 is the estimate of volume based on Smalian's equation. Measured dbh and the compiled length of eligible pieces included in both the cruise and check plots were used as input to the taper volume. Diameter measured at each end of a piece (with a diameter limit of 10 cm) and compiled length were used as input to Smalian's equation. Piece lengths were held constant for the two volume methods so that differences would be only attributable to the volume estimation method employed, and not to variability in the input measurements.

There were only relatively small differences, on average, between the Smalian and taper-based volumes for either of the structures (Table 9). None of the average differences were significant at $\alpha = 0.05$. However, the similarity was relatively low, especially in the case of windfalls, indicating high piece-to-piece variability in these estimates. This is illustrated graphically in Figures E-15 to E-17 in Appendix E.

An exact volume match was not expected because both approaches involve different assumptions. Smalian's equation provides exact volumes for sections of paraboloids. However, sections of tree boles, especially near the base (more neoloidal) and near the tip (more conical) do not necessarily conform to this shape. Estimation error is greatly decreased if short sections of logs are used. Smalian's equation is most appropriate for short pieces, providing an increasingly poor estimation of volume with increasing piece length. Kozak's taper equations represent species-specific relationships between distance along a stem and diameter, which can be rotated and integrated to yield volume. These are average relationships and may not well represent the shape of every tree or section of a tree.

The compilation program used by Claymore requires tree dbh and original height as input to determine volume using Kozak's taper equations. Assuming that the equations adequately represent tree shape, three factors influence the reliability of the taper volume estimate: 1) original tree height, 2) locating breast height, and 3) estimating dbh. For non-merchantable dead structures, all three of these attributes were estimated in the MIT cruise. In the case of broken tops, estimating original tree height becomes more difficult with increasing distance from the break, and broken tops are a common feature of non-merchantable dead structures. While establishing breast height is routine for windfalls and standing trees, this is not the case for chunks where breast height is estimated as 1.3 m above the base of

[33] Estimating the location of the minimum top diameter of well decomposed down trees and chunks was initially thought to be a factor involved in the underestimation of the cruise length. As illustrated in Appendix E there is no apparent trend between the absolute difference in length and CWD decay class.

Table 9. Comparison of taper and Smalian volumes for various structures.

Structure	n	Mean1	Mean2	Mean Diff.	St. Error of the Mean Diff.	P	E
Windfall	14	2.031	2.069	-0.039	0.222	0.864	1.206
Chunks	48	0.302	0.339	-0.038	0.021	0.078	0.249
CWD[a]	62	0.444	0.482	-0.038	0.026	0.154	0.356

Refer to Table 8 for an explanation of column titles.

Table 10. Sensitivity analysis of plot-level parameters based on cruised and check data (common structures).

Subset	Total volume (m^3/ha) Mean Diff.[a]	SE Diff.	% Diff./valid	CWD volume (m^3/ha) Mean Diff.	SE Diff.	% Diff./valid	Volume of Y & Z pieces (m^3/ha) Mean Diff.	SE Diff.	% Diff./valid	Large CWD volume (m^3/ha) Mean Diff.	SE Diff.	% Diff./valid
All	0.4	0.9	0.1	-0.3	0.8	-0.1	-15.5	8.5	-7.9	0.3	0.3	0.3
1	-0.1	1.0	-0.0	-1.0	0.8	-0.5	-14.1	10.1	-8.6	0.0	0.2	0.0
2	-0.1	1.1	-0.0	-0.8	0.9	-0.3	-12.8	9.7	-6.5	0.2	0.3	0.2
3	-0.1	1.0	-0.0	-0.4	0.9	-0.1	-8.0	6.8	-4.3	0.5	0.3	0.4
4	1.2	1.1	0.3	0.2	0.9	0.1	-21.2	10.3	-9.5	0.3	0.4	0.2
5	1.3	0.9	0.3	0.4	0.7	0.2	-21.4	10.1	-10.0	0.4	0.3	0.3

Subset	Total pieces per ha Mean Diff.	SE Diff.	% Diff./valid	Total CWD pieces per ha Mean Diff.	SE Diff.	% Diff./valid	Total Y & Z pieces per ha Mean Diff.	SE Diff.	% Diff./valid	Total large CWD pieces per ha Mean Diff.	SE Diff.	% Diff./valid
All	28.3	56.8	4.7	28.6	56.4	5.5	1.3	6.7	0.9	0.4	1.2	1.7
1	-29.6	26.4	-4.8	-29.0	25.1	-5.5	1.0	8.2	0.6	-0.2	1.3	-1.0
2	35.5	71.1	5.4	34.2	70.6	5.8	2.8	7.8	1.8	-0.7	1.2	-3.1
3	29.6	70.3	4.8	31.4	70.2	5.8	-5.0	4.5	-4.1	1.5	1.0	6.8
4	67.9	67.2	13.9	68.1	66.7	17.1	4.8	8.0	3.2	0.5	1.4	1.9
5	38.0	70.2	6.1	38.1	69.7	7.0	2.8	8.1	2.0	1.0	1.4	3.9

[a] Per ha value based on the cruise data minus the per ha value based on the check data.

Table 11. Sensitivity analysis of plot-level parameters based on cruised and check data (plot totals).

Subsets	Total volume (m^3/ha) mean Diff.[a]	SE Diff.	% Diff./valid	CWD volume (m^3/ha) mean Diff.	SE Dif.f	% Diff./valid	Volume of Y & Z pieces (m^3/ha) mean Diff.	SE Diff.	% Diff./valid	Large CWD volume (m^3/ha) mean Diff.	SE Diff.	% Diff./valid
All	-18.3	15.8	-4.1	-23.9	15	-8.3	-12.6	9.3	-5.9	-4.5	4.7	-4.1
1	-35.7*	14.8	-9.0	-39.6*	13.6	-16.2	-10.4	11.1	-5.6	-5.9	5.9	-11.9
2	-5.3	16.0	-1.2	-14.5	15.9	-4.7	-8.9	10.6	-4.2	-5.7	5.9	-4.7
3	-13.7	18.8	-3.1	-21	17.5	-6.8	-4.4	8.1	-2.2	-5.4	5.9	-4.4
4	-22.4	19.8	-4.7	-23.4	17.9	-8.0	-17.7	11.4	-7.4	0.3	0.4	0.2
5	-14.4	18.5	-3.1	-21	18.2	-7.2	-21.5*	10.2	-9.1	-5.5	5.9	-4.3

Subsets	Total pieces per ha mean Diff.	SE Diff.	% Diff./valid	Total CWD pieces per ha mean Diff.	SE Diff.	% Diff./valid	Total Y & Z pieces per ha mean Diff.	SE Diff.	% Diff./valid	Total large CWD pieces per ha mean Diff.	SE Diff.	% Diff./valid
All	-357.0*	114.5	-33.3	-190.0*	92.7	-25.3	-181.4*	69.2	-48.7	0.4	1.2	1.6
1	-444.5*	99.7	-40.6	-235.6*	64.0	-32.0	-227.3*	84.1	-51.4	-0.2	1.3	-0.9
2	-319.3*	127.9	-28.9	-167.4	109.6	-20.7	-170.5*	79.8	-45.9	-0.7	1.2	-2.9
3	-314.3*	134.4	-29.6	-154.4	109.4	-20.8	-183.1*	79.9	-52.2	1.5	1.0	6.4
4	-415.8*	140.5	-38.5	-205.1	115.2	-29.8	-225.6*	84.3	-52.1	0.5	1.4	1.9
5	-291.0*	133.3	-28.4	-187.6	112.7	-23.9	-100.3	52.5	-37.9	1.0	1.4	3.7

a. Per ha value based on the cruise data minus the per ha value based on the check data.

* Significant at α=0.05.

the piece. For broken and well-decayed chunks of wood, estimating breast height and dbh may be quite subjective. Further, in the compilation it was assumed that a chunk was a butt log, when in fact it may have been from the middle or top section of the original tree.

Given the small sample size, further comparisons are recommended to better quantify the magnitude of the variation between these two estimates of volume by piece type. This comparative information is required in order to interpret the MIT cruise CWD data within the context of CWD data reported in the literature, since the latter are typically based on Smalian's equation.

3.2.5 COMPARISON OF PLOT-LEVEL RESULTS

Tables 10 and 11 contain a summary of the results of the Monte Carlo experiment conducted on the 30 plots that were included in both the cruised and the check data sets. Table 10 contains plot-level differences based only on structures that

Table 12. Mean number of stems or pieces measured on a plot.

Stand Age		No. Plots	Live standing	Dead standing	Windfalls	Chunks	Total CWD	Total Dead
Mature	Total number of pieces	133	609	157	87	176	263	420
	Mean ± SE		4.6±0.17	1.2±0.10	0.7±0.09	1.3±0.13	2.0±0.17	3.2±0.20
Immature	Total number of pieces	161	689	208	99	407	506	714
	Mean ± SE		4.3±0.15	1.3±0.12	0.6±0.07	2.5±0.15	3.1±0.17	4.4±0.24

were common to both data sets. Table 11 is based on plot-level differences between comparable cruise and check plots with the calculations based on all structures assessed as being "in" each of the plots. Hence, the differences shown in Table 10 are due only to differences between the measurements and estimates that occurred during the cruise and the measurements that took place during the check. The plot-level differences shown in Table 11 include the impact of CWD pieces being inappropriately included or excluded during the cruise.

Not surprisingly, smaller differences are generally seen in Table 10 than in Table 11, especially in terms of the various components of pieces per ha examined. The various components of volume per ha were generally underestimated slightly by the cruise, but not usually significantly so. The great majority of the differences were less than 10%; most were less than 5%. There was good agreement among the subset estimates, indicating that a sample size of 24 plots appeared to be sufficiently large to capture the variability present. (Refer to Appendix F for means and standard errors).

There was less agreement between the cruise-based and the check-based estimates of the number of pieces per ha, especially in Table 11, although none of the differences were statistically significant for any component. Total pieces per ha, total CWD pieces per ha, and numbers of combined Y & Z Grade pieces per ha, were all underestimated by the cruise data when plot totals (per ha) were compared. The differences were large and generally significant, despite large variability. For each of the above attributes, the differences based on all data and each subset exceeded 20% of the check estimates. The large effect of pieces missed by the cruiser on the density estimates of the above attributes suggests that these pieces are probably small, since they appear to represent a large number of pieces/ha, but do not lower the volume per ha estimates by a large amount. In contrast, the number of pieces per ha of large CWD pieces estimated from the cruise and the check data was in close agreement in both Tables 10 and 11. Combined with comparable estimates of large CWD piece volume per ha, this indicates that large CWD pieces were generally appropriately included in the cruise.

3.3 OPERATIONAL CONSIDERATIONS

3.3.1 ADDITIONAL TIME REQUIRED TO COMPLETE AN MIT CRUISE PLOT

The operational cruisers did not keep formal time sheets but TWF's cruiser[34] reported that the estimation of the non-merchantable dead wood attributes increased the average survey time per plot by 25 to 50%. The Interfor cruiser[35] reported that the time required to complete a MIT cruise was 33 to 50% longer than an operational industrial cruise, which on average takes approximately 30 minutes per plot. The length of time varied with the stand age and species composition. Stand types reported to take the longest time were mature stands with a high western redcedar component, stands with a dense understory, and second growth stands with logging remnants. Table 12 contains a summary of the average number of stems or pieces recorded on a plot.

Mature western redcedar forests, with heavy salal, were reported to be particularly challenging and time consuming. In a number of areas with this forest type, the estimates for the non-merchantable dead structures were reported to take as long as the standard cruise measurements. Some of these forests had numerous large diameter windfalls lying on top of each other, which further increased the survey time. In cases where the salal was tall and thick, it was impossible to see dbh from plot centre, making it necessary to measure dbh and distance to each potentially "in" downed tree. Second growth stands with a high density of dead understory or remnants of old logging (i.e., stumps, logs) were also time consuming.

Both cruisers felt that the time needed to complete the MIT cruise could be reduced with further refinement of the MIT cruise procedures and more training. The TWF cruiser felt that it would be possible, with additional practice, to complete the estimated portions of the MIT cruise, other than in western redcedar stands, with an average increase in plot survey time of six to nine minutes (i.e., 20-30% of the standard cruise time).

3.3.2 FIELD CARDS, DATA ENTRY AND DATA COMPILATION

The modifications to the industrial timber cruise field procedures were few. Except for including non-merchantable dead structures, the changes were limited to 1) field codes to distinguish between the various dead wood structures and 2) adjustment of the net factoring to allow for the compilation of a gross volume and total length for pieces with broken tops. Fur-

[34] Personal communication, February 2003, Mike Johnston, TimberWest Forest Corp.

[35] Personal communication, February 2003, John Pitts, International Forest Products Ltd.

ther detail is provided in section 2.4.1.

Because all attributes were recorded on the field card in the same manner as the industrial timber cruise, irrespective of structure, revisions to the compilation program were, if not routine, at least straightforward. Further, Claymore was able to develop subroutines within its compilation program to provide various output summary tables of CWD volume/ha and density by set length and diameter criteria.

3.4 CONSIDERATIONS FOR FUTURE SURVEYS

The number of check plots in this field trial was small. Although the results were reassuring, further evaluation and revision are recommended prior to adopting the MIT cruise procedures for broader use. Items that require attention include the relatively high variation in the assignment of non-merchantable dead pieces between the MIT cruise and the check plots, and estimation of length on longer pieces.

Given the potential difficulty in estimating the location of dbh on chunks, one alternative is to estimate the volume of chunks using Huber's equation. The midpoint diameter and length can be recorded on the field card instead of original tree height and dbh. The field card and compilation routine will need to be modified to accommodate this change in data collection. This alternative might be considered where piece volume is the primary attribute of interest; however, if diameter and volume by grade are also of interest, the approach tested in this field trial may be a better choice.

Regardless of the approach taken, the following changes to the basic field procedures are recommended for future field trials.

MIT Cruise:

- Keep daily time sheets (i.e., start/finish time and number of plots completed);
- Check non-merchantable pieces which are borderline where visibility is compromised;
- Check estimated dbh and lengths of downed pieces where visibility is compromised;
- Periodically calibrate estimated dbh on downed dead wood to measured dbh;
- Assign the location of downed dead wood to either the butt, middle or top "log" on the original tree; and
- Record estimated length for non-merchantable windfalls in the same manner as for merchantable windfalls (irrespective of breaks).

Check Survey:

- Keep daily time sheets (i.e., start/finish time and number of plots completed);
- Record length to the mature or immature minimum top diameter defined by stand age (rather than 10 cm);
- Record diameter every 5 m along the length of downed dead wood (rather than only at the large and small ends);
- Record all measurements regardless of whether a structure is incorrectly assigned to the plot;
- Discontinue the use of a second prism (2P plot) in the mature stands; and
- Estimate original height on all non-merchantable dead pieces (for comparison);

4 CONCLUSIONS

The results of this field trial illustrate the potential effectiveness of using an MIT cruise as an alternative for collecting broad-based data on all dead structures. However, in light of the small sample size and comparative survey results, further investigation is required prior to endorsing such an approach for wide spread use.

The similarity in the cruise and check plot-level volume and density estimates, based on pieces common to both surveys, is reassuring. There is a need to test this similarly over a broader range of stands. Also promising is the similarity in volumes based on Smailian and Kozak's taper equations. This similarity suggests that volumes based on Kozak's taper equations may be compared directly to values found in the literature. However, these encouraging results are tempered by the low levels of accuracy associated with the estimates of dbh and length. The high piece-to-piece variation in the differences in the estimates of these two attributes provided by the cruise and check surveys indicate that relatively large mean differences between the two surveys could occur if only a small number of pieces were being compared.

If the MIT technique is to be applied more widely, revisions are required to address:

- the relatively high variation in the assignment of non-merchantable dead pieces between the MIT cruise and the check plots, and
- the apparent underestimation of piece length, particularly on longer pieces.

Although the cost of obtaining the dead wood information using the MIT cruise is likely cheaper than using independent surveys, the information does still come at a cost. The more precise the estimates of dead wood characteristics required, the longer the time spent per plot and hence the higher cost of the cruise. If a procedure like the MIT cruise as described here is to be carried out on a wider basis, some mechanism for covering the higher costs would have to be found.

5 REFERENCES

Arsenault, A. 1995. Patterns and processes in old growth temperate rain forests of southern BC. MSc thesis, University of British Columbia. Vancouver, BC.

BC Ministry of Forests. 1994. Logging Residue and Waste Procedures Manual. Revenue Branch. Victoria, BC.

—. 1997. Ministry Policy Manual. Volume 1, Resource Management,. Chapter 8, Tenure Administration Policy 8.1, Timber Utilization—Coastal and Interior. Resource Tenures and Engineering Branch. Victoria, B.C.

—. 1998. Vegetation Resources Inventory—Ground Sampling Procedures. Resources Inventory Branch. Victoria, BC..

—. 1999a. Landscape Unit Planning Guide. Forest Practices Branch, BC Ministry of Forests. Victoria, BC. Forest Practices Code of British Columbia Guidebook.

—. 1999b. Scaling Manual. Revenue Branch. Victoria, BC.

—. 2000a. Cruising Manual. Revenue Branch. Victoria, BC.

—. 2000b. A Short-Term Strategy for Coarse Woody Debris Management in British Columbia's Forests, March 2000. Victoria, BC.

—. 2000c. Vegetation Resources Inventory—Ground Sampling Procedures. Resources Inventory Branch. Victoria, BC..

—. 2000d. Logging Residue and Waste Procedures Manual. Revenue Branch. Victoria, BC.

BC Ministry of Forests and BC Ministry of Environment, Lands and Parks. 1995. Biodiversity Guidebook. September 1995. Forest Practices Branch, BC Ministry of Forests. Victoria, BC. Forest Practices Code of British Columbia Guidebook.

—. 1996. Forest Practices Code Timber Supply Analysis. Forest Practices Branch, BC Ministry of Forests. Victoria, BC.

Davis, G. and A. Nemec 2002. An operational trial to evaluate the effectiveness of using modified bucking/yarding practices in Coastal old-growth stands to maximize coarse woody debris levels in the setting: Establishment report. Prepared for the Coarse Woody Debris Working Group. Research Section, Vancouver Forest Region, BC Ministry of Forests, Nanaimo, BC. Technical Report TR-017.

Davis, H. 1996. Characteristics and selection of winter dens by black bears in coastal British Columbia. M.Sc. Simon Fraser University, Burnaby, BC.

Densmore, N. 2002. Coarse woody debris extensive pilot study in the SBSmk1, IDFdm2, ICHdw, and ICHvk2. Draft Internal Report. BC Ministry of Forests, Victoria, BC.

De Montigny, L. 2000. Silviculture treatments for ecosystem management in the Sayward (the STEMS project) - A silvicultural systems research project for young-growth production forests. Working Plan. Silviculturist, Research Branch, Ministry of Forests.

de Vries, P. G. 1986. Sampling Theory for Forest Inventory. Springer-Verlag. New York, pp. 223-241.

Freese, F. 1960. Testing accuracy. Forest Science 6:139-145.

Gore, J.A. and W.A. Patterson III. 1985. Mass of downed wood in northern hardwood forests in New Hampshire: potential effects of forest management. *In* Canadian Journal Forest Research 16:335-339.

Green, R.N. and K. Klinka. 1994. A Field Guide to Site Identification and Interpretations for the Vancouver Forest Region. BC. Ministry of Forests, Victoria, B.C. Land Management Handbook No. 28.

Harmon, M.E. and J. Sexton. 1996. Guidelines for measurements of woody detritus in forest ecosystems. US LTER Network Office: University of Washington. Seattle, WA. Publication No. 20.

Harmon, M.E.; J.F. Franklin; F.J. Swanson; P. Sollins; S.V. Gregory; J.D. Lattin; N.H. Anderson; S.P. Cline; N.G. Aumen; J.R. Sedell; G.W. Lienkaemper; K. Cromack Jr.; and K.W. Cummins. 1986. Ecology of coarse woody debris in temperate Ecosystems. *In* Advances in Ecological Research 15:133-302.

Huggard, D. 2000. Weyerhaeuser BC Variable Retention Adaptive Management Program: Habitat Monitoring 1999- Summary and Sample Design Analysis. Weyerhaeuser, BC Coastal Group. Nanaimo, BC. Internal document, January 2000.

Kozak, A. 1988. "A Variable-Exponent Taper Equation". *In* Canadian Journal Forest Research 18:1363-1368.

Lloyd, R. 2001. A comparison of coarse woody debris in harvested and unharvested sites in the SBSmc2, first-year report. Houston Forest Products Ltd. Houston, BC.

Lloyd, R. 2002. Post-harvest CWD - The long and short of it. *In* Optimizing wildlife trees and coarse woody debris retention at the stand and landscape level. Winter Workshop January 22-24, 2002, Prince George, BC. Northern Interior Vegetation Management Association and Northern Silviculture Committee, pp. 9-15.

McCarthy, B. and R. Bailey 1993. Distribution and abundance of coarse woody debris in a managed forest landscape of the Central Appalachians. *In* Canadian Journal Forest Research 24:1317-1329.

Manning, E. Todd. 2002. British Colubia's dangerous tree assessment process - a summary paper. *In*: Laudenslayer, William F., Jr.; Shea, Patrick J.; Valentine, Bradley E.; Weatherspoon, C. Phillip; Lisle, Thomas E., technical coordinators. Proceedings of a symosium on the ecology and management of dead wood in western forests. 1999 November 2-4; Reno, NV. Gen. Tech. Rep. PSW-GTR-181. Albany, CA: Pacific Southwest Research station, Forest Service, U.S. Department of Atriculture.

Marshall, P.L., and G. Davis. 2002. Measuring the length of coarse woody debris. B.C. Ministry of Forests, Vancouver

Forest Region. Extension Note EN-011.

Nagle, G.S. 1980. Analysis of salvage yarding systems and costs in Pacific Coast forests. ENFOR, Canadian Forestry Service; Dept. of Environment, Otawa, Ontario. BC-X-214.

Nemec, A. and G. Davis. 2002. Efficiency of six line intersect sampling designs for estimating volume and density of coarse woody debris. Res. Sec., Van. For. Reg., C.C. Min. For., Nanaimo, B.C. Tec. Rep. TR-021/2002.

Phillips, E. 2003. Coarse woody debris retention during harvesting of coastal old-growth forests. Advantage Vol. 4 No. 18 June 2003. Western Division, FERIC. Vancouver, BC.

Pollard, D.W.F. and J.A. Trofymow. 1993. "An introduction to the coastal forest chronosequences" pp. 5-7 *in* Proceedings of the Forest Ecosystem Dynamics Workshop, Februrary 10-11, 1993. FRDA II. BC Ministry of Forests.

Ruth, R.H. and A.S. Harris. 1975. Forest residues in hemlock-spruce forests of the Pacific Northwest and Alaska - a state-of-knowledge review with recommendations for residue management. Forest Service, USDA, Portland, Oregon. General Technical Report. PNW-39.

Stevens, V. 1996. The ecological role of coarse woody debris: An overview of the ecological importance of CWD in BC. Forests. Working Paper 30/1997. Research Branch, Ministry of Forests, Victoria, BC.

Stone, J., J. Parminter, A. Arsenault, T. Manning, N. Densmore, G. Davis and A. MacKinnon. 2002. Dead tree management in British Columbia. *In*: Proceedings of the symposium on the ecology and management of dead wood in western forests. November 2-4, 1999. Reno, Nevada. USDA Forest Service General Technical Report PSW-GTR-181. Albany, California, pp. 467-478.

Trowbridge, R. 1986. Field Handbook for Prescribed Fire Assessments in British Columbia: Logging Slash Fuels. BC Ministry of Forests, Victoria, BC Land Management Handbook 11, and FRDA Handbook 1.

USDA Forest Service and US Department of the Interior, Bureau of Land Management. 1994. Record of Decision: For amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl: Standards and Guidelines: For management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. [Northwest Forest Plan]. Portland, OR.

Waddell, K. 2001. Sampling coarse woody debris for multiple attributes in extensive resource inventories. Ecological Indicators 1:139-153.Wells, R.W. and J.A. Trofymow. 1997. Coarse Woody Debris on Chronosequences in Coastal Forests of British Columbia. Pacific Forestry Centre, Canadian Forest Service. Victoria, BC. Internal document.

Wells, R. 1996. Developmental trends of stand structure and tree mortality in coastal western hemlock forests. Report No. 196. MSc, School of Resource and Environmental Management, Simon Fraser University. Burnaby, BC.

Wells, R.W. and J.A. Trofymow. 1997. Coarse woody debris on chronosequences of forests on southern Vancouver Island. Pacific Forestry Centre, Canadian Forest Service, Victoria, B.C. Information Report BC-X-375.

Zar, J. H. 1984. Biostatistical Analysis. 2nd Ed. Prentice-Hall, Inc., Englewood Cliffs, NJ.

APPENDIX A: AN APPLICATION OF THE MIT CRUISE DATA

OVERVIEW

The MIT cruise provides a complete inventory of large forest structures. This type of dataset provides an opportunity to relate one ecosystem component to another (Harmon and Sexton 1996). The quantitative estimates of structural attributes provided by the MIT cruise are valuable in developing management goals for many forest structural attributes identified as important to biodiversity (BCMOF & BCMOELP 1995) and in evaluating harvesting strategies to meet these goals. The following illustrates how such MIT cruise data might be presented to investigate questions pertinent to the development of broad-scale management goals for dead wood and CWD.

BACKGROUND

Dead wood is not a static entity. It is constantly in a state of flux, both spatially and temporally. Spatially, dead wood may be standing or downed (i.e., on the ground). The relationship between standing and downed dead wood is highly variable and depends upon many factors, including the dominant form of mortality (e.g., wind versus insects), the age of the forests, and tree species (Harmon and Sexton 1996). Harmon and Sexton (1996) report that it is not unusual to find that this proportion varies widely even within a single forest type; snags can make up as little as 2% or as much as 98% of the dead wood volume. The data from the MIT cruise provides an opportunity to examine the relationships between total dead and total CWD attributes.

Temporally, dead wood attributes change at various stages of stand development. There are two stand development scenarios proposed for Coastal forests. A "U" shape is suggested as the generalized pattern of change in dead wood volume after a catastrophic stand-initiating event of natural origin such as a fire. According to this pattern, CWD and dead wood exhibit a high abundance immediately after the disturbance, decline to low levels during the intermediate stages of development, and increase again as the stand ages. It has been proposed that this trajectory applies to forests with longer-lived species and infrequent (i.e., mean return interval 250 years) catastrophic disturbance events (i.e., Natural Disturbance Type 1 (NDT1) forests). In the case of forests with more frequent natural stand-initiating events (i.e., mean return interval 150 years catastrophic events or NDT2 forests), the trajectory is truncated such that a stand-initiating event occurs before the live trees reach their potential maximum size and before there is significant mortality of the dominant and co-dominant trees (Stevens 1996). In mature forests, the current and future dead wood attributes are therefore closely related to the live standing trees in terms of the present and historical distributions of species and stem sizes.

The British Columbia Ministry of Forests is currently in the process of developing CWD management goals based on the first guiding principle in the Biodiversity Guidebook[36] (BCMOF and BCMELP 1995), which states that: "The more that managed forests resemble the forests that were established from natural disturbances, the greater the probability that all native species and ecological processes will be maintained."

Management guidance, in the form of goals, will be based on CWD attributes from unmanaged mature/old-growth forests in the same biogeoclimatic subzone/variant and broad moisture grouping. However, information from managed forests will also be used to evaluate the operational application of the goals. An integrated data set, such as that provided by the MIT cruise, would facilitate the development of CWD goals for the Coast because it would provide answers to the following related questions:

- What proportion of the total stand volume is represented by dead wood?
- What proportion of the total dead wood is downed?
- What are the dimensions of a large-sized piece of CWD by ecosystem or timber type
- What are the average densities and volumes/ha of large-sized pieces of CWD?
- Are the diameters of live and dead stems sufficient to provide for large CWD pieces?

Information on CWD piece size distributions is required to monitor and manage harvesting effects on CWD attributes. The available research for North American forests consistently reports a shift in CWD piece size distribution following harvesting. Most studies report an increase in total piece density, with reductions in diameter and/or piece length related to harvesting (e.g., Gore and Patterson III 1985; McCarthey and Baily 1993; Lloyd 2001; Davis and Nemec 2004[37]). In part this reduction in size reflects current harvesting utilization size limits (e.g., 3 m logs and 10 cm tops). The result is that large pieces are most at risk for removal and/or breakup during harvesting. Quantifying the distribution of these large CWD pieces in unmanaged and managed forests provides the background data needed to evaluate current and future harvesting impacts on these larger CWD pieces.

From a structural perspective, a piece of CWD is best described when both large-end diameter and length descriptors are provided – in much the same manner that diameter at breast height and height are used to describe the dimensions of a tree. "Large-end diameter and length provide visual descriptors of a CWD piece that can be easily conveyed to others, e.g., ecologists and operational field staff. These dimensions can also be tied to the more common descriptors of CWD used in the literature, e.g., volume/ha." (Marshall and Davis 2002).

[36] Personal communication, Don Heppner, Coastal Forest Region, BC Ministry of Forests, Nanaimo. April 2003; personal communication, Nancy Densmore, Forest Practices Branch, BC Ministry of Forests, Victoria. March 2004.

[37] Davis, G. and A. Nemec. 2004. An operational trial to evaluate the effectiveness of using modified bucking/yarding practices in Coastal old-growth stands to maximize coarse woody debris levels in the setting: Post-harvest report. Prepared for the Coarse Woody Debris Working Group. Research Section, Coastal Forest Region, BC Ministry of Forests, Nanaimo, BC. Technical Report in preparation.

The operational application of CWD dimensions is demonstrated in various CWD retention guidelines in the United States. For example, "For western Oregon and Washington north of and including the Willamette National Forest and the Eugene BLM District, leave 240 linear feet of logs per acre greater than or equal to 20 inches in diameter. Logs less than 20 feet in length cannot be credited toward this total." (USDA 1994).

What constitutes large CWD in various BC Coastal ecosystems is not currently specified. In part, this reflects the scant data available on CWD in unmanaged forests in many BC Coastal ecosystems. The definition of what comprises a large piece of CWD needs to be objective and based on field data from a broad range of unmanaged old-growth/mature forests.

Another factor requiring consideration in the development of goals for the management of CWD is the predicted source of this wood at the time of harvesting. The current BC Ministry of Forests directive is that CWD management is to have no impact on operating costs or timber supply (BCMOF and BCMELP 1996)[38]. The MIT cruise provides information on the merchantability of all merchantable sized wood, which can then be used to identify the source(s) and dimensions of low-value[39]/non-merchantable[40] wood in the stand prior to harvesting. For example:

- What are the predicted sources of low-value/non-merchantable wood on site (i.e., CWD, standing timber)?
- How much of the total CWD is merchantable (e.g., X-Grade-and-better)?
- What are the dimensions of the predicted low-value/non-merchantable wood?

Information on trends in the volumes of lower-value wood in stands by timber type or ecosystem provides an opportunity to "troubleshoot" management issues during the developmental stage rather than during the implementation of CWD goals. For example, answers to questions such as, "In which timber types/ecosystems does the CWD volume set out in the goal exceed the average predicted total low-value/non-merchantable wood volume in the stand?" allow the opportunity to evaluate other options to offset the shortfall. Further, the integrated data set provided through the MIT cruise provides background data on which to develop trials investigating harvesting options to maximize the retention of the low-value/non-merchantable wood resource on site (e.g., faller bucking to maximize log value, marking non-merchantable wood).

The following section presents data from the MIT cruise conducted on Interfor's blocks where information on the Biogeoclimatic subzone variant was available. Because certain subzone variant/site series combinations may include a number of timber types and/or site classes, further work is required to investigate trends between the subzone variant, timber type/site class, and total dead wood volume, through statistical approaches such as misclassification matrices, discriminant analyses or cluster analyses. However, these can only be undertaken with a larger data set than is currently available. The following summaries illustrate how the data might be presented to answer the above questions. Given the exploratory nature of the data, and small sample sizes, management interpretations are not made.

Eight blocks in three subzone variants were surveyed. The Coastal Western Hemlock Very Dry Maritime Subzone (CWHxm) is classified as NDT2, with a mean disturbance return interval of 200 years, while the CWH vm1 and vm1/2 (transitional) variants (Coastal Western Hemlock Submontane and Montane Very Wet Maritime Variant) are classified as NDT1, with a mean disturbance return interval of 250 years. Fire and wind are the two prominent catastrophic disturbance agents respectively for NDT2 and NDT1 (BCMOF and BCMOELP 1995). Most of the forests sampled were immature.

TOTAL VOLUME/HA

Table 13 presents total density and volume/ha partitioned by the main forest structures. The total volume partitioned by live and dead bole[41] wood is illustrated in Figure 1. For the two mature stands, the average total CWD volumes/ha are similar (133 and 143 m^3/ha). The variability about the total CWD volume/ha for the CWHvm2 (01/06) stand is particularly high, reflecting the small sample size (n=5 plots). The average total dead wood volumes (dead standing plus CWD) for the two mature stands are noticeably higher than the immature stand volumes at 349 and 537 m^3/ha. Basing post-harvest CWD management goals on pre-harvest total CWD volumes alone would mean that only 10% of the total stand bole wood volume would be targeted for retention in the two mature stands (assuming that the goal is to maintain CWD volumes at the pre-harvest level), even though the total dead wood volumes represent 25 to 38% of the total stand bole wood volumes. Since each of these two subzone variants is represented by only one block, further sampling is required to provide more representative numbers. However, this illustrates the importance of collecting information on the relationship between CWD, total dead wood and total stand volume, since in a catastrophic natural disturbance event much, if not all, of the total stand volume becomes CWD.

The total number of blocks sampled in the CWHxm subzone was higher than for the CWHvm subzone, but the numbers were still relatively small (i.e., <7 blocks). The stands sampled in the CWHxm subzone were immature, with remnants from prior logging. The average total CWD (205 to 267 m^3/ha) and dead wood (394 to 434 m^3/ha) volumes for the immature stands in the CWHxm subzone were comparable. The average total CWD volumes are comparable to those reported by Nemec and Davis (2002) for a mature stand in the CWHxm subzone. For the current immature stands, the total dead wood volumes represent 24 to 36% of the total stand bole volumes.

[38] Current CWD management is tied to the BC Ministry of Forests' timber utilization policy (BCMOF 1997; Landscape Unit Planning Guide, BCMOF and BCMELP 1999a). Also refer to footnote 4.

[39] See footnote 17.

[40] See footnote 17.

[41] Bole wood excludes the top, branches and stump.

Table 13. Total density and gross volume of wood partitioned by structure for several BEC subzone/variants (mean ± SE).

Age	BEC		Live standing	Dead standing	Dead windfall	CWD Chunks	Total dead	Total CWD[a]	Total	% Total Dead	% Total CWD
Mature	CWHvm1/2 01	Total density (no./ha)	404.0 ± 85.2	75.0 ± 28.0	51.8 ± 34.7	164.5 ± 49.1	291.3 ± 58.7	216.3 ± 48.5	695.3 ± 108.7		
		Total volume (m^3/ha)	1060.5 ± 105.8	215.6 ± 58.1	45.1 ± 25.0	87.9 ± 33.9	348.7 ± 78.5	133.0 ± 35.0	1409.2 ± 141.2	25	9
	n = 14 (plots)	Bole volume (m^3/ha)	1000.9 ± 98.6	201.6 ± 54.5	42.4 ± 23.8	87.9 ± 33.9	331.9 ± 75.1	130.3 ± 34.6	1332.7 ± 135.0		
	1 block	Top & stump vol. (m^3/ha)	59.6 ± 9.6	14.0 ± 3.9	2.7 ± 1.5	0.0 ± 0.0	16.8 ± 4.5	2.7 ± 1.5	76.4 ± 9.9		
	CWHvm2 01/06	Total density (no./ha)	561.2 ± 234.9	391.3 ± 238.9	0.0 ± 0.0	179.3 ± 110.9	570.6 ± 199.4	179.3 ± 110.9	1131.7 ± 426.8		
		Total volume (m^3/ha)	881.8 ± 165.5	393.8 ± 42.4	0.0 ± 0.0	142.8 ± 108.4	536.6 ± 138.6	142.8 ± 108.4	1418.4 ± 248.8	38	10
	n = 5	Bole volume (m^3/ha)	823.6 ± 170.6	363.7 ± 40.9	0.0 ± 0.0	142.8 ± 108.4	506.5 ± 137.6	142.8 ± 108.4	1330.1 ± 253.7		
	1 block	Top & stump vol. (m^3/ha)	58.3 ± 14.4	30.1 ± 3.2	0.0 ± 0.0	0.0 ± 0.0	30.1 ± 3.2	0.0 ± 0.0	88.4 ± 17.2		
Immature	CWHxm 01	Total density (no./ha)	830.1 ± 111.6	297.7 ± 112.9	339.4 ± 99.3	467.1 ± 80.8	1104.2 ± 170.2	806.5 ± 134.7	1934.4 ± 174.7		
		Total volume (m^3/ha)	776.5 ± 55.2	172.8 ± 37.9	92.2 ± 17.6	168.7 ± 20.8	433.6 ± 52.7	260.9 ± 27.8	1210.1 ± 81.2	36	22
	n = 44	Bole volume (m^3/ha)	735.9 ± 52.5	153.1 ± 34.6	79.1 ± 16.1	168.7 ± 20.8	400.9 ± 48.9	247.8 ± 26.5	1136.9 ± 77.1		
	2 blocks	Top & stump vol. (m^3/ha)	40.6 ± 3.8	19.6 ± 3.7	13.0 ± 3.8	0.0 ± 0.0	32.7 ± 5.5	13.0 ± 3.8	73.2 ± 6.3		
	CWHxm 01/06	Total density (no./ha)	791.8 ± 68.0	416.1 ± 71.4	135.6 ± 44.0	630.9 ± 77.8	1182.6 ± 115.4	766.5 ± 93.6	1974.4 ± 147.7		
		Total volume (m^3/ha)	917.1 ± 45.1	162.0 ± 22.1	54.9 ± 12.7	178.2 ± 17.0	395.1 ± 29.5	233.1 ± 20.8	1312.2 ± 56.0	30	18
	n = 74	Bole volume (m^3/ha)	875.7 ± 43.3	142.1 ± 19.3	49.3 ± 11.8	178.2 ± 17.0	369.5 ± 27.2	227.4 ± 20.1	1245.2 ± 52.6		
	3 blocks	Top & stump vol. (m^3/ha)	41.4 ± 2.4	19.9 ± 3.5	5.7 ± 1.7	0.0 ± 0.0	25.6 ± 3.7	5.7 ± 1.7	67.0 ± 5.0		
	CWHxm 01/05	Total density (no./ha)	743.0 ± 193.2	135.8 ± 37.4	92.3 ± 76.1	446.6 ± 124.0	674.7 ± 145.6	538.9 ± 130.6	1417.7 ± 226.8		
		Total volume (m^3/ha)	1222.0 ± 160.8	123.5 ± 22.4	74.4 ± 29.0	196.3 ± 46.3	394.2 ± 47.2	270.7 ± 42.0	1616.2 ± 161.0	24	17
	n = 15	Bole volume (m^3/ha)	1176.6 ± 155.3	107.0 ± 20.0	71.2 ± 28.0	196.3 ± 46.3	374.6 ± 45.1	267.5 ± 41.8	1551.2 ± 154.6		
	1 block	Top & stump vol. (m^3/ha)	45.4 ± 7.0	16.5 ± 2.9	3.2 ± 1.1	0.0 ± 0.0	19.7 ± 3.7	3.2 ± 1.1	65.0 ± 8.9		

[a] In a standard CWD survey, CWD volume is equal to the bole volume in the above table since tips and stump volumes are not included in the total volume/ha; total CWD = dead windfall + CWD chunks.

The relative proportion of dead wood is similar to that reported above for the mature stands; however, interpretation of the stand structural attributes of the immature stand requires comparable data from mature stands in the CWHxm subzone.

For stands other than the stand located in the transition between the CWHvm1 and CWHvm2 subzone variants, the variability associated with the average total CWD volumes/ha (based on Kozak's taper equations) is comparable to those reported in the literature (based on Smalian's equation) (e.g., Wells and Trofymow 1997; Davis and Nemec 2002).

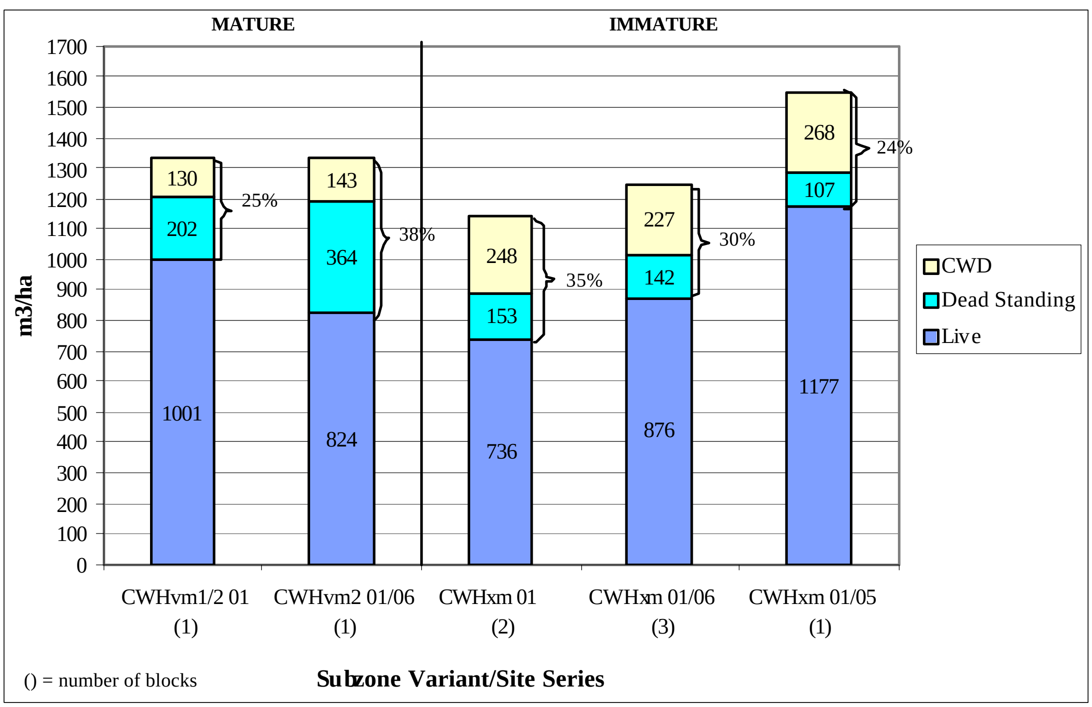

Figure 1. Total bole wood gross volume partitioned by CWD, dead standing, and live structures.

PREDICTED LOW-VALUE / NON-MERCHANTABLE WOOD VOLUME

Table 14 presents total density[42] and volume of logs by grade and structure. Figure 2 displays the combined total volume/ha of Y and Z Grade wood, stratified by structure.

Predicted sources and volumes/ha of low-value/non-merchantable wood reflect site factors such as stand age, timber type, current and historical damage agents, and historical logging practices. In this discussion, low-value and non-merchantable wood refer, respectively, to Y and Z Grade wood[43]. Additionally, this hypothetical discussion assumes that the utilization of Y Grade wood is not specified by the cutting authority[44] and that the management objective is to maximize the retention of both Y and Z Grade wood in the dispersed setting (even though the Y Grade wood will be charged against the cut control).

For the blocks sampled, the proportion of the total stand bole wood volume cruised as Y and Z Grade wood varies from 26 to 54% (351 to 723 m^3/ha), with the immature stands falling in the middle of the range (377 to 490 m^3/ha). As mentioned earlier, the sample size for each subzone/variant is very small; further sampling is required to provide values representative of each ecosystem. However, the results illustrate that the predicted volume of low-value/non-merchantable wood can be high in some immature stands, due to remnants from past logging.

As shown in Figure 2, the predicted sources of low-value/non-merchantable wood vary between stands. For the five ecosystems, standing structures (live and dead) represent 41 to 80%, while live stems alone represent 11 to 30% of the total predicted Y and Z Grade gross volume/ha in the stand. The total predicted gross volume/ha of Y and Z Grade wood in the standing structures (live and dead) approaches or surpasses the total CWD gross volume/ha across the stands. This indicates there is potential to replace the total background CWD volume should it become destroyed during harvesting.

The total predicted volume of Y and Z Grade wood from all sources represents the maximum volume of lower-value wood that could potentially be left in the setting at the time of harvesting. In reality, only a portion of the predicted volume in the standing structures will be bucked and left in the setting. Similarly, only a portion of the original CWD will be left intact during harvesting.

Various factors determine how many of the predicted Y and Z Grade logs in standing live and dead trees[45] are retained in the setting during harvest. Assuming the utilization of Y Grade logs is not specified in the cutting authority, the biggest factor influencing the retention of these Y Grade logs is the pulpwood market price. In low market conditions, it may be uneconomical to yard and haul Y Grade logs off site; however, this may not be the case with higher market prices. Certain factors determine whether these predicted Y and Z Grade logs are realized, while others determine whether the Y and Z Grade wood are retained in the setting rather than yarded to the roadside or dry land sort. These include:

- susceptibility of the tree species to shatter – certain species are more susceptible to shattering during the falling process. The amount of shatter affects the dimensions, not only of the recoverable wood, but also of the non-merchantable wood (Ruth and Harris 1975);
- bucking in the setting to preferred log lengths – when fallers buck to licensee preferred log lengths rather than bucking to maximize log value (without increasing bucking waste) there is less opportunity to maximize the dimensions and volume of lower-value log grades [Several Coastal licensees are already employing best practice bucking (i.e., bucking to maximize log grade) at the roadside as part of their Quality Assurance program (Phillips 2003)];
- poor visibility of logs at the time of yarding – particularly in cable harvesting operations the yarding engineer may not be able to visually assess merchantability until the log is yarded to roadside;
- concern that the operation will be penalized for leaving merchantable logs on the setting; and
- knowledge of the operators (Phillips 2001; Stone et al. 2002).

Similarly, it cannot be assumed that the original CWD will be retained during harvest. The proportion of the total CWD volume in merchantable log grades varies between stands, reflecting factors such as timber type, stand age, site characteristics, and local disturbance agents. In mature western redcedar timber types, for example, high-value logs may occur in both recent and historical windfalls, given western redcedar's decay-resistant properties. In the case of Interfor's blocks, much of the CWD volume was Y or Z Grade wood, with no more than 15% of the volume as X-Grade-and-better (i.e., 0-9 m^3/ha).

[42] Readers are reminded of the large plot-level differences between the two surveys in the total density of Y and Z Grade wood.

[43] The cutting authority, in accordance with the timber utilization policy (BCMOF 1997), specifies the timber utilization requirements for each cut-block. Residue and waste surveys are undertaken following harvesting to provide data and information for the 1) monetary billing of avoidable waste as liquidated damages for contract non-compliance, and 2) determination of residue and waste volumes for Cut Control (BCMOF 1994,2000d). In Coastal timber harvesting operations, live Y Grade is classified as Residue (Avoidable and Unavoidable). These logs are referred to as chipper logs and are primarily used for pulp, depending on market conditions. Avoidable Residue is billed only if mandatory utilization is specified in the cutting authority. In most cases the utilization of Y Grade logs is optional. Y Grade volume (Avoidable and Unavoidable) is subject to Cut Control charges. In Coastal timber harvesting operations there is no requirement for either dry or dead Y Grade logs (recorded as Grade 5) or Z Grade (Firmwood Reject wood) logs to be measured or recorded for Cut Control purposes. A further description of log grades is available in BCMOF (1999b).

[44] Cutting authority refers to one of the following: Timber Sale License, License to Cut, Road Permit, or Cutting Permit issued under a Tree Farm License, Forest License, Timber License, or Woodlot License.

[45] On the Coast, dead snags are not typically left standing because they can pose a safety hazard to fallers and workers in the area. Most often dead snags are only left standing in reserves or wildlife tree patches. Individual trees left in the a harvest block must be assessed to be windfirm and not a hazard/danger tree based on danger tree assessment procedures (Manning 2002) and meet the other safety criteria set out by the Worker's Compensation Board of British Columbia.

Table 14. Total bole wood gross volume (m³/ha) of Z, Y, U+X, and better than X Grade wood, partitioned by structure for five BEC subzone variants.

BEC	Grade	Live standing	Dead standing	Dead windfall	Dead chunks	Total dead	Total CWD	Total	% Total Stand Volume as Y+Z Grade Wood	% Total Y+Z Grade Wood Volume as Live Trees	% Total Y+Z Grade Wood Volume as Dead Standing	% Total Y+Z Grade Wood Volume as CWD
CWHvm1/2 01	Better-than-UX	830.8 ± 98.9	45.0 ± 31.1	0.0 ± 0.0	0.0 ± 0.0	45.0 ± 31.1	0.0 ± 0.0	875.7 ± 100.0				
Mature	U, X Grades	87.1 ± 18.2	3.9 ± 3.9	0.0 ± 0.0	15.6 ± 11.5	19.4 ± 11.7	15.6 ± 11.5	106.5 ± 24.2				
n = 14 (plots)	Y Grade	51.8 ± 21.9	48.1 ± 26.3	13.3 ± 13.3	3.8 ± 3.8	65.2 ± 29.5	17.0 ± 13.5	117.0 ± 29.0				
1 block	Z Grade	31.2 ± 14.6	104.6 ± 30.2	29.1 ± 21.2	68.6 ± 34.4	202.3 ± 52.0	97.7 ± 37.2	233.5 ± 54.1				
	Y, Z Grades	83.1 ± 23.8	152.7 ± 39.9	42.4 ± 23.8	72.4 ± 34.5	267.5 ± 65.5	114.7 ± 36.6	350.5 ± 65.0	26	24	44	33
CWHvm2 01/06	Better-than-UX	396.9 ± 185.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	396.9 ± 185.9				
Mature	U, X Grades	210.3 ± 63.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	210.3 ± 63.3				
n = 5	Y Grade	216.0 ± 150.1	168.6 ± 57.5	0.0 ± 0.0	71.7 ± 71.7	240.3 ± 110.8	71.7 ± 71.7	456.2 ± 180.1				
1 block	Z Grade	0.3 ± 0.3	195.1 ± 37.3	0.0 ± 0.0	71.1 ± 44.2	266.2 ± 67.5	71.1 ± 44.2	266.6 ± 67.7				
	Y, Z Grades	216.3 ± 150.0	363.7 ± 40.9	0.0 ± 0.0	142.8 ± 108.4	506.5 ± 137.6	142.8 ± 108.4	722.8 ± 178.1	54	30	50	20
CWHxm 01	Better-than-UX	552.4 ± 49.8	16.2 ± 8.4	5.8 ± 4.1	0.0 ± 0.0	22.0 ± 9.2	5.8 ± 4.1	574.3 ± 50.9				
Immature	U, X Grades	137.6 ± 25.7	17.2 ± 7.6	0.9 ± 0.9	0.0 ± 0.0	18.1 ± 7.6	0.9 ± 0.9	155.7 ± 25.6				
n = 44	Y Grade	33.2 ± 12.8	46.7 ± 14.1	36.5 ± 8.7	48.9 ± 12.9	132.2 ± 19.6	85.5 ± 15.7	165.4 ± 26.3				
2 blocks	Z Grade	11.3 ± 5.1	73.1 ± 18.0	35.9 ± 9.9	119.7 ± 18.5	228.8 ± 32.9	155.6 ± 21.4	240.1 ± 32.8				
	Y, Z Grades	44.6 ± 15.5	119.8 ± 28.0	72.4 ± 12.9	168.7 ± 20.8	360.9 ± 41.5	241.1 ± 24.7	405.5 ± 45.1	36	11	30	59
CWHxm 01/06	Better-than-UX	645.5 ± 41.4	14.4 ± 6.7	1.9 ± 1.9	0.0 ± 0.0	16.2 ± 7.8	1.9 ± 1.9	661.8 ± 40.5				
Immature	U, X Grades	180.5 ± 22.8	23.7 ± 7.2	0.6 ± 0.6	1.5 ± 1.5	25.8 ± 7.2	2.1 ± 1.6	206.2 ± 25.6				
n = 74	Y Grade	44.5 ± 9.7	34.6 ± 9.9	6.6 ± 3.8	8.3 ± 4.0	49.5 ± 11.8	14.9 ± 5.4	94.0 ± 15.4				
3 blocks	Z Grade	5.3 ± 2.2	69.4 ± 11.6	39.8 ± 10.0	168.4 ± 16.5	277.6 ± 22.0	208.1 ± 19.6	282.8 ± 21.8				
	Y, Z Grades	49.7 ± 10.1	104.0 ± 15.0	46.4 ± 10.8	176.7 ± 17.1	327.1 ± 23.3	223.1 ± 19.9	376.8 ± 25.3	30	13	28	59
CWHxm 01/05	Better-than-UX	808.4 ± 130.3	0.0 ± 0.0	9.2 ± 9.2	0.0 ± 0.0	9.2 ± 9.2	9.2 ± 9.2	817.6 ± 129.9				
Immature	U, X Grades	240.5 ± 40.5	0.0 ± 0.0	0.9 ± 0.9	0.0 ± 0.0	0.9 ± 0.9	0.9 ± 0.9	241.4 ± 40.9				
n = 15	Y Grade	112.4 ± 73.9	21.7 ± 16.5	17.7 ± 17.7	32.0 ± 21.9	71.4 ± 28.7	49.7 ± 26.6	183.8 ± 73.6				
1 block	Z Grade	15.4 ± 7.3	85.3 ± 19.9	41.4 ± 18.4	164.3 ± 39.3	291.1 ± 54.6	205.7 ± 40.9	306.4 ± 56.2				
	Y, Z Grades	127.8 ± 75.1	107.0 ± 20.0	59.1 ± 23.4	196.3 ± 46.3	362.5 ± 45.8	255.4 ± 42.3	490.2 ± 109.1	32	26	22	52

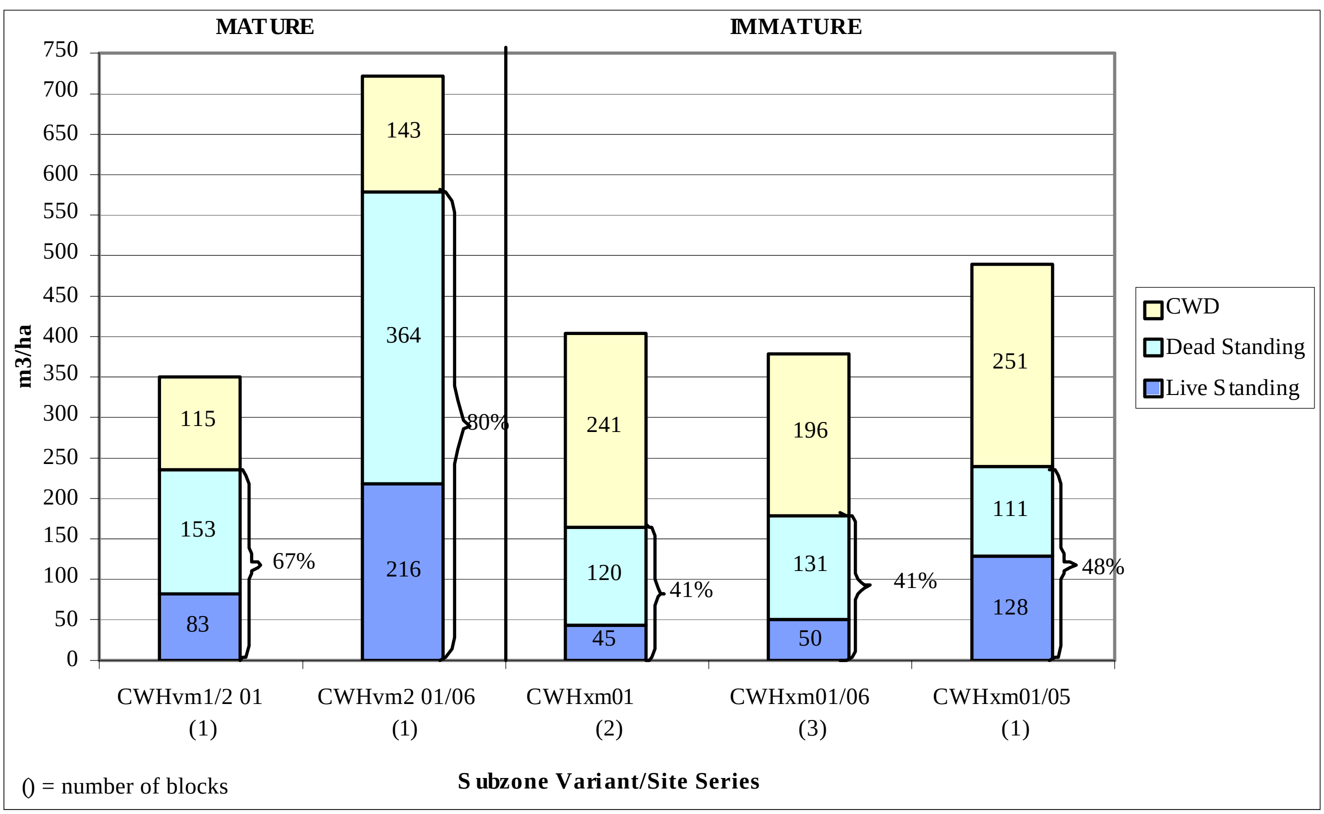

Figure 2. Total bole wood gross volume as Y+ Z Grade wood partitioned by CWD, dead standing, and live structures.

Table 15. Estimated percentiles for the large-end diameter (inside bark) of CWD pieces.

				Percentile															
Age	**BEC**	**Block**	**Site Series**	**20th (cm)**	**25th (cm)**	**30th (cm)**	**35th (cm)**	**40th (cm)**	**45th (cm)**	**50th (cm)**	**55th (cm)**	**60th (cm)**	**65th (cm)**	**70th (cm)**	**75th (cm)**	**80th (cm)**	**85th (cm)**	**90th (cm)**	**95th (cm)**	**98th (cm)**	**99th (cm)**
Mature	CWHvm1	102	01	38	38	38	39	40	41	42	44	45	45	46	46	49	53	63	66	72	79
	CWHvm2	12	01/06	40	41	41	41	41	41	41	42	42	42	42	42	42	43	44	61	107	119
	CWH xm1[a]		01											34				50	60		71
	CWH dm1[a]		01,06											28				46	54		66
	CWH vm2[b]		01							15				21				42	56		80
Immature	CWHxm	36	01/06	13	15	15	15	16	16	17	19	22	23	25	31	38	43	45	54	66	81
	CWHxm	66	01	.	.	.	15	16	16	17	20	25	27	32	36	38	42	55	56	86	89
	CWHxm	71	01/06	14	14	14	15	15	16	17	18	19	19	20	21	24	26	35	52	57	73
	CWHxm	109	01/06	15	15	16	21	24	27	29	30	33	36	40	44	47	50	54	64	78	89
	CWHxm	119	01	13	14	16	18	19	20	21	21	24	27	28	30	35	36	45	61	80	83
	CWHxm	121	01/05	14	15	15	22	27	30	32	36	37	39	42	45	49	53	60	68	87	93

Table 16. Estimated percentiles for the length of CWD pieces.

				Percentile															
Age	**BEC**	**Block**	**Site Series**	**20th (m)**	**25th (m)**	**30th (m)**	**35th (m)**	**40th (m)**	**45th (m)**	**50th (m)**	**55th (m)**	**60th (m)**	**65th (m)**	**70th (m)**	**75th (m)**	**80th (m)**	**85th (m)**	**90th (m)**	**95th (m)**	**98th (m)**	**99th (m)**
Mature	CWHvm1	102	01	1	2	2	3	3	3	3	4	4	4	4	5	5	5	6	10	12	12
	CWHvm2	12	01/06	3	3	4	4	4	4	4	4	4	4	5	5	5	5	5	7	19	25
	CWH xm1[a]		01							2				4				10	14		33
	CWH dm1[a]		01,06							2				4				9	12		20
	CWH vm2[b]		01							2				3				9	13		25
Immature	CWHxm	36	01/06	2	2	2	2	3	3	4	4	5	5	6	6	9	10	11	12	19	24
	CWHxm	66	01	5	5	5	5	5	6	6	6	6	6	6	6	6	7	8	8	9	10
	CWHxm	71	01/06	.	.	.	2	2	3	3	3	4	4	4	5	5	6	6	7	9	10
	CWHxm	109	01/06	2	2	3	3	3	3	4	4	4	4	5	5	6	8	8	12	14	19
	CWHxm	119	01	2	2	2	2	2	2	3	3	4	4	4	5	7	10	12	16	25	25
	CWHxm	121	01/05	.	.	.	2	2	3	4	5	5	5	6	6	7	8	9	11	16	28

a. Nemec and Davis (2002)
b. Davis and Nemec (2002)

The decision to retain Y Grade (assuming use is not specified in the cutting authority) or X-Grade-and-better logs up to the Avoidable Waste Benchmark volume will reflect the same economic and management considerations mentioned above for standing structures, i.e., market conditions, operational objectives, and harvesting system. The harvesting system can have a marked effect on how much of the original CWD is retained intact in the setting after harvesting. There is a greater chance for the original CWD to be crushed and/or displaced in ground-based (i.e., hoe forwarding) compared with cable harvesting operations. CWD pieces in decay classes 4 and 5 (BCMOF 2000c) are particularly susceptible to crushing.

Knowledge of the predicted sources of low-value/non-merchantable wood provides an opportunity to modify harvesting operations to capitalize on the retention of this lower-value wood at the time of harvest.

CWD ATTRIBUTES

Tables 15 and 16 and Figure 5 (Appendix D) present the cumulative frequency distributions for large-end diameter and length. The high variability between blocks within a similar subzone variant and moisture group can be attributed to the very small sample size. Using the 90th percentile of the cumulative distribution as an objective rule for defining the dimensions of a large-sized CWD is only one of several possible approaches. However, the data provided by the MIT cruise can easily be used with other approaches (i.e., set diameter classes (Lloyd 2001; also, http://www.for.gov.bc.ca/hre/deadwood/DTdat.htm)).

For the two mature stands (CWHvm1/2 and CWHvm2), the 90th percentile for the large-end diameters ranges from 44 to 64 cm, while for the immature stands, the upper 90th percentile ranges from 35 to 60 cm. In terms of length, the 90th percentile corresponds to 5-6 m in length for the mature stands, and 6-11 m for the immature blocks. For two mature stands in the CWHxm subzone (mesic site series), Nemec and Davis (2002) report 50 cm and 8 m, respectively, as the upper 90th percentile for the cumulative frequency distributions for large-end diameter and length. For a mature forest in the CWHvm2 subzone variant (mesic site series) Davis and Nemec (2002) report the upper 90th percentile for the cumulative frequency distributions for large-end diameter and length at 65 cm and 10 m respectively. Compared with these values, the 90th percentiles for large-end diameter and length reported for the two mature stands in this report appear low. With increased sample size, it is anticipated that trends in the 90th percentiles for large-end diameter and length will become apparent by subzone/variant and/or timber types.

Tables 17 and 18 present CWD density and volume/ha by large-end diameter and length classes, respectively. For the purpose of this discussion (given the difference in the 90th percentiles for the two mature stands in different ecosystems), a large-sized CWD is defined as having a large-end diameter (inside bark) greater than 50 cm and a length greater than 8 m. For the two mature stands, there are less than 20 pieces/ha meeting the above size criteria. These CWD pieces represent 2% and 5% of the total CWD density (11±11 and 20±13 per ha). On a volume basis, they represent 41% and 62% of the total CWD volume/ha (55±31 and 88±88 m^3/ha). These attributes are highly variable for both stands. For the six immature stands, the large dimensional pieces represent, on average, 4 to 5% of the total density of CWD pieces (20±11 to 38±8 no./ha). These few pieces correspond to 31 to 73% of the total CWD volume/ha (85±33 to105±19 m^3/ha).

PREDICTED SOURCES OF LARGE DIMENSIONAL CWD

Figures 3 and 4 illustrate by structure the predicted density[46] and volume/ha of large dimensional Y and Z Grade wood (i.e., minimum 50 cm large-end diameter and 8 m length), respectively (also refer to Table 19). The two mature stands have

Table 17. Pieces per ha of CWD, partitioned by large-end diameter and length classes (mean ± SE).

Age	BEC	Diameter (cm)	<3m	3m - 5m	5m - 10m	15m - 20m	20m - 25m	≥25m	≥20m	≥10m	≥8m	Total
Mature	CWHvm 1/ 2	<20	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	01,02	20-40	30.6 ± 20.8	20.2 ± 20.2	29.7 ± 29.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	80.5 ± 37.4
		40-60	22.7 ± 15.4	69.7 ± 33.9	9.0 ± 9.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	101.5 ± 33.1
		60-80	5.1 ± 5.1	0.0 ± 0.0	6.0 ± 6.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	18.0 ± 13.0	18.0 ± 13.0	29.1 ± 16.2
		≥80	0.0 ± 0.0	0.0 ± 0.0	3.7 ± 3.7	0.0 ± 0.0	0.0 ± 0.0	1.5 ± 1.5	1.5 ± 1.5	1.5 ± 1.5	1.5 ± 1.5	5.2 ± 3.9
		≥60	5.1 ± 5.1	0.0 ± 0.0	9.7 ± 9.7	0.0 ± 0.0	0.0 ± 0.0	1.5 ± 1.5	1.5 ± 1.5	19.5 ± 13.0	19.5 ± 13.0	34.3 ± 18.5
		≥50	5.1 ± 5.1	0.0 ± 0.0	18.7 ± 18.7	0.0 ± 0.0	0.0 ± 0.0	1.5 ± 1.5	1.5 ± 1.5	19.5 ± 13.0	19.5 ± 13.0	43.3 ± 25.7
		Total	58.4 ± 23.4	90.0 ± 36.6	48.4 ± 33.9	0.0 ± 0.0	0.0 ± 0.0	1.5 ± 1.5	1.5 ± 1.5	19.5 ± 13.0	19.5 ± 13.0	216.3 ± 48.5
	CWHvm 2	<20	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	01,06	20-40	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		40-60	0.0 ± 0.0	69.0 ± 69.0	99.5 ± 99.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	168.5 ± 106.0
		60-80	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		≥80	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	6.6 ± 6.6	6.6 ± 6.6	10.8 ± 10.8	10.8 ± 10.8	10.8 ± 10.8
		≥60	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	6.6 ± 6.6	6.6 ± 6.6	10.8 ± 10.8	10.8 ± 10.8	10.8 ± 10.8
		≥50	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	6.6 ± 6.6	6.6 ± 6.6	10.8 ± 10.8	10.8 ± 10.8	10.8 ± 10.8
		Total	0.0 ± 0.0	69.0 ± 69.0	99.5 ± 99.5	0.0 ± 0.0	0.0 ± 0.0	6.6 ± 6.6	6.6 ± 6.6	10.8 ± 10.8	10.8 ± 10.8	179.3 ± 110.9
Immature	CWHxm	<20	104.4 ± 47.6	122.2 ± 71.6	113.5 ± 65.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	14.3 ± 14.3	14.3 ± 14.3	354.4 ± 110.9
	01	20-40	174.0 ± 58.2	36.5 ± 18.6	65.2 ± 23.9	14.1 ± 10.2	0.0 ± 0.0	11.6 ± 11.6	11.6 ± 11.6	75.3 ± 29.4	95.7 ± 34.1	350.9 ± 74.6
		40-60	1.9 ± 1.9	19.1 ± 6.7	17.5 ± 7.6	3.8 ± 3.8	1.9 ± 1.9	2.9 ± 2.9	4.7 ± 3.4	18.7 ± 6.9	24.5 ± 7.7	57.2 ± 12.8
		60-80	0.0 ± 0.0	3.7 ± 2.2	11.4 ± 4.0	3.2 ± 1.8	0.0 ± 0.0	1.2 ± 1.2	1.2 ± 1.2	10.1 ± 4.1	15.0 ± 4.5	25.2 ± 6.3
		≥80	0.6 ± 0.6	4.4 ± 2.2	6.5 ± 2.6	2.8 ± 1.5	2.5 ± 1.4	1.1 ± 0.7	3.6 ± 1.6	7.4 ± 2.3	9.6 ± 2.9	18.8 ± 4.5
		≥60	0.6 ± 0.6	8.2 ± 3.0	17.9 ± 5.2	6.0 ± 2.3	2.5 ± 1.4	2.3 ± 1.4	4.8 ± 2.0	17.4 ± 4.4	24.6 ± 4.8	44.0 ± 8.3
		≥50	0.6 ± 0.6	11.0 ± 3.9	32.5 ± 8.4	6.0 ± 2.3	2.5 ± 1.4	5.2 ± 3.2	7.7 ± 3.4	24.9 ± 6.9	37.9 ± 7.5	68.9 ± 12.9
		Total	280.8 ± 71.7	186.0 ± 72.4	214.1 ± 66.6	23.9 ± 10.8	4.3 ± 2.3	16.7 ± 11.9	21.1 ± 12.0	125.7 ± 32.7	159.0 ± 37.3	806.5 ± 134.7
	CWHxm	<20	145.3 ± 44.9	117.1 ± 53.3	128.2 ± 38.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	31.7 ± 18.1	390.6 ± 80.4
	01.06	20-40	50.4 ± 16.4	87.5 ± 18.7	70.4 ± 24.8	1.9 ± 1.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	24.9 ± 10.9	44.1 ± 16.2	233.3 ± 42.7
		40-60	16.3 ± 5.2	28.6 ± 9.2	40.7 ± 8.6	2.2 ± 1.6	3.2 ± 1.8	1.8 ± 1.8	5.0 ± 2.6	26.9 ± 6.3	35.0 ± 6.9	112.6 ± 15.6
		60-80	1.3 ± 1.3	3.9 ± 1.8	6.5 ± 2.2	0.5 ± 0.5	2.2 ± 1.3	0.0 ± 0.0	2.2 ± 1.3	7.1 ± 2.3	9.5 ± 2.7	18.7 ± 4.1
		≥80	2.0 ± 1.1	2.5 ± 1.6	2.4 ± 1.1	0.9 ± 0.5	1.4 ± 0.9	0.5 ± 0.3	1.9 ± 0.9	4.5 ± 1.3	5.1 ± 1.4	11.3 ± 2.6
		≥60	3.3 ± 2.2	6.4 ± 2.5	8.8 ± 2.4	1.4 ± 0.7	3.6 ± 1.6	0.5 ± 0.3	4.1 ± 1.6	11.6 ± 2.8	14.6 ± 3.3	30.1 ± 5.0
		≥50	5.8 ± 2.8	15.0 ± 5.4	25.7 ± 5.9	3.6 ± 1.7	4.4 ± 1.7	2.3 ± 1.8	6.7 ± 2.5	28.2 ± 5.5	35.0 ± 6.3	74.7 ± 10.8
		Total	215.2 ± 51.2	239.6 ± 56.3	248.2 ± 45.4	5.5 ± 2.5	6.8 ± 2.8	2.3 ± 1.8	9.1 ± 3.3	63.5 ± 13.5	125.5 ± 24.8	766.5 ± 93.6
	CWHxm	<20	75.5 ± 75.5	0.0 ± 0.0	86.6 ± 86.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	162.1 ± 110.7
	01,05	20-40	69.5 ± 40.2	54.3 ± 38.9	29.7 ± 20.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	27.2 ± 27.2	56.8 ± 32.2	180.7 ± 64.5
		40-60	36.6 ± 16.5	21.8 ± 12.0	69.5 ± 22.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	13.1 ± 13.1	34.6 ± 22.4	141.0 ± 37.7
		60-80	4.0 ± 4.0	6.5 ± 6.5	20.6 ± 11.1	3.5 ± 3.5	0.0 ± 0.0	7.6 ± 5.2	7.6 ± 5.2	11.0 ± 5.9	11.0 ± 5.9	42.2 ± 15.2
		≥80	1.9 ± 1.9	8.0 ± 6.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	3.1 ± 2.1	3.1 ± 2.1	3.1 ± 2.1	3.1 ± 2.1	12.9 ± 6.4
		≥60	5.9 ± 4.3	14.6 ± 8.6	20.6 ± 11.1	3.5 ± 3.5	0.0 ± 0.0	10.6 ± 5.3	10.6 ± 5.3	14.1 ± 5.9	14.1 ± 5.9	55.1 ± 17.7
		≥50	17.1 ± 11.6	29.6 ± 17.0	36.3 ± 19.0	3.5 ± 3.5	0.0 ± 0.0	10.6 ± 5.3	10.6 ± 5.3	14.1 ± 5.9	20.4 ± 10.5	97.1 ± 37.6
		Total	187.5 ± 89.0	90.7 ± 41.0	206.4 ± 83.7	3.5 ± 3.5	0.0 ± 0.0	10.6 ± 5.3	10.6 ± 5.3	54.4 ± 28.5	105.5 ± 48.1	538.9 ± 130.6

a noticeably higher density of large dimensional Y and Z Grade wood in the standing live and dead stems compared with the six immature stands. The contribution of CWD to the total density varies across the eight blocks. With the exception of the two blocks in the CWHxm subzone (01), the predicted density of large dimensional Y and Z Grade wood in the standing stems exceeds the predicted density in the CWD.

The mature stands also have a noticeably higher volume/ha of large dimensional Y and Z Grade wood in the standing live and dead stems compared with the immature stands. In the mature stands, the volume of large dimensional Y and Z Grade wood in the standing stems exceeds the total CWD volume/ha; whereas for the immature stands, the volume of large dimensional Y and Z Grade wood from all sources is approximately one-half the corresponding total CWD volume/ha. Protecting the existing CWD on the ground will be particularly important on the immature blocks because the predicted volume/ha of large low-value/non-merchantable wood in the standing stems is low. In immature stands such as these, it will be necessary to employ a variety of strategies (e.g., reserves, alternative silviculture systems) to provide for CWD over the next rotation. Capitalizing on the retention of lower-value wood present in the stand is one such strategy.

[46] Readers are reminded of the large plot-level differences between the two surveys in the total density of Y and Z Grade wood.

Table 18. Volume/ha of CWD, partitioned by large-end diameter and length classes (mean ± SE).

Age	BEC	Diameter (cm)	<3m	3m - 5m	5m - 10m	15m - 20m	20m - 25m	^{3}25m	^{3}20m	^{3}10m	^{3}8m	Total
Mature	CWHvm 1/ 2	<20	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	01,02	20-40	2.8 ± 1.9	4.7 ± 4.7	13.3 ± 13.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	20.7 ± 13.6
		40-60	5.2 ± 3.6	26.4 ± 12.3	6.9 ± 6.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	38.6 ± 12.5
		60-80	2.7 ± 2.7	0.0 ± 0.0	6.9 ± 6.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	34.6 ± 25.3	34.6 ± 25.3	44.2 ± 26.2
		≥80	0.0 ± 0.0	0.0 ± 0.0	7.1 ± 7.1	0.0 ± 0.0	0.0 ± 0.0	19.7 ± 19.7	19.7 ± 19.7	19.7 ± 19.7	19.7 ± 19.7	26.8 ± 20.4
		≥60	2.7 ± 2.7	0.0 ± 0.0	14.0 ± 14.0	0.0 ± 0.0	0.0 ± 0.0	19.7 ± 19.7	19.7 ± 19.7	54.2 ± 30.4	54.2 ± 30.4	71.0 ± 32.6
		≥50	2.7 ± 2.7	0.0 ± 0.0	20.9 ± 20.9	0.0 ± 0.0	0.0 ± 0.0	19.7 ± 19.7	19.7 ± 19.7	54.2 ± 30.4	54.2 ± 30.4	77.9 ± 35.9
		Total	10.7 ± 4.2	31.1 ± 12.4	34.2 ± 23.9	0.0 ± 0.0	0.0 ± 0.0	19.7 ± 19.7	19.7 ± 19.7	54.2 ± 30.4	54.2 ± 30.4	130.3 ± 34.6
	CWHvm 2	<20	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	01,06	20-40	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		40-60	0.0 ± 0.0	23.9 ± 23.9	30.9 ± 30.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	54.8 ± 34.0
		60-80	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		≥80	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	58.3 ± 58.3	58.3 ± 58.3	88.0 ± 88.0	88.0 ± 88.0	88.0 ± 88.0
		≥60	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	58.3 ± 58.3	58.3 ± 58.3	88.0 ± 88.0	88.0 ± 88.0	88.0 ± 88.0
		≥50	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	58.3 ± 58.3	58.3 ± 58.3	88.0 ± 88.0	88.0 ± 88.0	88.0 ± 88.0
		Total	0.0 ± 0.0	23.9 ± 23.9	30.9 ± 30.9	0.0 ± 0.0	0.0 ± 0.0	58.3 ± 58.3	58.3 ± 58.3	88.0 ± 88.0	88.0 ± 88.0	142.8 ± 108.4
Immature	CWHxm	<20	2.9 ± 1.3	4.8 ± 2.4	7.7 ± 4.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	2.7 ± 2.7	2.7 ± 2.7	18.0 ± 5.9
	01	20-40	13.7 ± 4.3	7.4 ± 3.6	20.2 ± 7.4	7.0 ± 5.0	0.0 ± 0.0	5.5 ± 5.5	5.5 ± 5.5	30.9 ± 12.0	40.2 ± 14.3	72.2 ± 17.7
		40-60	0.5 ± 0.5	8.3 ± 2.9	12.1 ± 4.9	2.7 ± 2.7	3.7 ± 3.7	4.4 ± 4.4	8.1 ± 5.7	24.6 ± 9.2	29.0 ± 9.5	45.5 ± 11.3
		60-80	0.0 ± 0.0	3.4 ± 2.0	16.6 ± 5.9	9.3 ± 5.3	0.0 ± 0.0	4.0 ± 4.0	4.0 ± 4.0	22.9 ± 9.1	31.4 ± 9.7	42.8 ± 11.4
		≥80	0.6 ± 0.6	5.8 ± 2.8	12.7 ± 4.7	15.9 ± 6.8	13.3 ± 6.4	16.8 ± 9.8	30.0 ± 12.6	50.2 ± 15.8	55.7 ± 16.3	69.3 ± 17.3
		≥60	0.6 ± 0.6	9.1 ± 3.4	29.2 ± 7.9	25.2 ± 8.2	13.3 ± 6.4	20.8 ± 10.5	34.0 ± 13.0	73.1 ± 17.1	87.1 ± 17.1	112.1 ± 19.8
		≥50	0.6 ± 0.6	10.8 ± 3.7	39.7 ± 8.8	25.2 ± 8.2	13.3 ± 6.4	25.2 ± 11.2	38.4 ± 13.5	83.7 ± 18.5	102.2 ± 18.1	134.9 ± 21.1
		Total	17.8 ± 4.3	29.6 ± 5.8	69.2 ± 11.7	35.0 ± 9.4	17.0 ± 7.2	30.7 ± 12.2	47.7 ± 14.4	131.2 ± 21.8	159.0 ± 23.2	247.8 ± 26.5
	CWHxm	<20	3.9 ± 1.2	4.8 ± 2.1	10.5 ± 3.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	3.5 ± 2.0	19.2 ± 4.6
	01,06	20-40	4.7 ± 1.5	14.0 ± 2.8	17.3 ± 5.1	1.9 ± 1.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	12.1 ± 5.0	16.8 ± 5.7	48.2 ± 7.9
		40-60	3.8 ± 1.2	13.0 ± 4.3	28.2 ± 5.8	3.2 ± 2.3	6.3 ± 3.6	5.0 ± 5.0	11.4 ± 6.1	41.6 ± 10.4	48.2 ± 10.6	86.6 ± 12.7
		60-80	0.6 ± 0.6	3.0 ± 1.5	9.4 ± 3.2	1.7 ± 1.7	8.5 ± 5.2	0.0 ± 0.0	8.5 ± 5.2	22.1 ± 7.2	26.2 ± 7.8	35.1 ± 8.1
		≥80	2.0 ± 1.0	2.6 ± 1.4	6.8 ± 3.2	5.2 ± 3.0	8.4 ± 4.1	5.3 ± 3.8	13.7 ± 5.5	26.9 ± 7.0	29.8 ± 7.2	38.3 ± 7.8
		≥60	2.6 ± 1.5	5.7 ± 2.1	16.2 ± 4.4	6.9 ± 3.4	16.9 ± 6.5	5.3 ± 3.8	22.2 ± 7.3	48.9 ± 10.3	56.0 ± 11.0	73.4 ± 11.2
		≥50	3.5 ± 1.6	10.4 ± 3.4	29.5 ± 5.4	10.1 ± 4.0	19.3 ± 6.8	10.4 ± 6.2	29.7 ± 8.9	78.1 ± 13.0	88.6 ± 13.9	121.6 ± 15.7
		Total	15.0 ± 2.9	37.5 ± 6.0	72.2 ± 10.1	12.0 ± 4.4	23.2 ± 7.7	10.4 ± 6.2	33.6 ± 9.5	102.7 ± 15.4	124.6 ± 16.7	227.4 ± 20.1
	CWHxm	<20	2.0 ± 2.0	0.0 ± 0.0	5.3 ± 5.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	7.2 ± 5.5
	01,05	20-40	7.0 ± 3.8	8.6 ± 6.2	16.2 ± 11.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	12.5 ± 12.5	28.7 ± 15.9	44.3 ± 18.0
		40-60	9.8 ± 4.7	12.5 ± 7.6	50.2 ± 14.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.5 ± 11.5	31.9 ± 19.4	84.0 ± 22.4
		60-80	2.0 ± 2.0	6.9 ± 6.9	30.4 ± 16.4	10.8 ± 10.8	0.0 ± 0.0	32.0 ± 22.0	32.0 ± 22.0	42.8 ± 23.4	42.8 ± 23.4	82.1 ± 27.4
		≥80	1.9 ± 1.9	14.8 ± 12.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	33.1 ± 22.6	33.1 ± 22.6	33.1 ± 22.6	33.1 ± 22.6	49.8 ± 24.1
		≥60	3.9 ± 2.6	21.7 ± 13.5	30.4 ± 16.4	10.8 ± 10.8	0.0 ± 0.0	65.1 ± 29.0	65.1 ± 29.0	75.9 ± 29.3	75.9 ± 29.3	131.9 ± 33.2
		≥50	7.7 ± 4.5	31.5 ± 17.6	45.8 ± 22.7	10.8 ± 10.8	0.0 ± 0.0	65.1 ± 29.0	65.1 ± 29.0	75.9 ± 29.3	82.8 ± 32.3	161.0 ± 42.6
		Total	22.7 ± 7.5	42.9 ± 18.3	102.0 ± 25.0	10.8 ± 10.8	0.0 ± 0.0	65.1 ± 29.0	65.1 ± 29.0	99.9 ± 29.4	136.5 ± 38.4	267.5 ± 41.8

The differences between the immature and mature stands highlighted above were not unexpected. In contrast to mature Coastal stands, immature stands tend to have fewer defects in the timber and therefore lower volumes of lower-value log grades (Ruth and Harris 1975; Nagle 1980). The very high densities and volumes/ha reported for the two mature stands must however be viewed with caution because of the associated high variance and lack of replication.

CONCLUDING COMMENTS

This appendix explores how the data from the MIT cruise might be used to provide insight into questions related to the management of CWD in Coastal forests. Because the MIT cruise includes estimates of dbh, height, volume and log grades for all large forest structures, it provides a unique data set which could easily be applied to investigate a range of other issues related to wildlife habitat and forest structure. However, further work is required to address the survey considerations outlined in the main report.

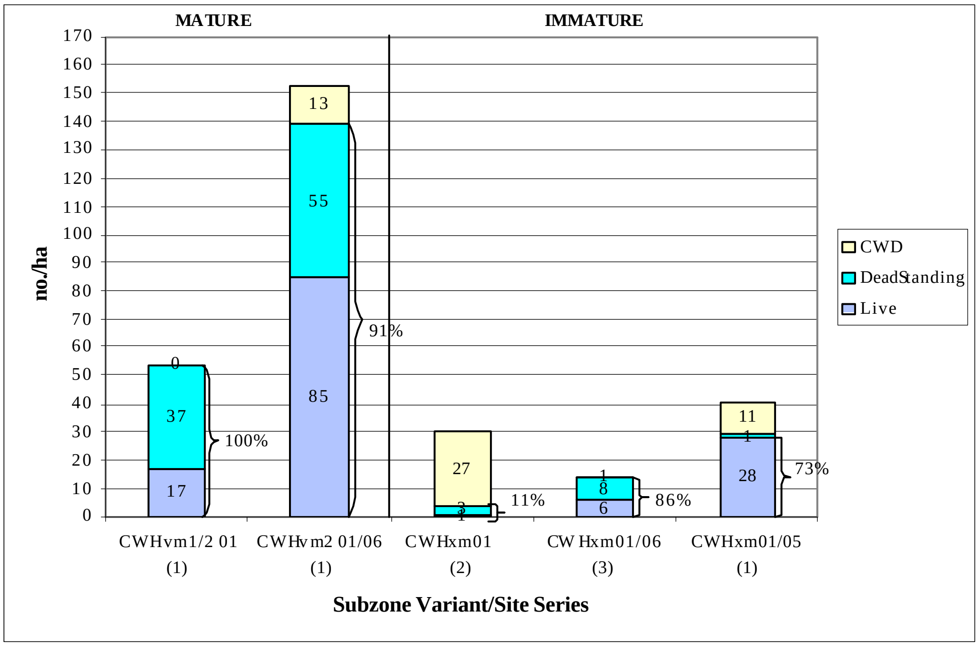

Figure 3. Density of large dimensional Y+Z Grade wood by structure.

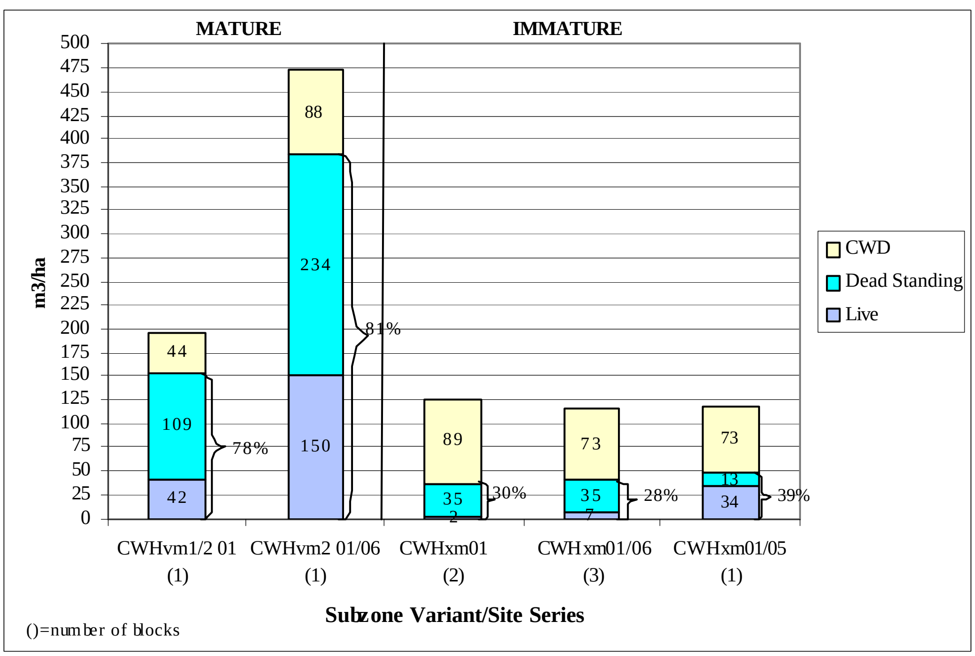

Figure 4. Volume/ha of large dimensional Y +Z Grade wood by structure.

APPENDIX B: MODIFICATIONS TO THE INDUSTRIAL TIMBER CRUISE PROCEDURES

Field Procedures:

All tree data is based on call grading and net factoring, using preferred log lengths. These TWF criteria are compatible with the Vegetation Inventory and could be used in conjunction with its data.

LIVE MERCH TREES	MoF REQ.	as per TWF standards	cg/nf	pr. length
DEAD MERCH TREES	MoF REQ.	as per TWF standards	cg/nf	pr. length
W / F MERCH TREES[47]	MoF REQ.	as per TWF standards	cg/nf	pr. length
DEAD TREES	CWD REQ.	as per TWF standards	cg/nf	pr. length
W / F TREES	CWD REQ.	as per TWF standards	cg/nf	pr. length
STUMPS	CWD REQ.	as per TWF standards	cg/nf	length
PIECES	CWD REQ.	as per TWF standards	cg/nf	length

DBH	all trees (stump attached) are measured (estimated) at 1.3 meters above high side
	all pieces are estimated at 1.3 meters from the 'large end'
IN / OUT	all items are measured (estimated) as they lie
HEIGHTS	all trees or pieces have a total height recorded
MISSING WOOD	Z grade, net factor 0, with a length for the missing piece(s) is recorded; if the top of the tree is missing, the conventions is to record Z 99 0
BROKEN WINDFALL	merch logs, if available, will be bucked out, thence the remaining log lengths are determined by the lengths between the breaks
LOG LENGTHS	all merch logs are based on preferred lengths, all other log lengths are in one-meter multiples, maximum log length is 13 meters, minimum log length is 3 meters (except for bucked-out Z grade)
NET FACTORING	all 'logs' are net factored, in units of 10%, for percentage sound remaining; 100% sound is recorded as a dash (-)
BREAKAGE	with the exception of 'spike top' cedar, breakage is not recorded or compiled
UTILIZATION	for the mature stands, merch volume is compiled to a 30 cm stump and a 15 cm top dib

CALL GRADING AND NET FACTORING CRITERIA

The cruiser is trained (and required) to emulate the faller, who will maximize industrial end use sorts using preferred log lengths. Using this methodology the sort is maximized first, the preferred log length second, and thence the alpha grade and net factor is applied.

These Mature sorts[48] are:	Highgrade	in general D and F grades
	Peeler	in general B and C grades
	Standard	in general H and I grades
	Shingle	in general K.L and M grades
	Gang	in general J grade (and some U)
	Pulp	in general X and Y grades (and some (U)

The preferred log lengths are 13 m, 12 m, 11 m, 8 m, and 6 m.

The minimum lengths are:	• gang and greater	5 meters.
	• shingle	4 meters
	• pulp	3 meters
	• Z grade (non recoverable)	1 meter

[47] In/out trees are based on dbh, plot radius factors, and horizontal distance to the dbh as it lies.

[48] All transactional data is by log sort, not by BCMOF alpha grades

NET FACTORING CRITERIA[49]

	Length	NF	Grade
Blind Conk	whole tree	50%	Y
Conk	2m above and 4 m below	50%	Y
Rotten Branch	1m below	50%	Z
Butt Rot	assigned by cruiser from scaling tables		assigned
Frost Crack		10% per	assigned
Fork/Crook	1m	assigned	Z
Scar		assigned	
Broken Top	assigned	0%	Z
Dead Top	assigned	assigned	assigned
Breakage	assigned	assigned	assigned
Undersized	whole tree	assigned	Z

[49] The net factor criteria are basically the same as those specified in the original Vegetation Resource Inventory manual.

APPENDIX C: EXAMPLE OF GENERAL OUTPUT FORMAT

Licencee	Block	Plot	Age	MCVC	BAF	Plot Type	F/H	Tree#	Cruise Height	Species	Cruise DBH	Tree Class	CWD TC	Check DBH	Damage Code	Log 1 Grade	Log 1 Length	Log 1 Net Factor	Log 2 Grade	Log 2 Length	Log 2 Net Factor	Log 3 Grade	Log 3 Length	Log 3 Net Factor	Log 4 Grade	Log 4 Length	Log 4 Net Factor	Log 5 Grade	Log 5 Length	Log 5 Net Factor	Log 6 Grade	Log 6 Length	Log 6 Net Factor	Compiled Log Length	Actual Log Length
IFP	119	2-1	8	M6	16	P	B	4	31.0	H	35.0	4	C	30.0	G	R	1	0	Y	5	30	Z	18.6	0										5.0	6.1
IFP	119	2-1	8	M6	16	P	B	5	38.0	F	55.0	4	ST	61.0		Z	3	20	Z	30.6	0													3.0	3.3
IFP	119	2-1	8	M6	16	P	B	6	36.0	F	45.0	4	C	44.0	G	R	1	0	Z	4	20	Z	25.9	0										4.0	10.0
IFP	119	2-9	8	M6	16	P	F	4	40.0	C	80.0	4	ST	83.3		Z	2	10	Z	33.3	0													2.0	2.5
IFP	119	2-9	8	M6	16	P	F	5	36.0	F	43.0	4	C	43.0	G	R	1	0	Y	4	50	Z	25.7	0										4.0	4.1
IFP	119	2-9	8	M6	16	P	F	6	39.0	C	78.0	4	ST	76.1		Z	2	30	Z	32.3	0													2.0	1.5
IFP	119	3-2	8	M4	16	P	F	2	28.0	C	56.8	7	ST	57.0		H	8	80	Z	2	100	J	10	100	Z	3.5	100							23.5	22.1
IFP	119	3-2	8	M4	16	P	F	7	23.0	F	20.0	4	C	18.6	G	R	1	0	Y	6	40	Z	8.2	0										6.0	6.9

Licencee	Block	Plot	Age	MCVC	BAF	Plot Type	F/H	Tree#	Cruise Tally Change	Comments	Geo. Mean Butt	Geo. Mean Top	Cruise M3/Ha	Check M3/Ha	Cruise M3	Check M3	Chunk ?	Smailian M3	Cruise Butt DIB	Cruise Log 1 Top DIB	Cruise Log 1 M3	Cruise Log 2 Top DIB	Cruise Log 2 M3	Cruise Log 3 Top DIB	Cruise Log 3 M3	Cruise Log 4 Top DIB
IFP	119	2-1	8	M6	16	P	B	4	Y		30.00	20.98	130.138	129.882	0.391	0.287	Y	0.311	39.0	29.2	0.391					
IFP	119	2-1	8	M6	16	P	B	5	Y				65.745	64.945	0.488	0.593			54.2	41.8	0.488	10.0	0.000			
IFP	119	2-1	8	M6	16	P	B	6	Y		46.00	20.49	85.52	85.789	0.425	0.408	Y	0.868	44.6	33.7	0.425					
IFP	119	2-9	8	M6	16	P	F	4	Y				32.921	32.825	1.034	1.118			110.6	68.0	1.034	10.0	0.000			
IFP	119	2-9	8	M6	16	P	F	5	Y		40.89	34.41	43.034	43.034	0.391	0.391	Y	0.456	42.8	32.3	0.391					
IFP	119	2-9	8	M6	16	P	F	6	Y				32.783	32.847	0.979	0.934			107.6	66.2	0.979	10.0	0.000			
IFP	119	3-2	8	M4	16	P	F	2	Y				137.823	137.672	2.183	2.196			75.6	37.0	1.319	34.7	0.202	18.1	0.604	10.0
IFP	119	3-2	8	M4	16	P	F	7	Y		18.00	10.60	63.508	64.326	0.125	0.109	Y	0.111	20.2	14.8	0.125					

Licencee	Block	Plot	Age	MCVC	BAF	Plot Type	F/H	Tree#	Cruise Log 4 M3	Cruise Log 5 Top DIB	Cruise Log 5 M3	Cruise Log 6 Top DIB	Cruise Log 6 M3	Check Butt DIB	Check Log 1 Top DIB	Check Log 1 M3	Check Log 2 Top DIB	Check Log 2 M3	Check Log 3 Top DIB	Check Log 3 M3	Check Log 4 Top DIB	Check Log 4 M3	Check Log 5 Top DIB	Check Log 5 M3	Check Log 6 Top DIB	Check Log 6 M3	Cruise 15 to 10 cm DIB Volume	Cruise 15 to 10 Total Length	Check 15 to 10 cm DIB Volume	Check 15 to 10 Total Length
IFP	119	2-1	8	M6	16	P	B	4						33.3	25.1	0.287											0	0	0	0
IFP	119	2-1	8	M6	16	P	B	5						59.8	46.0	0.593	10.0	0.000									0	0	0	0
IFP	119	2-1	8	M6	16	P	B	6						43.7	33.0	0.408											0	0	0	0
IFP	119	2-9	8	M6	16	P	F	4						115.1	70.7	1.118	10.0	0.000									0	0	0	0
IFP	119	2-9	8	M6	16	P	F	5						42.8	32.3	0.391											0	0	0	0
IFP	119	2-9	8	M6	16	P	F	6						105.0	64.7	0.934	10.0	0.000									0	0	0	0
IFP	119	3-2	8	M4	16	P	F	2	0.057					75.8	37.1	1.327	34.8	0.203	18.2	0.607	10.0	0.057					0	0	0	0
IFP	119	3-2	8	M4	16	P	F	7						18.9	13.9	0.109											0	0	0	0

APPENDIX D: DEAD WOOD ATTRIBUTES BY SUBZONE VARIANT AND TIMBER TYPE

D1: DEAD WOOD ATTRIBUTES BY SUBZONE VARIANT

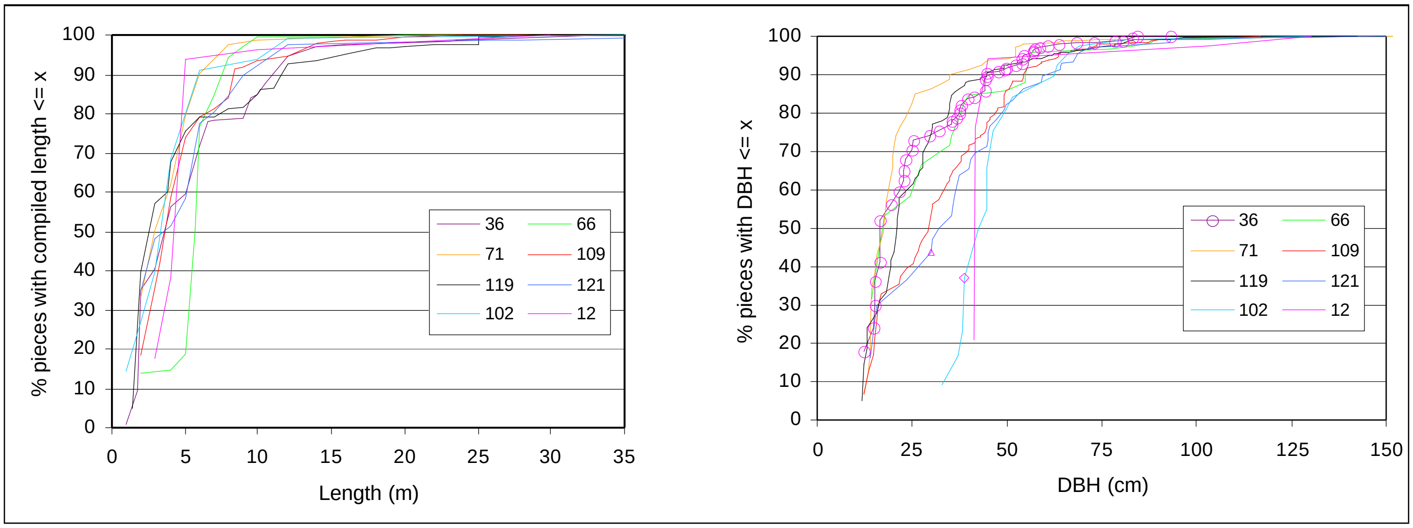

Figure 5. Length (left) and diameter (right) cumulative distributions by block.

Table 19. Density (no./ha) and volume (m^3/ha) of large dimensional wood by structure and grade.

			Density (no./ha)						Volume (m^3/ha)					
Age	BEC	Structure	All Grades	Y Grade	Y, Z Grades	U Grade	X Grade	U,X Grades	All Grades	Y Grade	Y, Z Grades	U Grade	X Grade	U, X Grades
Mature	CWHvm1/2	Live	191.6 ± 32.1	8.5 ± 4.2	17.0 ± 8.4	15.0 ± 4.3	2.0 ± 1.4	17.0 ± 4.3	740.7 ± 97.2	33.2 ± 20.2	42.1 ± 21.0	45.0 ± 13.0	8.3 ± 5.7	53.3 ± 14.7
	01	Dead standing	42.4 ± 29.8	18.3 ± 15.1	36.6 ± 30.1	0.0 ± 0.0	0.9 ± 0.9	0.9 ± 0.9	158.3 ± 51.9	47.4 ± 26.4	109.4 ± 32.1	0.0 ± 0.0	3.9 ± 3.9	3.9 ± 3.9
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	19.7 ± 19.7	0.0 ± 0.0	19.7 ± 19.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD chunk	6.0 ± 6.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	6.0 ± 6.0	6.0 ± 6.0	34.6 ± 25.3	0.0 ± 0.0	23.8 ± 23.8	0.0 ± 0.0	10.8 ± 10.8	10.8 ± 10.8
	N=14	Total dead	48.4 ± 30.5	18.3 ± 15.1	36.6 ± 30.1	0.0 ± 0.0	6.9 ± 6.0	6.9 ± 6.0	212.5 ± 66.0	47.4 ± 26.4	152.9 ± 53.1	0.0 ± 0.0	14.6 ± 11.1	14.6 ± 11.1
	1 block	Total CWD[a]	6.0 ± 6.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	6.0 ± 6.0	6.0 ± 6.0	54.2 ± 30.4	0.0 ± 0.0	43.5 ± 29.7	0.0 ± 0.0	10.8 ± 10.8	10.8 ± 10.8
		Total	240.1 ± 52.3	26.8 ± 14.8	53.6 ± 29.7	15.0 ± 4.3	8.9 ± 6.9	23.9 ± 7.1	953.2 ± 134.7	80.7 ± 29.4	195.0 ± 51.8	45.0 ± 13.0	22.9 ± 15.4	67.9 ± 18.9
	CWHvm2	Live	192.0 ± 52.1	42.5 ± 26.0	84.9 ± 52.1	42.0 ± 13.2	1.7 ± 1.7	43.6 ± 13.3	597.4 ± 185.3	150.2 ± 116.2	150.2 ± 116.2	154.8 ± 54.1	2.3 ± 2.3	157.1 ± 56.0
	01/06	Dead standing	54.5 ± 23.7	27.3 ± 11.9	54.5 ± 23.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	233.6 ± 68.7	155.5 ± 64.5	233.6 ± 68.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD chunk	13.2 ± 13.2	6.6 ± 6.6	13.2 ± 13.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	88.0 ± 88.0	58.3 ± 58.3	88.0 ± 88.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	N=5	Total dead	67.7 ± 27.9	33.8 ± 14.0	67.7 ± 27.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	321.6 ± 144.7	213.8 ± 105.1	321.6 ± 144.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	1 block	Total CWD	13.2 ± 13.2	6.6 ± 6.6	13.2 ± 13.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	88.0 ± 88.0	58.3 ± 58.3	88.0 ± 88.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	259.6 ± 66.7	76.3 ± 26.7	152.6 ± 53.4	42.0 ± 13.2	1.7 ± 1.7	43.6 ± 13.3	919.1 ± 279.3	364.0 ± 147.0	471.8 ± 152.9	154.8 ± 54.1	2.3 ± 2.3	157.1 ± 56.0
Immature	CWHxm	Live	102.3 ± 13.8	0.3 ± 0.3	0.5 ± 0.5	0.3 ± 0.3	0.0 ± 0.0	0.3 ± 0.3	233.6 ± 28.6	2.0 ± 2.0	2.0 ± 2.0	0.6 ± 0.6	0.0 ± 0.0	0.6 ± 0.6
	01	Dead standing	10.7 ± 4.3	1.4 ± 0.9	2.9 ± 1.7	0.5 ± 0.4	0.1 ± 0.1	0.6 ± 0.4	59.6 ± 23.8	16.0 ± 7.5	35.3 ± 17.0	8.0 ± 5.7	1.0 ± 1.0	9.0 ± 6.5
		Dead windfall	15.5 ± 6.6	7.7 ± 3.3	15.3 ± 6.6	0.0 ± 0.0	0.1 ± 0.1	0.1 ± 0.1	35.0 ± 12.6	17.9 ± 6.8	31.8 ± 10.2	0.0 ± 0.0	0.9 ± 0.9	0.9 ± 0.9
		CWD chunk	11.6 ± 4.7	5.8 ± 2.3	11.6 ± 4.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	57.0 ± 12.7	24.6 ± 10.3	57.0 ± 12.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	N=44	Total dead	37.7 ± 8.1	14.9 ± 3.8	29.8 ± 7.6	0.5 ± 0.4	0.2 ± 0.1	0.7 ± 0.4	151.6 ± 33.0	58.6 ± 14.1	124.0 ± 25.8	8.0 ± 5.7	1.9 ± 1.3	9.9 ± 6.6
	2 blocks	Total CWD	27.0 ± 7.6	13.4 ± 3.8	26.9 ± 7.6	0.0 ± 0.0	0.1 ± 0.1	0.1 ± 0.1	92.0 ± 16.4	42.5 ± 12.4	88.7 ± 15.0	0.0 ± 0.0	0.9 ± 0.9	0.9 ± 0.9
		Total	140.0 ± 18.0	15.1 ± 3.9	30.3 ± 7.8	0.8 ± 0.4	0.2 ± 0.1	0.9 ± 0.5	385.1 ± 54.1	60.5 ± 14.3	126.0 ± 25.8	8.6 ± 5.7	1.9 ± 1.3	10.5 ± 6.6
	CWHxm	Live	122.7 ± 12.9	2.9 ± 2.0	5.8 ± 4.1	7.9 ± 3.7	0.1 ± 0.1	8.0 ± 3.7	263.3 ± 27.5	6.5 ± 4.7	7.4 ± 4.8	13.9 ± 6.3	0.6 ± 0.6	14.5 ± 6.3
	01/06	Dead standing	8.6 ± 4.7	3.3 ± 2.2	6.5 ± 4.3	0.2 ± 0.1	0.0 ± 0.0	0.2 ± 0.1	33.5 ± 11.0	13.9 ± 7.1	24.6 ± 8.3	5.2 ± 4.0	0.0 ± 0.0	5.2 ± 4.0
		Dead windfall	1.3 ± 1.0	0.3 ± 0.3	0.6 ± 0.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	26.0 ± 8.0	2.5 ± 2.5	25.1 ± 7.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD chunk	1.3 ± 0.9	0.6 ± 0.5	1.3 ± 0.9	0.1 ± 0.1	0.0 ± 0.0	0.1 ± 0.1	59.6 ± 11.6	3.5 ± 2.1	58.1 ± 11.5	1.5 ± 1.5	0.0 ± 0.0	1.5 ± 1.5
	N=74	Total dead	11.2 ± 5.1	4.2 ± 2.2	8.4 ± 4.4	0.2 ± 0.1	0.0 ± 0.0	0.2 ± 0.1	119.2 ± 17.9	19.9 ± 8.3	107.8 ± 16.3	6.7 ± 4.2	0.0 ± 0.0	6.7 ± 4.2
	3 blocks	Total CWD	2.7 ± 1.3	0.9 ± 0.5	1.9 ± 1.1	0.1 ± 0.1	0.0 ± 0.0	0.1 ± 0.1	85.6 ± 13.4	6.0 ± 3.2	83.2 ± 13.4	1.5 ± 1.5	0.0 ± 0.0	1.5 ± 1.5
		Total	134.0 ± 13.9	7.1 ± 3.0	14.2 ± 5.9	8.1 ± 3.7	0.1 ± 0.1	8.2 ± 3.7	382.5 ± 33.9	26.4 ± 9.5	115.3 ± 16.5	20.6 ± 7.4	0.6 ± 0.6	21.2 ± 7.4
	CWHxm	Live	195.4 ± 42.6	14.1 ± 9.5	28.3 ± 19.1	7.7 ± 3.9	0.0 ± 0.0	7.7 ± 3.9	497.8 ± 96.2	33.6 ± 24.6	33.6 ± 24.6	42.1 ± 20.6	0.0 ± 0.0	42.1 ± 20.6
	01/05	Dead standing	1.1 ± 1.1	0.6 ± 0.6	1.1 ± 1.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	13.1 ± 9.0	5.9 ± 5.9	13.1 ± 9.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	9.6 ± 8.1	4.0 ± 4.0	8.0 ± 8.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	59.6 ± 27.0	17.7 ± 17.7	50.4 ± 23.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD chunk	3.1 ± 3.1	1.5 ± 1.5	3.1 ± 3.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	22.3 ± 16.4	15.4 ± 15.4	22.3 ± 16.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	N=15	Total dead	13.7 ± 8.3	6.1 ± 4.2	12.2 ± 8.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	95.1 ± 30.8	38.9 ± 22.7	85.8 ± 28.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	1 block	Total CWD	12.6 ± 8.4	5.6 ± 4.2	11.1 ± 8.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	81.9 ± 31.9	33.0 ± 22.6	72.7 ± 29.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	209.1 ± 45.7	20.2 ± 10.9	40.5 ± 21.8	7.7 ± 3.9	0.0 ± 0.0	7.7 ± 3.9	592.9 ± 92.0	72.5 ± 34.0	119.5 ± 40.3	42.1 ± 20.6	0.0 ± 0.0	42.1 ± 20.6

[a] Total CWD = Dead windfall + CWD chunks.

D2: DEAD WOOD ATTRIBUTES BY TIMBER TYPE

Table 20. Timber types: total density (no./ha) and volume (m^3/ha) partitioned by structure (mean ± SE).

Age	Timber Type	Structure	Total Density no./ha	Total Volume m^3/ha	Bole m^3/ha	Stump m^3/ha	Top m^3/ha	Stump & Top m^3/ha
Mature	# 7 F H 6 + 250 35	Live	302.0 ± 105.4	1277.2 ± 167.7	1230.1 ± 164.0	11.4 ± 4.2	35.6 ± 5.0	47.0 ± 8.2
	n = 9 (plots)	Dead standing	58.1 ± 17.9	204.9 ± 74.3	197.3 ± 72.4	0.0 ± 0.0	7.6 ± 2.3	7.6 ± 2.3
		Dead windfall	46.6 ± 31.6	63.9 ± 42.3	60.6 ± 41.2	0.0 ± 0.0	3.4 ± 1.7	3.4 ± 1.7
		CWD Chunk	293.9 ± 144.0	85.7 ± 42.5	85.7 ± 42.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	398.7 ± 147.5	354.6 ± 130.7	343.6 ± 128.5	0.0 ± 0.0	11.0 ± 2.8	11.0 ± 2.8
		CWD [a]	340.5 ± 140.3	149.7 ± 75.4	146.3 ± 74.7	0.0 ± 0.0	3.4 ± 1.7	3.4 ± 1.7
		Total	700.7 ± 163.9	1631.8 ± 205.9	1573.8 ± 201.1	11.4 ± 4.2	46.6 ± 6.5	58.0 ± 9.3
	#15 C H 6 + 250 25	Live	242.4 ± 52.9	766.4 ± 81.3	715.2 ± 75.9	11.8 ± 3.1	39.5 ± 3.2	51.2 ± 5.8
	n = 18	Dead standing	54.8 ± 13.6	154.7 ± 40.0	142.9 ± 37.4	0.4 ± 0.2	11.5 ± 2.7	11.9 ± 2.8
		Dead windfall	112.1 ± 39.7	313.5 ± 72.8	290.8 ± 68.9	4.7 ± 2.9	18.1 ± 4.1	22.7 ± 5.1
		CWD Chunk	138.5 ± 44.3	108.2 ± 40.2	108.2 ± 40.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	305.4 ± 68.2	576.4 ± 87.0	541.8 ± 83.8	5.1 ± 2.9	29.5 ± 4.1	34.6 ± 4.7
		CWD	250.7 ± 65.9	421.6 ± 85.3	398.9 ± 81.9	4.7 ± 2.9	18.1 ± 4.1	22.7 ± 5.1
		Total	547.8 ± 100.9	1342.8 ± 124.8	1257.0 ± 118.6	16.8 ± 5.1	69.0 ± 5.0	85.8 ± 8.0
	#16 C H 6 + 250 30	Live	371.8 ± .	1803.3 ± .	1721.1 ± .	15.1 ± .	67.1 ± .	82.2 ± .
	n = 1	Dead standing	40.3 ± .	34.4 ± .	28.6 ± .	0.0 ± .	5.8 ± .	5.8 ± .
		Dead windfall	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		CWD Chunk	433.9 ± .	206.7 ± .	206.7 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		Total dead	474.2 ± .	241.0 ± .	235.3 ± .	0.0 ± .	5.8 ± .	5.8 ± .
		CWD	433.9 ± .	206.7 ± .	206.7 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		Total	846.0 ± .	2044.4 ± .	1956.4 ± .	15.1 ± .	72.9 ± .	88.0 ± .
	#23 H F 6 + 250 25	Live	303.0 ± 34.8	1338.8 ± 144.7	1290.1 ± 142.3	12.2 ± 1.5	36.4 ± 2.9	48.6 ± 3.5
	n = 14	Dead standing	89.9 ± 24.7	169.8 ± 47.1	160.0 ± 44.9	1.4 ± 1.0	8.3 ± 1.7	9.7 ± 2.4
		Dead windfall	150.6 ± 71.3	57.4 ± 22.1	45.7 ± 20.4	7.9 ± 5.2	3.7 ± 1.2	11.6 ± 5.8
		CWD Chunk	406.8 ± 125.5	161.8 ± 41.6	161.8 ± 41.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	647.3 ± 158.1	389.0 ± 58.6	367.6 ± 56.0	9.3 ± 6.0	12.1 ± 2.0	21.4 ± 6.9
		CWD	557.4 ± 149.6	219.2 ± 38.0	207.5 ± 38.7	7.9 ± 5.2	3.7 ± 1.2	11.6 ± 5.8
		Total	950.4 ± 161.2	1727.7 ± 136.0	1657.7 ± 136.1	21.6 ± 6.7	48.5 ± 2.9	70.0 ± 7.3
	#24 H F 6 + 250 30	Live	399.3 ± 125.5	1291.6 ± 136.1	1238.9 ± 130.8	20.6 ± 9.0	32.1 ± 3.5	52.6 ± 10.9
	n = 5	Dead standing	125.4 ± 54.7	198.2 ± 110.7	187.7 ± 106.1	2.2 ± 1.4	8.4 ± 4.3	10.5 ± 4.8
		Dead windfall	101.1 ± 101.1	79.3 ± 79.3	75.6 ± 75.6	0.0 ± 0.0	3.8 ± 3.8	3.8 ± 3.8
		CWD Chunk	445.1 ± 217.1	179.5 ± 54.4	179.5 ± 54.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	671.6 ± 246.4	457.1 ± 130.6	442.7 ± 124.6	2.2 ± 1.4	12.1 ± 6.5	14.3 ± 6.6
		CWD	546.2 ± 222.3	258.9 ± 82.5	255.1 ± 79.6	0.0 ± 0.0	3.8 ± 3.8	3.8 ± 3.8
		Total	1070.9 ± 315.2	1748.6 ± 87.2	1681.7 ± 76.5	22.8 ± 8.5	44.2 ± 6.2	67.0 ± 14.4
	#25 H F 6 + 250 35	Live	268.3 ± 50.8	1504.4 ± 134.3	1453.7 ± 131.4	12.0 ± 2.8	38.6 ± 3.2	50.7 ± 4.9
	n = 16	Dead standing	44.9 ± 13.7	134.7 ± 35.5	127.3 ± 34.0	0.4 ± 0.2	7.0 ± 1.7	7.4 ± 1.8
		Dead windfall	100.4 ± 37.1	98.9 ± 36.0	89.7 ± 34.3	2.7 ± 2.0	6.5 ± 2.0	9.2 ± 3.0
		CWD Chunk	220.7 ± 57.9	145.0 ± 38.7	145.0 ± 38.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	366.0 ± 66.5	378.6 ± 54.2	362.0 ± 53.0	3.2 ± 2.0	13.4 ± 2.6	16.6 ± 3.1
		CWD	321.0 ± 67.6	243.9 ± 44.9	234.7 ± 43.8	2.7 ± 2.0	6.5 ± 2.0	9.2 ± 3.0
		Total	634.2 ± 82.2	1883.0 ± 133.7	1815.7 ± 130.1	15.2 ± 3.3	52.1 ± 3.9	67.3 ± 6.6
	#28 H C 4 - 250 30	Live	166.6 ± 47.7	441.9 ± 11.6	422.5 ± 13.5	7.9 ± 3.2	11.5 ± 1.2	19.4 ± 2.0
	n = 2	Dead standing	63.4 ± 63.4	209.5 ± 209.5	198.8 ± 198.8	0.5 ± 0.5	10.2 ± 10.2	10.7 ± 10.7
		Dead windfall	24.1 ± 24.1	97.8 ± 97.8	92.2 ± 92.2	1.1 ± 1.1	4.6 ± 4.6	5.6 ± 5.6
		CWD Chunk	124.4 ± 10.1	245.4 ± 14.5	245.4 ± 14.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	211.9 ± 77.4	552.8 ± 321.9	536.5 ± 305.5	1.6 ± 1.6	14.8 ± 14.8	16.3 ± 16.3
		CWD	148.5 ± 14.0	343.3 ± 112.3	337.6 ± 106.7	1.1 ± 1.1	4.6 ± 4.6	5.6 ± 5.6
		Total	378.5 ± 29.7	994.7 ± 333.4	959.0 ± 319.1	9.5 ± 1.6	26.2 ± 16.0	35.7 ± 14.3
	#29 H C 6 + 250 25	Live	456.7 ± 149.8	613.3 ± 119.0	562.8 ± 127.0	28.0 ± 12.6	22.6 ± 3.5	50.5 ± 10.6
	n = 3	Dead standing	10.6 ± 10.6	70.9 ± 70.9	68.4 ± 68.4	0.3 ± 0.3	2.2 ± 2.2	2.5 ± 2.5
		Dead windfall	38.8 ± 19.1	143.4 ± 17.8	134.0 ± 16.4	1.1 ± 1.0	8.3 ± 0.9	9.4 ± 1.5
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	49.4 ± 11.9	214.3 ± 82.5	202.4 ± 79.5	1.4 ± 0.9	10.5 ± 2.9	11.9 ± 3.2
		CWD	38.8 ± 19.1	143.4 ± 17.8	134.0 ± 16.4	1.1 ± 1.0	8.3 ± 0.9	9.4 ± 1.5
		Total	506.1 ± 160.4	827.6 ± 104.5	765.2 ± 115.5	29.4 ± 13.5	33.1 ± 2.2	62.5 ± 11.3
	#30 H C 6 + 250 30	Live	238.6 ± 39.9	775.9 ± 115.3	734.1 ± 109.7	10.2 ± 2.0	31.6 ± 6.0	41.8 ± 6.3
	n = 11	Dead standing	102.2 ± 29.3	210.5 ± 85.2	198.7 ± 82.1	0.3 ± 0.2	11.4 ± 3.3	11.7 ± 3.5
		Dead windfall	116.2 ± 61.0	356.7 ± 160.4	331.0 ± 151.5	6.4 ± 4.6	19.4 ± 8.6	25.7 ± 9.7
		CWD Chunk	439.8 ± 151.1	139.5 ± 31.9	139.5 ± 31.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	658.1 ± 164.5	706.7 ± 223.9	669.2 ± 214.3	6.6 ± 4.5	30.8 ± 10.1	37.4 ± 10.9
		CWD	556.0 ± 159.4	496.2 ± 173.8	470.5 ± 165.1	6.4 ± 4.6	19.4 ± 8.6	25.7 ± 9.7
		Total	896.7 ± 182.7	1482.6 ± 185.5	1403.3 ± 178.1	16.8 ± 4.5	62.5 ± 8.9	79.3 ± 8.6

[a] Total CWD = Dead windfall + CWD chunks.

Table 20. (cont.) Timber types: total density (no./ha) and volume (m³/ha) partitioned by structure (mean ± SE).

Age	Timber Type	Structure	Total Density no./ha	Total Volume m^3/ha	Bole m^3/ha	Stump m^3/ha	Top m^3/ha	Stump & Top m^3/ha
Mature	#36 H B 6 + 250 25	Live	429.3 ± 55.1	1070.2 ± 67.3	1012.5 ± 64.7	21.9 ± 4.3	35.8 ± 2.0	57.7 ± 5.0
	n = 29	Dead standing	110.4 ± 31.9	181.1 ± 34.3	167.6 ± 32.2	2.2 ± 1.1	11.3 ± 2.0	13.6 ± 2.4
		Dead windfall	47.5 ± 26.9	30.4 ± 13.5	26.4 ± 12.5	2.3 ± 2.3	1.7 ± 0.8	4.0 ± 2.5
		CWD Chunk	140.4 ± 32.1	105.3 ± 25.4	105.3 ± 25.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	298.3 ± 44.2	316.8 ± 50.3	299.3 ± 48.8	4.5 ± 2.5	13.0 ± 2.3	17.6 ± 3.2
		CWD	187.9 ± 37.1	135.7 ± 26.2	131.7 ± 26.1	2.3 ± 2.3	1.7 ± 0.8	4.0 ± 2.5
		Total	727.6 ± 72.5	1387.0 ± 82.5	1311.7 ± 80.0	26.5 ± 4.8	48.8 ± 2.7	75.2 ± 5.4
	#39 B H 6 + 250 25	Live	467.2 ± 230.7	973.0 ± 185.6	918.4 ± 163.7	24.7 ± 16.6	30.0 ± 5.6	54.7 ± 22.1
	n = 3	Dead standing	27.5 ± 10.3	193.9 ± 64.9	182.0 ± 63.5	0.0 ± 0.0	11.9 ± 3.4	11.9 ± 3.4
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	76.2 ± 41.9	72.7 ± 43.6	72.7 ± 43.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	103.6 ± 51.6	266.6 ± 105.1	254.8 ± 104.4	0.0 ± 0.0	11.9 ± 3.4	11.9 ± 3.4
		CWD	76.2 ± 41.9	72.7 ± 43.6	72.7 ± 43.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	570.8 ± 278.5	1239.7 ± 250.7	1173.1 ± 229.0	24.7 ± 16.6	41.8 ± 8.9	66.5 ± 25.4
	#48 Y H 4 - 250 20	Live	569.6 ± 232.8	877.1 ± 99.3	811.7 ± 108.9	25.7 ± 14.5	39.7 ± 2.5	65.4 ± 12.6
	n = 5	Dead standing	414.7 ± 225.6	199.9 ± 81.8	183.0 ± 75.6	0.0 ± 0.0	16.9 ± 6.9	16.9 ± 6.9
		Dead windfall	25.5 ± 25.5	40.5 ± 40.5	38.1 ± 38.1	0.9 ± 0.9	1.5 ± 1.5	2.4 ± 2.4
		CWD Chunk	249.6 ± 212.5	16.2 ± 10.6	16.2 ± 10.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	689.7 ± 273.1	256.6 ± 60.3	237.3 ± 54.6	0.9 ± 0.9	18.4 ± 6.5	19.3 ± 6.4
		CWD	275.0 ± 206.4	56.7 ± 37.8	54.3 ± 35.4	0.9 ± 0.9	1.5 ± 1.5	2.4 ± 2.4
		Total	1259.3 ± 431.8	1133.7 ± 119.4	1048.9 ± 123.5	26.6 ± 14.5	58.1 ± 6.1	84.8 ± 18.6
	#50 Y H 6 + 250 25	Live	427.1 ± 76.5	1284.7 ± 125.8	1222.5 ± 121.2	15.0 ± 2.9	47.2 ± 4.2	62.2 ± 6.1
	n = 17	Dead standing	57.8 ± 24.6	134.3 ± 41.4	123.1 ± 38.4	0.1 ± 0.1	11.1 ± 3.2	11.3 ± 3.2
		Dead windfall	42.2 ± 24.6	66.9 ± 34.8	62.4 ± 33.0	1.5 ± 1.0	3.0 ± 1.5	4.5 ± 2.3
		CWD Chunk	146.2 ± 40.0	90.9 ± 33.0	90.9 ± 33.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	246.2 ± 54.5	292.1 ± 68.4	276.3 ± 65.3	1.7 ± 1.0	14.1 ± 3.4	15.8 ± 3.9
		CWD	188.4 ± 47.9	157.7 ± 47.3	153.2 ± 45.8	1.5 ± 1.0	3.0 ± 1.5	4.5 ± 2.3
		Total	673.3 ± 102.5	1576.8 ± 148.8	1498.8 ± 142.5	16.7 ± 3.1	61.3 ± 5.4	78.0 ± 7.7
Immature	# 1 F H 6 + 55 35	Live	542.4 ± 72.9	694.0 ± 49.5	664.2 ± 47.3	8.1 ± 1.3	21.7 ± 2.0	29.8 ± 3.0
	n = 15	Dead standing	25.5 ± 9.2	27.7 ± 7.8	23.4 ± 7.1	0.0 ± 0.0	4.2 ± 1.2	4.3 ± 1.2
		Dead windfall	19.5 ± 12.3	15.0 ± 7.1	12.3 ± 5.9	0.0 ± 0.0	2.8 ± 1.3	2.8 ± 1.3
		CWD Chunk	373.8 ± 45.8	224.6 ± 31.6	224.6 ± 31.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	418.8 ± 50.4	267.3 ± 39.2	260.3 ± 38.1	0.0 ± 0.0	7.0 ± 1.6	7.0 ± 1.6
		CWD	393.3 ± 49.8	239.6 ± 34.6	236.8 ± 34.0	0.0 ± 0.0	2.8 ± 1.3	2.8 ± 1.3
		Total	961.3 ± 87.2	961.3 ± 58.7	924.5 ± 55.5	8.1 ± 1.3	28.7 ± 2.8	36.8 ± 3.8
	# 2 F H 6 + 65 30	Live	856.8 ± 129.0	823.4 ± 74.3	784.0 ± 71.4	14.5 ± 2.7	24.9 ± 2.1	39.4 ± 4.2
	n = 19	Dead standing	32.7 ± 28.1	11.6 ± 7.9	10.4 ± 7.3	0.5 ± 0.5	0.6 ± 0.3	1.2 ± 0.7
		Dead windfall	60.3 ± 39.2	17.9 ± 8.9	16.3 ± 8.1	0.5 ± 0.3	1.1 ± 0.5	1.6 ± 0.8
		CWD Chunk	458.7 ± 96.6	58.3 ± 15.0	58.3 ± 15.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	551.7 ± 85.3	87.7 ± 16.6	85.0 ± 16.1	1.0 ± 0.5	1.7 ± 0.6	2.8 ± 1.0
		CWD	519.0 ± 89.6	76.2 ± 16.0	74.5 ± 15.6	0.5 ± 0.3	1.1 ± 0.5	1.6 ± 0.8
		Total	1408.5 ± 152.5	911.1 ± 74.6	869.0 ± 71.8	15.6 ± 3.1	26.6 ± 2.1	42.2 ± 4.6
	# 3 F H 6 + 65 35	Live	615.8 ± 93.3	971.7 ± 105.8	936.5 ± 102.0	10.0 ± 1.7	25.2 ± 3.0	35.2 ± 4.2
	n = 10	Dead standing	115.4 ± 88.9	34.2 ± 15.6	29.1 ± 13.6	1.8 ± 1.8	3.3 ± 1.6	5.1 ± 2.5
		Dead windfall	10.1 ± 7.2	9.4 ± 6.3	8.5 ± 5.7	0.0 ± 0.0	0.9 ± 0.6	0.9 ± 0.6
		CWD Chunk	444.6 ± 220.4	134.5 ± 35.1	134.5 ± 35.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	570.1 ± 221.8	178.1 ± 47.5	172.1 ± 46.3	1.8 ± 1.8	4.2 ± 1.5	6.0 ± 2.4
		CWD	454.7 ± 220.5	143.9 ± 38.3	143.0 ± 37.9	0.0 ± 0.0	0.9 ± 0.6	0.9 ± 0.6
		Total	1185.8 ± 276.4	1149.9 ± 129.3	1108.7 ± 125.9	11.8 ± 1.9	29.4 ± 3.4	41.2 ± 4.2
	# 4 F M P 6 + 65 35	Live	1264.2 ± 776.0	831.7 ± 235.2	776.9 ± 206.0	28.0 ± 18.8	26.9 ± 10.4	54.9 ± 29.1
	n = 2	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	417.0 ± 63.7	332.2 ± 36.3	332.2 ± 36.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	417.0 ± 63.7	332.2 ± 36.3	332.2 ± 36.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	417.0 ± 63.7	332.2 ± 36.3	332.2 ± 36.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	1681.2 ± 712.3	1163.9 ± 271.5	1109.0 ± 242.3	28.0 ± 18.8	26.9 ± 10.4	54.9 ± 29.1
	# 5 F D 6 + 65 35	Live	685.3 ± 196.9	1039.1 ± 102.7	1001.7 ± 100.7	11.2 ± 3.7	26.3 ± 3.2	37.5 ± 6.0
	n = 6	Dead standing	27.0 ± 19.0	43.8 ± 26.9	40.7 ± 26.1	0.0 ± 0.0	3.1 ± 1.6	3.1 ± 1.6
		Dead windfall	158.7 ± 108.4	206.3 ± 169.6	198.7 ± 164.0	1.8 ± 1.8	5.8 ± 3.8	7.6 ± 5.6
		CWD Chunk	349.9 ± 262.5	128.7 ± 51.1	128.7 ± 51.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	535.6 ± 381.8	378.8 ± 203.2	368.0 ± 196.7	1.8 ± 1.8	8.9 ± 5.0	10.7 ± 6.8
		CWD	508.6 ± 363.5	335.0 ± 201.5	327.4 ± 196.2	1.8 ± 1.8	5.8 ± 3.8	7.6 ± 5.6
		Total	1220.9 ± 501.9	1417.9 ± 211.4	1369.7 ± 204.4	13.0 ± 4.7	35.2 ± 5.6	48.2 ± 9.9
	# 6 F 4 - 75 30	Live	430.9 ± 106.5	598.6 ± 130.5	574.6 ± 127.1	8.2 ± 2.9	15.7 ± 3.3	23.9 ± 4.6
	n = 5	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	142.4 ± 102.8	33.7 ± 26.5	31.0 ± 24.3	0.5 ± 0.5	2.3 ± 1.7	2.7 ± 2.2
		CWD Chunk	204.0 ± 57.7	60.7 ± 23.9	60.7 ± 23.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	346.4 ± 76.5	94.4 ± 19.5	91.7 ± 18.5	0.5 ± 0.5	2.3 ± 1.7	2.7 ± 2.2
		CWD	346.4 ± 76.5	94.4 ± 19.5	91.7 ± 18.5	0.5 ± 0.5	2.3 ± 1.7	2.7 ± 2.2
		Total	777.3 ± 158.4	693.0 ± 132.1	666.3 ± 128.2	8.7 ± 2.8	18.0 ± 4.3	26.7 ± 5.6

Table 20. (cont.) Timber types: total density (no./ha) and volume (m³/ha) partitioned by structure (mean ± SE).

Age	Timber Type	Structure	Total Density No./ha	Total Volume m^3/ha	Bole m^3/ha	Stump m^3/ha	Top m^3/ha	Stump & Top m^3/ha
Immature	# 7 F H 6 + 75 35	Live	788.1 ± 127.2	748.7 ± 58.1	710.8 ± 55.8	14.5 ± 2.7	23.3 ± 1.8	37.8 ± 3.8
	n = 36	Dead standing	274.1 ± 132.3	130.0 ± 27.1	115.3 ± 24.9	2.6 ± 1.2	12.2 ± 2.3	14.8 ± 2.7
		Dead windfall	322.9 ± 104.3	100.1 ± 20.4	86.5 ± 18.8	8.3 ± 4.0	5.4 ± 1.0	13.6 ± 4.4
		CWD Chunk	510.2 ± 94.3	172.6 ± 21.9	172.6 ± 21.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	1107.1 ± 185.9	402.7 ± 47.3	374.3 ± 44.3	10.8 ± 4.2	17.5 ± 2.6	28.4 ± 5.0
		CWD	833.1 ± 149.5	272.7 ± 33.4	259.1 ± 31.8	8.3 ± 4.0	5.4 ± 1.0	13.6 ± 4.4
		Total	1895.2 ± 200.9	1151.4 ± 82.5	1085.2 ± 79.1	25.4 ± 4.5	40.8 ± 3.5	66.2 ± 5.6
	# 8 H F 6 + 75 35	Live	633.9 ± 88.9	597.1 ± 129.4	564.9 ± 125.4	9.1 ± 1.0	23.0 ± 5.0	32.1 ± 5.4
	n = 4	Dead standing	188.6 ± 100.4	166.7 ± 58.1	149.3 ± 51.2	0.0 ± 0.0	17.4 ± 9.0	17.4 ± 9.0
		Dead windfall	5.5 ± 5.5	47.4 ± 47.4	46.3 ± 46.3	0.0 ± 0.0	1.1 ± 1.1	1.2 ± 1.2
		CWD Chunk	419.7 ± 220.4	152.1 ± 118.3	152.1 ± 118.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	613.8 ± 266.4	366.2 ± 133.9	347.7 ± 130.3	0.1 ± 0.0	18.5 ± 8.3	18.6 ± 8.3
		CWD	425.2 ± 219.2	199.6 ± 113.6	198.4 ± 113.5	0.0 ± 0.0	1.1 ± 1.1	1.2 ± 1.2
		Total	1247.7 ± 270.0	963.3 ± 205.5	912.6 ± 196.3	9.2 ± 1.0	41.5 ± 10.8	50.7 ± 11.4
	# 9 H F 6 + 75 30	Live	1079.4 ± 360.2	953.2 ± 156.2	904.6 ± 146.5	18.9 ± 6.3	29.8 ± 5.3	48.7 ± 11.3
		Dead standing	311.8 ± 132.0	132.6 ± 36.6	118.1 ± 33.8	0.2 ± 0.2	14.3 ± 3.5	14.5 ± 3.6
		Dead windfall	385.4 ± 175.6	96.8 ± 51.1	83.1 ± 48.2	8.8 ± 4.6	4.9 ± 2.5	13.7 ± 5.5
		CWD Chunk	766.5 ± 223.1	174.3 ± 38.5	174.3 ± 38.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	1463.8 ± 306.9	403.6 ± 82.1	375.4 ± 78.9	9.0 ± 4.6	19.2 ± 5.2	28.2 ± 6.8
		CWD	1152.0 ± 286.7	271.1 ± 50.7	257.4 ± 50.4	8.8 ± 4.6	4.9 ± 2.5	13.7 ± 5.5
		Total	2543.2 ± 477.1	1356.9 ± 185.6	1280.0 ± 175.7	27.8 ± 6.4	49.0 ± 6.6	76.8 ± 11.2
	#12 F H 6 + 85 25	Live	623.5 ± 17.4	769.2 ± 83.6	731.3 ± 74.1	9.0 ± 0.4	28.9 ± 9.9	37.9 ± 9.5
	n = 2	Dead standing	721.5 ± 693.3	68.8 ± 0.9	40.4 ± 24.8	24.1 ± 24.1	4.4 ± 0.2	28.5 ± 23.9
		Dead windfall	352.5 ± 352.5	47.9 ± 47.9	38.1 ± 38.1	7.4 ± 7.4	2.5 ± 2.5	9.9 ± 9.9
		CWD Chunk	551.9 ± 175.7	189.7 ± 15.3	189.7 ± 15.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	1625.8 ± 165.1	306.5 ± 64.1	268.1 ± 78.1	31.5 ± 16.6	6.9 ± 2.6	38.3 ± 14.0
		CWD	904.3 ± 528.2	237.6 ± 63.2	227.7 ± 53.3	7.4 ± 7.4	2.5 ± 2.5	9.9 ± 9.9
		Total	2249.3 ± 147.7	1075.6 ± 147.7	999.4 ± 152.2	40.4 ± 17.0	35.8 ± 12.6	76.2 ± 4.5
	#13 F H 6 + 85 35	Live	336.7 ± 136.6	902.0 ± 268.3	875.9 ± 260.0	4.8 ± 2.1	21.3 ± 6.3	26.1 ± 8.3
	n = 4	Dead standing	122.5 ± 103.6	65.6 ± 31.9	57.3 ± 29.1	2.5 ± 2.5	5.8 ± 2.2	8.3 ± 3.0
		Dead windfall	79.4 ± 49.3	76.6 ± 44.1	72.0 ± 42.3	0.0 ± 0.0	4.6 ± 1.9	4.6 ± 1.9
		CWD Chunk	785.4 ± 481.6	124.5 ± 53.6	124.5 ± 53.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	987.2 ± 418.4	266.7 ± 66.1	253.8 ± 64.2	2.5 ± 2.5	10.4 ± 3.5	12.9 ± 4.9
		CWD	864.7 ± 465.7	201.1 ± 50.8	196.5 ± 50.7	0.0 ± 0.0	4.6 ± 1.9	4.6 ± 1.9
		Total	1323.9 ± 368.6	1168.7 ± 285.8	1129.7 ± 276.8	7.3 ± 3.4	31.7 ± 7.3	39.0 ± 10.3
	#14 H F 6 + 85 30	Live	653.8 ± 88.1	919.8 ± 63.8	883.1 ± 63.0	12.0 ± 2.1	24.7 ± 1.4	36.6 ± 2.6
	n = 23	Dead standing	175.2 ± 55.3	81.9 ± 26.5	73.3 ± 24.6	2.6 ± 1.2	6.0 ± 1.3	8.6 ± 2.2
		Dead windfall	174.3 ± 108.2	54.4 ± 16.3	47.1 ± 14.0	4.2 ± 4.2	3.1 ± 0.8	7.3 ± 4.6
		CWD Chunk	427.9 ± 79.3	220.3 ± 30.8	220.3 ± 30.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	777.4 ± 170.5	356.7 ± 46.9	340.8 ± 44.2	6.8 ± 4.3	9.1 ± 1.3	15.9 ± 4.7
		CWD	602.2 ± 162.5	274.8 ± 38.7	267.4 ± 36.2	4.2 ± 4.2	3.1 ± 0.8	7.3 ± 4.6
		Total	1431.2 ± 186.3	1276.4 ± 92.3	1223.9 ± 88.4	18.8 ± 4.9	33.8 ± 2.1	52.5 ± 6.0
	#16 H D 6 + 85 35	Live	755.5 ± 283.5	1213.2 ± 296.2	1167.6 ± 283.8	12.8 ± 4.7	32.7 ± 9.4	45.5 ± 13.4
	n = 5	Dead standing	171.8 ± 88.7	162.1 ± 68.0	154.7 ± 65.0	2.2 ± 1.9	5.1 ± 2.3	7.3 ± 3.3
		Dead windfall	109.4 ± 109.4	87.5 ± 87.5	82.6 ± 82.6	0.0 ± 0.0	4.8 ± 4.8	4.8 ± 4.8
		CWD Chunk	135.7 ± 73.1	68.3 ± 29.6	68.3 ± 29.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	416.9 ± 158.7	317.8 ± 93.0	305.7 ± 89.8	2.2 ± 1.9	10.0 ± 4.0	12.2 ± 4.1
		CWD	245.1 ± 173.2	155.8 ± 96.9	150.9 ± 92.3	0.0 ± 0.0	4.8 ± 4.8	4.8 ± 4.8
		Total	1172.4 ± 178.0	1531.0 ± 212.3	1473.3 ± 202.2	15.0 ± 4.4	42.7 ± 7.4	57.7 ± 10.6
	#17 F H 6 + 95 25	Live	518.9 ± 144.3	813.8 ± 294.0	782.9 ± 290.4	7.6 ± 3.0	23.2 ± 6.2	30.8 ± 3.6
	n = 3	Dead standing	38.6 ± 9.2	70.7 ± 19.2	64.4 ± 21.8	0.0 ± 0.0	6.3 ± 3.1	6.3 ± 3.1
		Dead windfall	44.8 ± 14.8	294.9 ± 77.4	282.4 ± 76.3	0.0 ± 0.0	12.5 ± 3.1	12.5 ± 3.1
		CWD Chunk	259.4 ± 121.9	288.8 ± 72.2	288.8 ± 72.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	342.8 ± 131.8	654.3 ± 136.4	635.6 ± 132.4	0.0 ± 0.0	18.8 ± 5.4	18.8 ± 5.4
		CWD	304.2 ± 126.7	583.6 ± 149.6	571.2 ± 148.4	0.0 ± 0.0	12.5 ± 3.1	12.5 ± 3.1
		Total	861.7 ± 263.9	1468.1 ± 174.9	1418.5 ± 172.4	7.6 ± 3.0	42.0 ± 7.3	49.6 ± 4.7
	#18 H 6 + 95 30	Live	520.3 ± 119.2	1093.8 ± 176.8	1056.5 ± 172.1	8.7 ± 2.3	28.6 ± 4.2	37.3 ± 5.6
	n = 12	Dead standing	121.2 ± 36.7	116.2 ± 22.4	99.8 ± 19.7	0.3 ± 0.3	16.0 ± 2.8	16.4 ± 3.0
		Dead windfall	112.4 ± 95.0	83.5 ± 35.1	80.5 ± 34.0	0.1 ± 0.1	2.9 ± 1.2	3.0 ± 1.2
		CWD Chunk	531.8 ± 143.7	214.3 ± 50.6	214.3 ± 50.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	765.3 ± 170.0	414.0 ± 38.9	394.6 ± 38.0	0.4 ± 0.3	19.0 ± 3.5	19.4 ± 3.6
		CWD	644.1 ± 146.5	297.8 ± 35.8	294.8 ± 36.0	0.1 ± 0.1	2.9 ± 1.2	3.0 ± 1.2
		Total	1285.7 ± 224.4	1507.8 ± 186.0	1451.1 ± 180.2	9.1 ± 2.3	47.6 ± 6.2	56.7 ± 7.9
	#19 D H 6 + 75 30	Live	963.3 ± 461.8	705.3 ± 253.2	666.9 ± 238.6	18.2 ± 10.3	20.2 ± 6.1	38.4 ± 15.8
	n = 5	Dead standing	139.8 ± 108.1	52.1 ± 39.7	44.2 ± 33.1	0.0 ± 0.0	8.0 ± 6.7	8.0 ± 6.7
		Dead windfall	7.1 ± 7.1	22.7 ± 22.7	20.4 ± 20.4	0.0 ± 0.0	2.3 ± 2.3	2.3 ± 2.3
		CWD Chunk	449.2 ± 202.1	256.7 ± 114.7	256.7 ± 114.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	596.0 ± 285.5	331.5 ± 144.1	321.2 ± 138.6	0.0 ± 0.0	10.3 ± 8.9	10.3 ± 8.9
		CWD	456.2 ± 201.1	279.4 ± 122.5	277.1 ± 121.5	0.0 ± 0.0	2.3 ± 2.3	2.3 ± 2.3
		Total	1559.4 ± 538.0	1036.8 ± 334.8	988.1 ± 311.3	18.2 ± 10.3	30.5 ± 14.5	48.7 ± 24.5

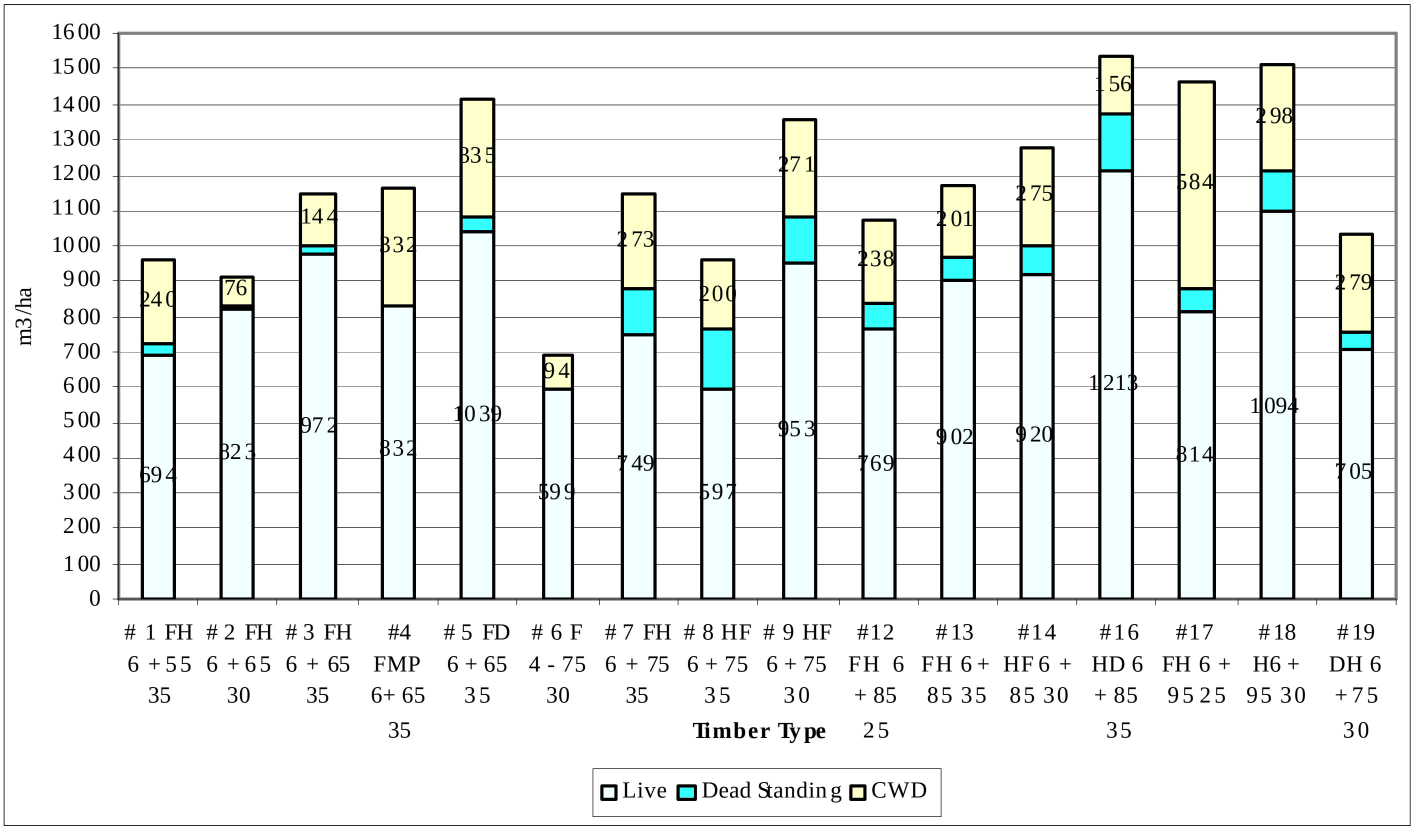

Figure 6. Immature timber types: mean total volume (m^3/ha) partitioned by structure.

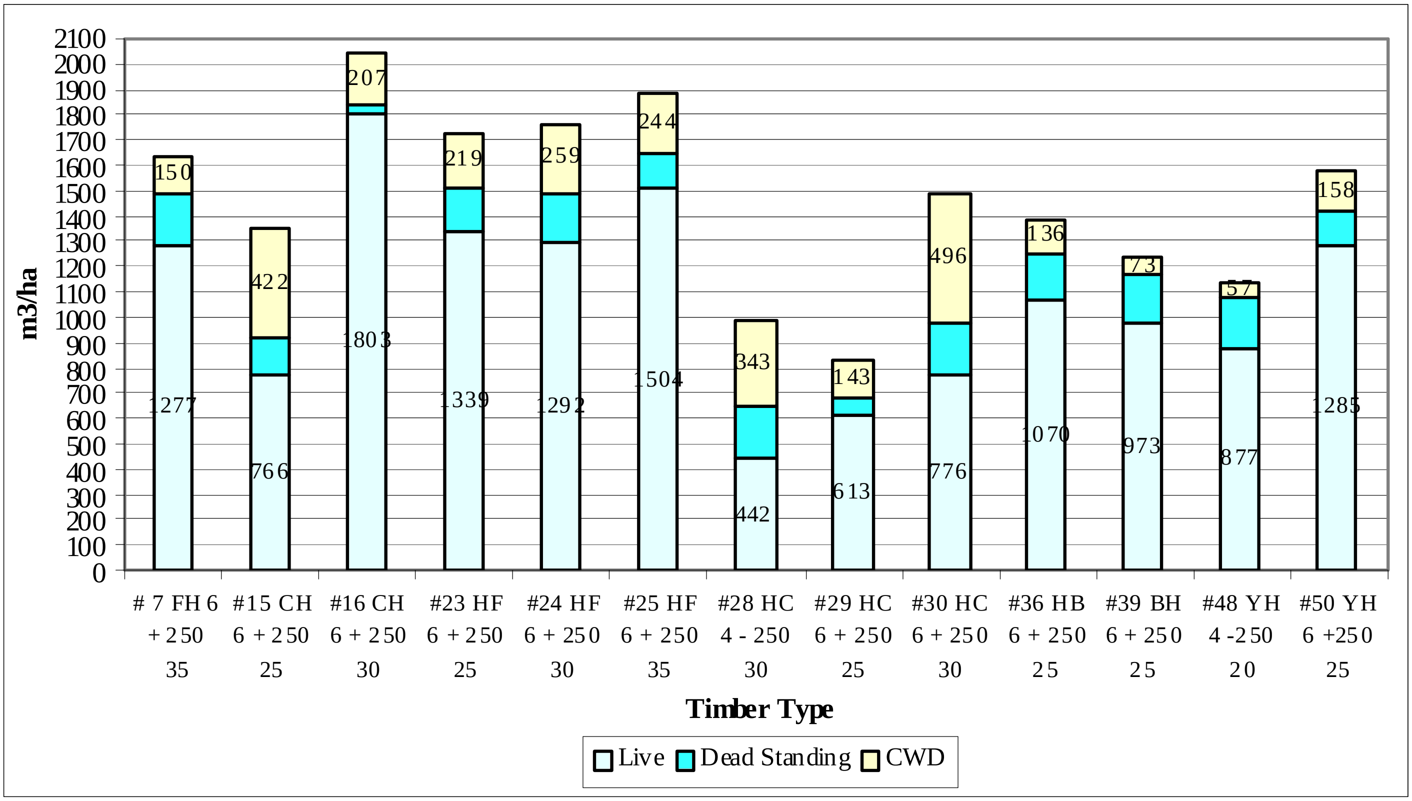

Figure 7. Mature timber types: mean total volume (m^3/ha) partitioned by structure.

Table 21. Timber types: total bole wood volume (m^3/ha) by grades and structure (mean ± SE).

Age	Timber Type	Structure	U Grade m^3/ha	X Grade m^3/ha	Y Grade m^3/ha	Z Grade m^3/ha	Y, Z Grades m^3/ha	Better-than-UX m^3/ha
Mature	# 7 F H 6 + 250 35	Live	136.3 ± 33.0	79.2 ± 23.9	33.6 ± 17.3	6.3 ± 2.6	39.9 ± 16.3	974.6 ± 155.2
	n = 9 (plots)	Dead standing	33.2 ± 33.2	10.1 ± 10.1	55.6 ± 37.0	98.4 ± 37.5	154.1 ± 45.9	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	9.3 ± 9.3	51.2 ± 41.6	60.6 ± 41.2	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	85.7 ± 42.5	85.7 ± 42.5	0.0 ± 0.0
		Total dead	33.2 ± 33.2	10.1 ± 10.1	65.0 ± 36.4	235.4 ± 83.7	300.4 ± 108.5	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	9.3 ± 9.3	137.0 ± 76.2	146.3 ± 74.7	0.0 ± 0.0
		Total	169.6 ± 38.8	89.3 ± 21.8	98.6 ± 35.7	241.7 ± 84.0	340.3 ± 102.5	974.6 ± 155.2
	#15 C H 6 + 250 25	Live	46.3 ± 12.9	12.8 ± 9.0	22.8 ± 13.4	15.1 ± 4.2	38.0 ± 15.4	618.1 ± 69.5
	n = 18	Dead standing	3.2 ± 2.2	1.4 ± 1.4	0.0 ± 0.0	52.8 ± 14.7	52.8 ± 14.7	85.5 ± 34.6
		Dead windfall	21.6 ± 13.3	9.1 ± 5.1	23.0 ± 13.3	104.8 ± 26.5	127.8 ± 33.0	132.3 ± 40.7
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	6.0 ± 6.0	102.1 ± 40.1	108.2 ± 40.2	0.0 ± 0.0
		Total dead	24.7 ± 13.2	10.5 ± 5.2	29.0 ± 14.1	259.8 ± 51.1	288.8 ± 59.5	217.7 ± 44.4
		CWD	21.6 ± 13.3	9.1 ± 5.1	29.0 ± 14.1	207.0 ± 48.1	236.0 ± 55.4	132.3 ± 40.7
		Total	71.0 ± 16.6	23.3 ± 9.7	51.8 ± 23.5	274.9 ± 51.1	326.8 ± 62.2	835.8 ± 82.1
	#16 C H 6 + 250 30	Live	44.6 ± .	0.0 ± .	435.5 ± .	355.7 ± .	791.2 ± .	885.3 ± .
	n = 1	Dead standing	0.0 ± .	0.0 ± .	0.0 ± .	28.6 ± .	28.6 ± .	0.0 ± .
		Dead windfall	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		CWD Chunk	0.0 ± .	0.0 ± .	142.6 ± .	64.1 ± .	206.7 ± .	0.0 ± .
		Total dead	0.0 ± .	0.0 ± .	142.6 ± .	92.7 ± .	235.3 ± .	0.0 ± .
		CWD	0.0 ± .	0.0 ± .	142.6 ± .	64.1 ± .	206.7 ± .	0.0 ± .
		Total	44.6 ± .	0.0 ± .	578.1 ± .	448.4 ± .	1026.5 ± .	885.3 ± .
	#23 H F 6 + 250 25	Live	148.1 ± 21.1	44.2 ± 13.3	18.1 ± 9.1	3.4 ± 1.1	21.5 ± 9.1	1076.4 ± 133.0
	n = 14	Dead standing	21.3 ± 21.3	0.0 ± 0.0	19.6 ± 14.7	107.1 ± 37.9	126.7 ± 37.7	12.1 ± 12.1
		Dead windfall	0.0 ± 0.0	8.3 ± 8.3	0.0 ± 0.0	37.4 ± 19.8	37.4 ± 19.8	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	5.7 ± 5.7	156.2 ± 42.2	161.8 ± 41.6	0.0 ± 0.0
		Total dead	21.3 ± 21.3	8.3 ± 8.3	25.3 ± 15.2	300.6 ± 59.4	325.9 ± 55.0	12.1 ± 12.1
		CWD	0.0 ± 0.0	8.3 ± 8.3	5.7 ± 5.7	193.5 ± 40.9	199.2 ± 40.2	0.0 ± 0.0
		Total	169.3 ± 26.6	52.6 ± 14.9	43.4 ± 15.6	304.0 ± 59.4	347.4 ± 53.3	1088.4 ± 131.4
	#24 H F 6 + 250 30	Live	176.3 ± 46.9	18.2 ± 14.3	40.7 ± 19.3	3.7 ± 1.4	44.4 ± 19.0	1000.0 ± 129.9
	n = 5	Dead standing	69.5 ± 47.5	0.0 ± 0.0	0.0 ± 0.0	47.2 ± 30.2	47.2 ± 30.2	71.0 ± 48.8
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	75.6 ± 75.6	75.6 ± 75.6	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	78.2 ± 46.6	101.3 ± 67.0	179.5 ± 54.4	0.0 ± 0.0
		Total dead	69.5 ± 47.5	0.0 ± 0.0	78.2 ± 46.6	224.0 ± 106.4	302.2 ± 97.7	71.0 ± 48.8
		CWD	0.0 ± 0.0	0.0 ± 0.0	78.2 ± 46.6	176.9 ± 86.7	255.1 ± 79.6	0.0 ± 0.0
		Total	245.8 ± 57.0	18.2 ± 14.3	118.9 ± 41.3	227.7 ± 106.6	346.6 ± 108.5	1071.1 ± 91.0
	#25 H F 6 + 250 35	Live	123.0 ± 17.3	52.9 ± 17.3	35.4 ± 17.6	21.5 ± 5.0	56.8 ± 18.2	1220.9 ± 114.9
	n = 16	Dead standing	2.2 ± 1.6	0.0 ± 0.0	28.5 ± 20.2	72.2 ± 24.3	100.7 ± 32.3	24.4 ± 16.7
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	89.7 ± 34.3	89.7 ± 34.3	0.0 ± 0.0
		CWD Chunk	10.0 ± 10.0	0.0 ± 0.0	49.5 ± 36.8	85.6 ± 23.8	135.0 ± 38.0	0.0 ± 0.0
		Total dead	12.2 ± 10.0	0.0 ± 0.0	77.9 ± 45.4	247.4 ± 57.2	325.4 ± 57.2	24.4 ± 16.7
		CWD	10.0 ± 10.0	0.0 ± 0.0	49.5 ± 36.8	175.2 ± 40.5	224.7 ± 44.6	0.0 ± 0.0
		Total	135.3 ± 16.1	52.9 ± 17.3	113.3 ± 48.0	268.9 ± 58.7	382.2 ± 60.2	1245.3 ± 113.0
	#28 H C 4 - 250 30	Live	35.9 ± 15.4	2.8 ± 2.8	0.0 ± 0.0	0.8 ± 0.8	0.8 ± 0.8	383.1 ± 0.2
	n = 2	Dead standing	121.7 ± 121.7	0.0 ± 0.0	60.2 ± 60.2	16.9 ± 16.9	77.1 ± 77.1	0.0 ± 0.0
		Dead windfall	18.3 ± 18.3	0.0 ± 0.0	0.0 ± 0.0	0.8 ± 0.8	0.8 ± 0.8	73.1 ± 73.1
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	245.4 ± 14.5	245.4 ± 14.5	0.0 ± 0.0
		Total dead	140.0 ± 140.0	0.0 ± 0.0	60.2 ± 60.2	263.1 ± 32.2	323.3 ± 92.4	73.1 ± 73.1
		CWD	18.3 ± 18.3	0.0 ± 0.0	0.0 ± 0.0	246.2 ± 15.3	246.2 ± 15.3	73.1 ± 73.1
		Total	175.9 ± 155.4	2.8 ± 2.8	60.2 ± 60.2	263.8 ± 32.9	324.1 ± 93.2	456.2 ± 73.4
	#29 H C 6 + 250 25	Live	41.7 ± 28.1	2.7 ± 2.7	33.0 ± 33.0	0.4 ± 0.3	33.4 ± 33.0	484.9 ± 109.4
	n = 3	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	68.4 ± 68.4	68.4 ± 68.4	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	53.3 ± 26.2	53.3 ± 26.2	80.7 ± 41.1
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	121.7 ± 70.3	121.7 ± 70.3	80.7 ± 41.1
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	53.3 ± 26.2	53.3 ± 26.2	80.7 ± 41.1
		Total	41.7 ± 28.1	2.7 ± 2.7	33.0 ± 33.0	122.1 ± 70.0	155.2 ± 73.0	565.5 ± 68.7
	#30 H C 6 + 250 30	Live	25.3 ± 13.4	18.3 ± 13.4	0.0 ± 0.0	3.0 ± 1.6	3.0 ± 1.6	687.5 ± 100.4
	n = 11	Dead standing	0.0 ± 0.0	1.0 ± 1.0	157.6 ± 74.6	21.7 ± 9.1	179.3 ± 77.4	18.4 ± 18.4
		Dead windfall	20.2 ± 14.5	22.2 ± 10.1	7.2 ± 7.2	95.8 ± 32.1	103.0 ± 36.7	185.6 ± 113.1
		CWD Chunk	0.0 ± 0.0	17.3 ± 11.8	29.9 ± 17.2	92.3 ± 32.3	122.2 ± 31.0	0.0 ± 0.0
		Total dead	20.2 ± 14.5	40.6 ± 15.2	194.7 ± 79.4	209.8 ± 42.8	404.5 ± 109.8	204.0 ± 111.5
		CWD	20.2 ± 14.5	39.5 ± 14.6	37.1 ± 17.4	188.1 ± 43.4	225.2 ± 52.3	185.6 ± 113.1
		Total	45.5 ± 17.0	58.8 ± 17.2	194.7 ± 79.4	212.9 ± 42.1	407.5 ± 109.3	891.5 ± 112.1

Table 21. (cont.) Timber types: total bole wood volume (m^3/ha) by grades and structure (mean ± SE).

Age	Timber Type	Structure	U Grade m^3/ha	X Grade m^3/ha	Y Grade m^3/ha	Z Grade m^3/ha	Y, Z Grades m^3/ha	Better-than-UX m^3/ha
Mature	#36 H B 6 + 250 25	Live	123.9 ± 19.3	50.5 ± 16.5	91.3 ± 18.5	50.8 ± 20.0	142.1 ± 28.4	696.0 ± 69.1
	n = 29	Dead standing	4.0 ± 3.6	1.9 ± 1.9	40.4 ± 17.5	108.5 ± 18.8	148.9 ± 25.4	12.8 ± 12.8
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	6.4 ± 6.4	20.0 ± 11.2	26.4 ± 12.5	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	14.2 ± 12.4	91.1 ± 20.0	105.3 ± 25.4	0.0 ± 0.0
		Total dead	4.0 ± 3.6	1.9 ± 1.9	61.0 ± 26.6	219.6 ± 30.1	280.6 ± 43.8	12.8 ± 12.8
		CWD	0.0 ± 0.0	0.0 ± 0.0	20.6 ± 13.8	111.1 ± 21.7	131.7 ± 26.1	0.0 ± 0.0
		Total	127.9 ± 19.0	52.3 ± 16.4	152.3 ± 27.8	270.5 ± 32.9	422.7 ± 45.7	708.8 ± 71.6
	#39 B H 6 + 250 25	Live	112.2 ± 68.0	43.3 ± 22.2	150.5 ± 62.3	42.9 ± 40.9	193.4 ± 52.1	569.5 ± 86.8
	n = 3	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	95.9 ± 69.8	95.9 ± 69.8	86.1 ± 86.1
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	22.5 ± 22.5	50.2 ± 50.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	22.5 ± 22.5	50.2 ± 50.2	0.0 ± 0.0	95.9 ± 69.8	95.9 ± 69.8	86.1 ± 86.1
		CWD	22.5 ± 22.5	50.2 ± 50.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	134.7 ± 88.8	93.5 ± 67.2	150.5 ± 62.3	138.8 ± 109.8	289.3 ± 80.9	655.6 ± 81.3
	#48 Y H 4 - 250 20	Live	142.8 ± 64.8	28.2 ± 12.9	429.9 ± 100.4	67.3 ± 42.9	497.2 ± 105.4	143.5 ± 68.8
	n = 5	Dead standing	0.0 ± 0.0	0.0 ± 0.0	56.8 ± 42.3	126.2 ± 46.6	183.0 ± 75.6	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	38.1 ± 38.1	0.0 ± 0.0	38.1 ± 38.1	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	16.2 ± 10.6	16.2 ± 10.6	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	94.8 ± 46.5	142.4 ± 43.2	237.3 ± 54.6	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	38.1 ± 38.1	16.2 ± 10.6	54.3 ± 35.4	0.0 ± 0.0
		Total	142.8 ± 64.8	28.2 ± 12.9	524.7 ± 132.5	209.7 ± 39.4	734.5 ± 119.0	143.5 ± 68.8
	#50 Y H 6 + 250 25	Live	174.8 ± 40.5	205.7 ± 42.0	258.9 ± 43.7	49.5 ± 18.4	308.4 ± 45.6	533.6 ± 65.3
	n = 17	Dead standing	0.0 ± 0.0	0.7 ± 0.7	16.3 ± 11.6	96.0 ± 27.6	112.3 ± 35.5	10.0 ± 10.0
		Dead windfall	0.0 ± 0.0	9.4 ± 9.4	8.9 ± 8.9	44.0 ± 23.9	52.9 ± 25.5	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	15.1 ± 10.3	75.8 ± 31.7	90.9 ± 33.0	0.0 ± 0.0
		Total dead	0.0 ± 0.0	10.2 ± 9.4	40.3 ± 19.8	215.8 ± 50.9	256.1 ± 60.0	10.0 ± 10.0
		CWD	0.0 ± 0.0	9.4 ± 9.4	24.0 ± 17.5	119.8 ± 35.4	143.8 ± 42.0	0.0 ± 0.0
		Total	174.8 ± 40.5	215.9 ± 43.2	299.2 ± 43.4	265.3 ± 49.9	564.5 ± 55.6	543.6 ± 65.9
Immature	# 1 F H 6 + 55 35	Live	0.0 ± 0.0	8.3 ± 6.4	1.0 ± 1.0	9.5 ± 6.6	10.5 ± 6.6	645.4 ± 49.9
	n = 15	Dead standing	0.0 ± 0.0	5.1 ± 5.1	3.7 ± 3.7	14.6 ± 4.2	18.4 ± 5.4	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	12.3 ± 5.9	12.3 ± 5.9	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	9.2 ± 6.9	215.4 ± 32.9	224.6 ± 31.6	0.0 ± 0.0
		Total dead	0.0 ± 0.0	5.1 ± 5.1	12.9 ± 7.5	242.3 ± 36.6	255.2 ± 37.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	9.2 ± 6.9	227.7 ± 35.5	236.8 ± 34.0	0.0 ± 0.0
		Total	0.0 ± 0.0	13.4 ± 7.8	13.9 ± 7.5	251.8 ± 34.5	265.7 ± 34.7	645.4 ± 49.9
	# 2 F H 6 + 65 30	Live	3.4 ± 3.0	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.3	0.3 ± 0.3	780.3 ± 72.1
	n = 19	Dead standing	0.0 ± 0.0	0.0 ± 0.0	3.9 ± 3.9	3.5 ± 3.0	7.3 ± 6.8	3.1 ± 3.1
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	16.3 ± 8.1	16.3 ± 8.1	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	3.3 ± 3.3	55.0 ± 14.8	58.3 ± 15.0	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	7.2 ± 4.9	74.7 ± 15.9	81.9 ± 16.7	3.1 ± 3.1
		CWD	0.0 ± 0.0	0.0 ± 0.0	3.3 ± 3.3	71.3 ± 15.6	74.5 ± 15.6	0.0 ± 0.0
		Total	3.4 ± 3.0	0.0 ± 0.0	7.2 ± 4.9	75.0 ± 15.9	82.2 ± 16.7	783.4 ± 72.8
	# 3 F H 6 + 65 35	Live	4.4 ± 4.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	932.1 ± 99.6
	n = 10	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	29.1 ± 13.6	29.1 ± 13.6	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	8.5 ± 5.7	8.5 ± 5.7	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	16.5 ± 16.5	0.0 ± 0.0	118.0 ± 37.3	118.0 ± 37.3	0.0 ± 0.0
		Total dead	0.0 ± 0.0	16.5 ± 16.5	0.0 ± 0.0	155.6 ± 46.9	155.6 ± 46.9	0.0 ± 0.0
		CWD	0.0 ± 0.0	16.5 ± 16.5	0.0 ± 0.0	126.5 ± 40.4	126.5 ± 40.4	0.0 ± 0.0
		Total	4.4 ± 4.4	16.5 ± 16.5	0.0 ± 0.0	155.6 ± 46.9	155.6 ± 46.9	932.1 ± 99.6
	# 4 F M P 6 + 65 35	Live	0.0 ± 0.0	109.7 ± 109.7	50.3 ± 50.3	5.2 ± 5.2	55.5 ± 55.5	611.7 ± 260.3
	n = 2	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	45.8 ± 45.8	286.4 ± 9.5	332.2 ± 36.3	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	45.8 ± 45.8	286.4 ± 9.5	332.2 ± 36.3	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	45.8 ± 45.8	286.4 ± 9.5	332.2 ± 36.3	0.0 ± 0.0
		Total	0.0 ± 0.0	109.7 ± 109.7	96.1 ± 96.1	291.6 ± 4.2	387.7 ± 91.8	611.7 ± 260.3
	# 5 F D 6 + 65 35	Live	14.9 ± 6.7	25.4 ± 18.4	0.0 ± 0.0	13.3 ± 8.4	13.3 ± 8.4	948.2 ± 86.6
	n = 6	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	40.7 ± 26.1	40.7 ± 26.1	0.0 ± 0.0
		Dead windfall	30.4 ± 30.4	35.6 ± 35.6	18.2 ± 18.2	57.1 ± 30.3	75.3 ± 44.9	57.3 ± 57.3
		CWD Chunk	0.0 ± 0.0	15.7 ± 15.7	0.0 ± 0.0	113.0 ± 43.6	113.0 ± 43.6	0.0 ± 0.0
		Total dead	30.4 ± 30.4	51.3 ± 51.3	18.2 ± 18.2	210.7 ± 48.3	228.9 ± 63.3	57.3 ± 57.3
		CWD	30.4 ± 30.4	51.3 ± 51.3	18.2 ± 18.2	170.0 ± 49.8	188.3 ± 64.2	57.3 ± 57.3
		Total	45.3 ± 28.1	76.7 ± 49.5	18.2 ± 18.2	224.0 ± 47.9	242.2 ± 62.2	1005.5 ± 97.2
	# 6 F 4 - 75 30	Live	3.5 ± 3.5	0.0 ± 0.0	0.0 ± 0.0	0.9 ± 0.9	0.9 ± 0.9	570.2 ± 125.2
	n = 5	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	31.0 ± 24.3	31.0 ± 24.3	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	60.7 ± 23.9	60.7 ± 23.9	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	91.7 ± 18.5	91.7 ± 18.5	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	91.7 ± 18.5	91.7 ± 18.5	0.0 ± 0.0
		Total	3.5 ± 3.5	0.0 ± 0.0	0.0 ± 0.0	92.6 ± 18.8	92.6 ± 18.8	570.2 ± 125.2

Table 21. (cont.) Timber types: total bole wood volume (m^3/ha) by grades and structure (mean ± SE).

Age	Timber Type	Structure	U Grade m^3/ha	X Grade m^3/ha	Y Grade m^3/ha	Z Grade m^3/ha	Y, Z Grades m^3/ha	Better-than-UX m^3/ha
Immature	# 7 F H 6 + 75 35	Live	120.7 ± 26.3	0.0 ± 0.0	38.9 ± 15.7	15.8 ± 6.4	54.7 ± 19.4	533.7 ± 55.9
	n = 36	Dead standing	11.5 ± 5.8	0.0 ± 0.0	37.3 ± 12.9	49.8 ± 11.0	87.1 ± 17.1	16.6 ± 9.9
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	43.9 ± 10.2	38.3 ± 14.6	82.2 ± 17.0	4.2 ± 4.2
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	59.8 ± 15.2	112.8 ± 18.4	172.6 ± 21.9	0.0 ± 0.0
		Total dead	11.5 ± 5.8	0.0 ± 0.0	141.0 ± 20.8	200.9 ± 33.0	341.9 ± 38.4	20.9 ± 10.6
		CWD	0.0 ± 0.0	0.0 ± 0.0	103.7 ± 17.8	151.1 ± 27.0	254.8 ± 30.4	4.2 ± 4.2
		Total	132.2 ± 26.0	0.0 ± 0.0	179.8 ± 28.4	216.8 ± 33.5	396.6 ± 43.6	554.6 ± 56.9
	# 8 H F 6 + 75 35	Live	82.8 ± 48.0	11.7 ± 11.7	155.6 ± 67.0	0.4 ± 0.4	156.0 ± 67.3	314.4 ± 44.7
	n = 4	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	149.3 ± 51.2	149.3 ± 51.2	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	46.3 ± 46.3	0.0 ± 0.0	46.3 ± 46.3	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	152.1 ± 118.3	152.1 ± 118.3	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	46.3 ± 46.3	301.4 ± 150.6	347.7 ± 130.3	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	46.3 ± 46.3	152.1 ± 118.3	198.4 ± 113.5	0.0 ± 0.0
		Total	82.8 ± 48.0	11.7 ± 11.7	201.9 ± 71.2	301.8 ± 150.6	503.7 ± 166.3	314.4 ± 44.7
	# 9 H F 6 + 75 30	Live	211.8 ± 84.7	0.0 ± 0.0	15.6 ± 15.6	9.0 ± 8.2	24.6 ± 16.9	668.2 ± 91.7
		Dead standing	24.8 ± 24.2	0.0 ± 0.0	8.4 ± 8.4	58.2 ± 18.3	66.6 ± 20.6	26.6 ± 26.6
		Dead windfall	4.1 ± 4.1	0.0 ± 0.0	30.5 ± 20.4	34.6 ± 18.2	65.1 ± 32.2	13.8 ± 13.8
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	10.5 ± 10.5	163.8 ± 34.0	174.3 ± 38.5	0.0 ± 0.0
		Total dead	29.0 ± 24.2	0.0 ± 0.0	49.4 ± 21.2	256.6 ± 48.3	306.1 ± 53.8	40.4 ± 40.4
		CWD	4.1 ± 4.1	0.0 ± 0.0	41.0 ± 21.4	198.4 ± 36.9	239.5 ± 41.4	13.8 ± 13.8
		Total	240.7 ± 103.4	0.0 ± 0.0	65.1 ± 22.9	265.6 ± 47.4	330.7 ± 47.3	708.6 ± 83.1
	#12 F H 6 + 85 25	Live	54.5 ± 54.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	676.8 ± 19.6
	n = 2	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	40.4 ± 24.8	40.4 ± 24.8	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	38.1 ± 38.1	38.1 ± 38.1	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	189.7 ± 15.3	189.7 ± 15.3	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	268.1 ± 78.1	268.1 ± 78.1	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	227.7 ± 53.3	227.7 ± 53.3	0.0 ± 0.0
		Total	54.5 ± 54.5	0.0 ± 0.0	0.0 ± 0.0	268.1 ± 78.1	268.1 ± 78.1	676.8 ± 19.6
	#13 F H 6 + 85 35	Live	32.5 ± 24.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	843.5 ± 255.9
	n = 4	Dead standing	34.6 ± 34.6	0.0 ± 0.0	0.0 ± 0.0	22.7 ± 13.1	22.7 ± 13.1	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	64.3 ± 43.6	64.3 ± 43.6	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	124.5 ± 53.6	124.5 ± 53.6	0.0 ± 0.0
		Total dead	34.6 ± 34.6	0.0 ± 0.0	0.0 ± 0.0	211.5 ± 42.0	211.5 ± 42.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	188.8 ± 55.1	188.8 ± 55.1	0.0 ± 0.0
		Total	67.1 ± 59.0	0.0 ± 0.0	0.0 ± 0.0	211.5 ± 42.0	211.5 ± 42.0	843.5 ± 255.9
	#14 H F 6 + 85 30	Live	116.7 ± 33.7	0.0 ± 0.0	54.4 ± 17.4	5.4 ± 3.5	59.8 ± 17.7	706.6 ± 83.3
	n = 23	Dead standing	13.2 ± 9.1	0.0 ± 0.0	36.1 ± 19.7	24.0 ± 7.5	60.2 ± 21.5	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	47.1 ± 14.0	47.1 ± 14.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	220.3 ± 30.8	220.3 ± 30.8	0.0 ± 0.0
		Total dead	13.2 ± 9.1	0.0 ± 0.0	36.1 ± 19.7	291.5 ± 36.2	327.6 ± 42.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	267.4 ± 36.2	267.4 ± 36.2	0.0 ± 0.0
		Total	129.9 ± 33.9	0.0 ± 0.0	90.5 ± 27.6	296.9 ± 35.5	387.5 ± 43.7	706.6 ± 83.3
	#16 H D 6 + 85 35	Live	156.6 ± 89.2	0.0 ± 0.0	56.1 ± 38.5	6.0 ± 6.0	62.1 ± 36.7	948.9 ± 213.5
	n = 5	Dead standing	0.0 ± 0.0	0.0 ± 0.0	92.1 ± 56.5	62.6 ± 62.6	154.7 ± 65.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	82.6 ± 82.6	82.6 ± 82.6	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	68.3 ± 29.6	68.3 ± 29.6	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	92.1 ± 56.5	213.5 ± 111.3	305.7 ± 89.8	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	150.9 ± 92.3	150.9 ± 92.3	0.0 ± 0.0
		Total	156.6 ± 89.2	0.0 ± 0.0	148.2 ± 63.2	219.5 ± 108.5	367.7 ± 111.8	948.9 ± 213.5
	#17 F H 6 + 95 25	Live	20.6 ± 20.6	39.2 ± 19.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	723.1 ± 256.6
	n = 3	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	30.6 ± 19.2	30.6 ± 19.2	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	170.6 ± 111.3	111.8 ± 111.8	282.4 ± 76.3	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	34.1 ± 34.1	0.0 ± 0.0	254.7 ± 106.2	254.7 ± 106.2	0.0 ± 0.0
		Total dead	0.0 ± 0.0	34.1 ± 34.1	170.6 ± 111.3	397.1 ± 193.7	567.7 ± 199.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	34.1 ± 34.1	170.6 ± 111.3	366.5 ± 185.2	537.1 ± 182.3	0.0 ± 0.0
		Total	20.6 ± 20.6	73.2 ± 45.6	170.6 ± 111.3	397.1 ± 193.7	567.7 ± 199.0	723.1 ± 256.6
	#18 H 6 + 95 30	Live	249.4 ± 40.1	0.0 ± 0.0	49.8 ± 30.1	16.7 ± 8.9	66.5 ± 37.9	740.6 ± 137.1
	n = 12	Dead standing	0.0 ± 0.0	0.0 ± 0.0	7.3 ± 7.3	92.5 ± 21.4	99.8 ± 19.7	0.0 ± 0.0
		Dead windfall	1.2 ± 1.2	0.0 ± 0.0	22.1 ± 22.1	43.3 ± 22.0	65.4 ± 28.2	11.5 ± 11.5
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	40.1 ± 27.0	174.3 ± 41.4	214.3 ± 50.6	0.0 ± 0.0
		Total dead	1.2 ± 1.2	0.0 ± 0.0	69.5 ± 32.1	310.0 ± 49.8	379.5 ± 39.9	11.5 ± 11.5
		CWD	1.2 ± 1.2	0.0 ± 0.0	62.1 ± 32.5	217.6 ± 38.2	279.7 ± 38.0	11.5 ± 11.5
		Total	250.6 ± 40.7	0.0 ± 0.0	119.2 ± 41.8	326.7 ± 53.2	446.0 ± 70.4	752.1 ± 137.1
	#19 D H 6 + 75 30	Live	39.3 ± 39.3	0.0 ± 0.0	345.4 ± 193.0	0.0 ± 0.0	345.4 ± 193.0	282.3 ± 142.7
	n = 5	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	44.2 ± 33.1	44.2 ± 33.1	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	20.4 ± 20.4	20.4 ± 20.4	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	256.7 ± 114.7	256.7 ± 114.7	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	321.2 ± 138.6	321.2 ± 138.6	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	277.1 ± 121.5	277.1 ± 121.5	0.0 ± 0.0
		Total	39.3 ± 39.3	0.0 ± 0.0	345.4 ± 193.0	321.2 ± 138.6	666.6 ± 286.6	282.3 ± 142.7

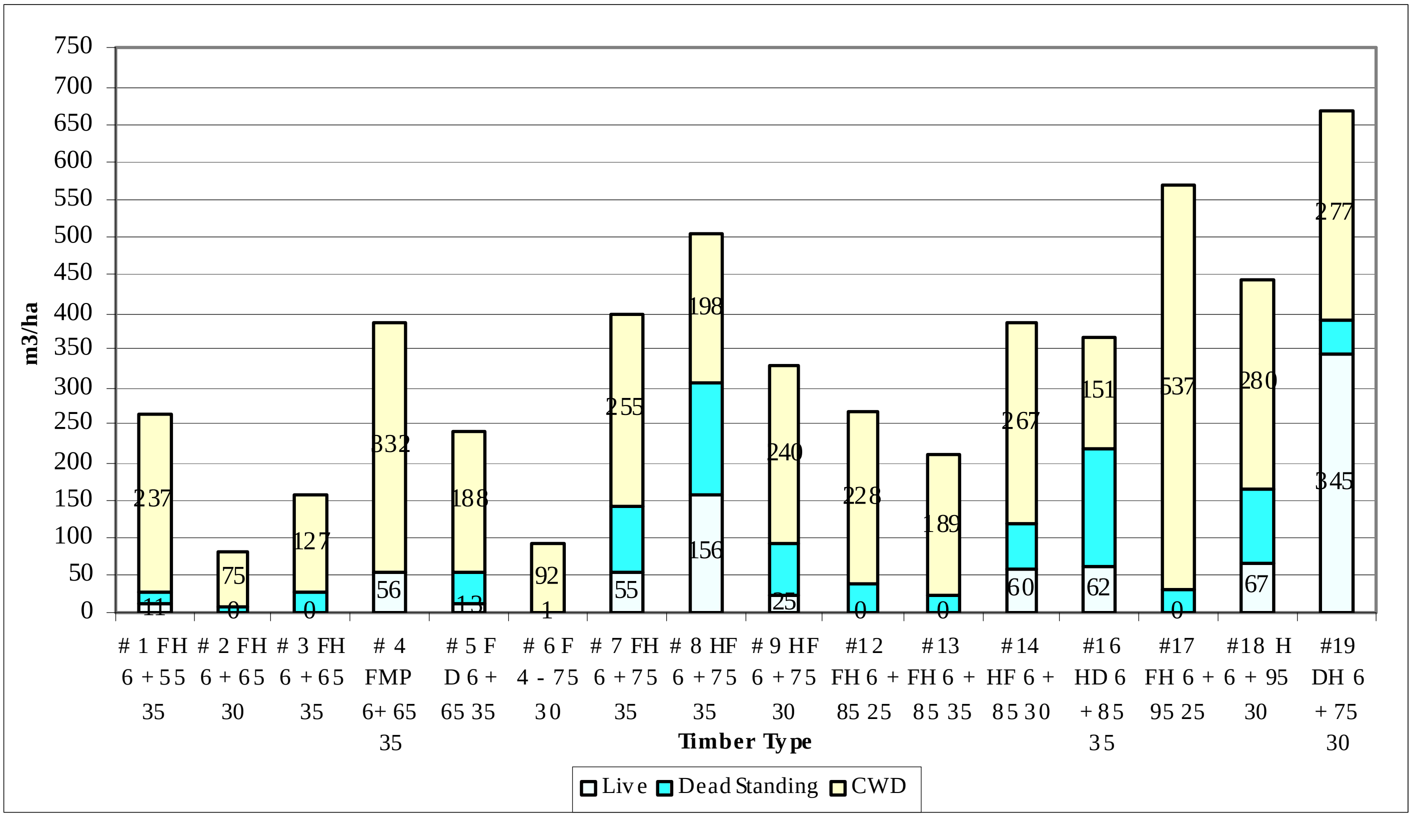

Figure 8. Immature timber types: mean total volume (m^3/ha) of Y+Z Grade wood partitioned by structure.

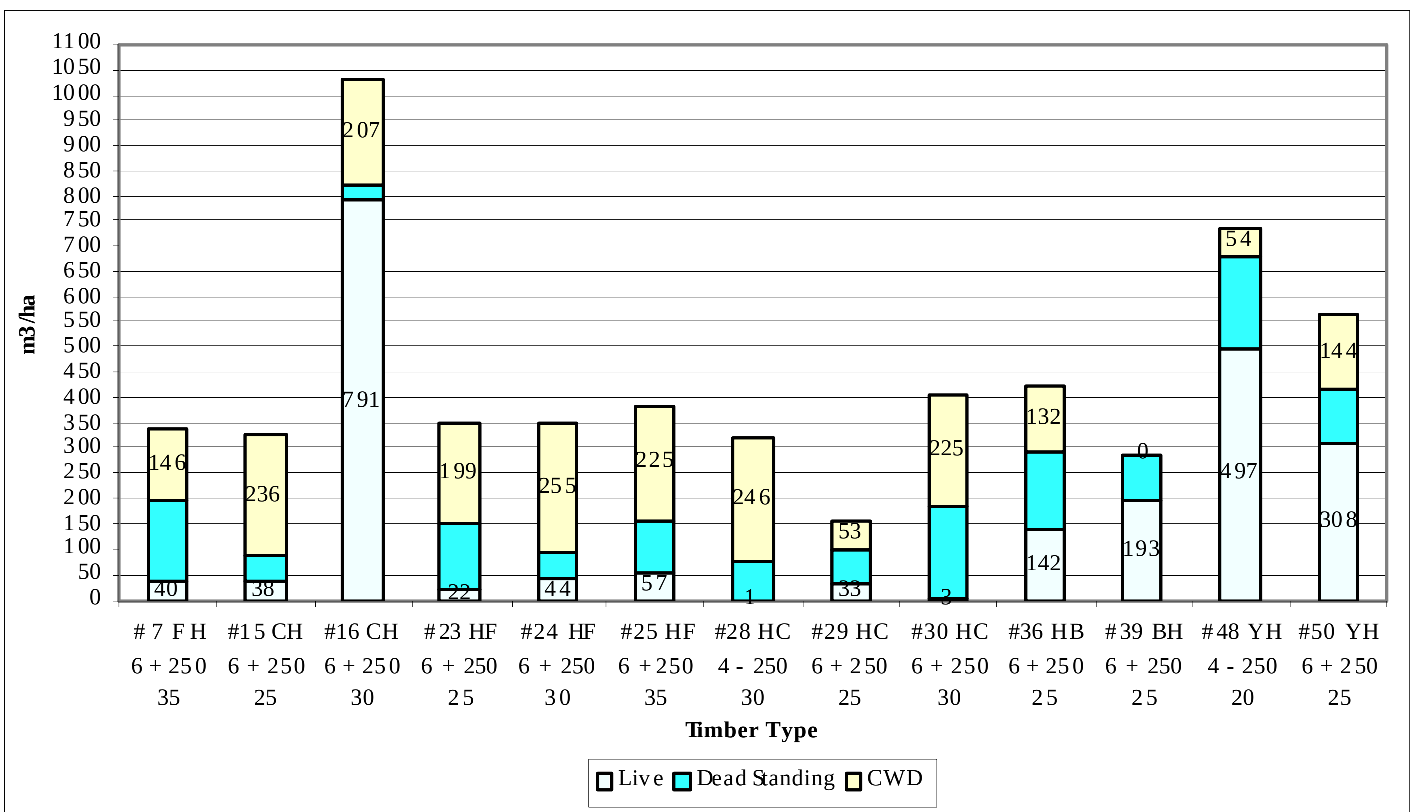

Figure 9. Mature timber types: mean total volume (m^3/ha) of Y+Z Grade wood partitioned by structure.

Table 22. Timber types: total volume (m^3/ha) of large dimensional wood (dib ≥ 50 cm, length ≥ 8 m) by grade and structure.

Age	Timber Type	Structure	All Grades m^3/ha	Y Grade m^3/ha	Y, Z Grades m^3/ha	U Grade m^3/ha	X Grade m^3/ha	U, X Grades m^3/ha
Mature	# 7 F H 6 + 250 35	Live	1006.1 ± 149.8	15.7 ± 15.7	15.7 ± 15.7	49.4 ± 26.3	48.3 ± 24.0	97.7 ± 43.4
	n = 9 (plots)	Dead standing	133.9 ± 65.2	55.6 ± 37.0	100.6 ± 41.6	33.2 ± 33.2	0.0 ± 0.0	33.2 ± 33.2
		Dead windfall	41.7 ± 41.7	0.0 ± 0.0	41.7 ± 41.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	18.1 ± 18.1	0.0 ± 0.0	18.1 ± 18.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	193.7 ± 96.2	55.6 ± 37.0	160.4 ± 85.1	33.2 ± 33.2	0.0 ± 0.0	33.2 ± 33.2
		CWD[a]	59.8 ± 59.8	0.0 ± 0.0	59.8 ± 59.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	1199.8 ± 175.8	71.3 ± 37.3	176.1 ± 82.8	82.6 ± 37.2	48.3 ± 24.0	130.9 ± 46.7
	#15 C H 6 + 250 25	Live	468.2 ± 50.2	0.0 ± 0.0	6.8 ± 4.0	18.0 ± 9.9	0.2 ± 0.2	18.2 ± 9.9
	n = 18	Dead standing	71.9 ± 23.8	0.0 ± 0.0	23.6 ± 13.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	187.0 ± 54.5	17.0 ± 12.4	77.1 ± 28.6	0.0 ± 0.0	1.8 ± 1.8	1.8 ± 1.8
		CWD Chunk	52.1 ± 32.2	0.0 ± 0.0	52.1 ± 32.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	311.0 ± 64.5	17.0 ± 12.4	152.8 ± 47.0	0.0 ± 0.0	1.8 ± 1.8	1.8 ± 1.8
		CWD	239.1 ± 59.9	17.0 ± 12.4	129.2 ± 41.6	0.0 ± 0.0	1.8 ± 1.8	1.8 ± 1.8
		Total	779.3 ± 86.1	17.0 ± 12.4	159.6 ± 46.8	18.0 ± 9.9	2.0 ± 1.8	20.0 ± 9.9
	#16 C H 6 + 250 30	Live	1531.4 ± .	435.5 ± .	786.9 ± .	38.3 ± .	0.0 ± .	38.3 ± .
	n = 1	Dead standing	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		Dead windfall	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		CWD Chunk	142.6 ± .	142.6 ± .	142.6 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		Total dead	142.6 ± .	142.6 ± .	142.6 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		CWD	142.6 ± .	142.6 ± .	142.6 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		Total	1674.0 ± .	578.1 ± .	929.5 ± .	38.3 ± .	0.0 ± .	38.3 ± .
	#23 H F 6 + 250 25	Live	917.5 ± 143.3	0.0 ± 0.0	0.0 ± 0.0	57.9 ± 20.9	15.4 ± 10.3	73.4 ± 20.5
	n = 14	Dead standing	92.4 ± 34.9	14.0 ± 14.0	92.4 ± 34.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	27.5 ± 20.1	0.0 ± 0.0	27.5 ± 20.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	38.2 ± 28.0	0.0 ± 0.0	38.2 ± 28.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	158.1 ± 42.9	14.0 ± 14.0	158.1 ± 42.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	65.7 ± 32.1	0.0 ± 0.0	65.7 ± 32.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	1075.6 ± 139.6	14.0 ± 14.0	158.1 ± 42.9	57.9 ± 20.9	15.4 ± 10.3	73.4 ± 20.5
	#24 H F 6 + 250 30	Live	919.1 ± 86.8	0.0 ± 0.0	0.0 ± 0.0	104.5 ± 43.7	15.0 ± 15.0	119.6 ± 36.8
	n = 5	Dead standing	92.0 ± 92.0	0.0 ± 0.0	0.0 ± 0.0	42.5 ± 42.5	0.0 ± 0.0	42.5 ± 42.5
		Dead windfall	64.7 ± 64.7	0.0 ± 0.0	64.7 ± 64.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	75.5 ± 50.4	50.5 ± 50.5	75.5 ± 50.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	232.2 ± 79.4	50.5 ± 50.5	140.2 ± 65.5	42.5 ± 42.5	0.0 ± 0.0	42.5 ± 42.5
		CWD	140.2 ± 65.5	50.5 ± 50.5	140.2 ± 65.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	1151.3 ± 77.4	50.5 ± 50.5	140.2 ± 65.5	147.0 ± 38.7	15.0 ± 15.0	162.0 ± 47.1
	#25 H F 6 + 250 35	Live	1137.2 ± 119.9	27.0 ± 14.7	29.4 ± 15.0	50.6 ± 16.4	31.4 ± 14.3	82.0 ± 19.9
	n = 16	Dead standing	95.7 ± 33.4	19.6 ± 19.6	75.8 ± 33.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	46.4 ± 28.4	0.0 ± 0.0	46.4 ± 28.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	32.9 ± 19.0	26.7 ± 18.6	32.9 ± 19.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	174.9 ± 49.8	46.3 ± 25.7	155.0 ± 52.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	79.2 ± 36.3	26.7 ± 18.6	79.2 ± 36.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	1312.2 ± 112.7	73.3 ± 29.7	184.4 ± 53.6	50.6 ± 16.4	31.4 ± 14.3	82.0 ± 19.9
	#28 H C 4 - 250 30	Live	289.2 ± 42.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 2	Dead standing	121.7 ± 121.7	0.0 ± 0.0	0.0 ± 0.0	121.7 ± 121.7	0.0 ± 0.0	121.7 ± 121.7
		Dead windfall	73.1 ± 73.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	174.6 ± 54.4	0.0 ± 0.0	174.6 ± 54.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	369.5 ± 249.3	0.0 ± 0.0	174.6 ± 54.4	121.7 ± 121.7	0.0 ± 0.0	121.7 ± 121.7
		CWD	247.7 ± 127.5	0.0 ± 0.0	174.6 ± 54.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	658.6 ± 291.4	0.0 ± 0.0	174.6 ± 54.4	121.7 ± 121.7	0.0 ± 0.0	121.7 ± 121.7
	#29 H C 6 + 250 25	Live	360.7 ± 179.2	33.0 ± 33.0	33.0 ± 33.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 3	Dead standing	68.4 ± 68.4	0.0 ± 0.0	68.4 ± 68.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	123.7 ± 11.1	0.0 ± 0.0	49.5 ± 29.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	192.1 ± 74.5	0.0 ± 0.0	117.9 ± 73.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	123.7 ± 11.1	0.0 ± 0.0	49.5 ± 29.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	552.8 ± 134.0	33.0 ± 33.0	150.9 ± 76.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	#30 H C 6 + 250 30	Live	519.5 ± 114.0	0.0 ± 0.0	0.0 ± 0.0	1.5 ± 1.5	8.2 ± 8.2	9.7 ± 9.7
	n = 11	Dead standing	174.1 ± 78.9	157.6 ± 74.6	157.6 ± 74.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	191.9 ± 105.1	0.0 ± 0.0	34.9 ± 18.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	11.5 ± 11.5	0.0 ± 0.0	11.5 ± 11.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	377.6 ± 159.2	157.6 ± 74.6	203.9 ± 79.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	203.4 ± 103.6	0.0 ± 0.0	46.4 ± 19.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	897.0 ± 123.2	157.6 ± 74.6	203.9 ± 79.8	1.5 ± 1.5	8.2 ± 8.2	9.7 ± 9.7

[a] Total CWD = Dead windfall + CWD chunks.

Table 22. (cont.) Timber types: total volume (m^3/ha) of large dimensional wood (dib ≥ 50cm, length ≥ 8m) by grade and structure.

Age	Timber Type	Structure	All Grades m^3/ha	Y Grade m^3/ha	Y, Z Grades m^3/ha	U Grade m^3/ha	X Grade m^3/ha	U, X Grades m^3/ha
Mature	#36 H B 6 + 250 25	Live	721.1 ± 64.9	77.2 ± 17.0	114.6 ± 26.6	79.3 ± 17.9	43.4 ± 15.3	122.7 ± 21.0
	n = 29	Dead standing	126.4 ± 30.0	36.1 ± 17.4	111.7 ± 22.6	0.0 ± 0.0	1.9 ± 1.9	1.9 ± 1.9
		Dead windfall	14.2 ± 10.5	0.0 ± 0.0	14.2 ± 10.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	59.5 ± 20.7	10.1 ± 10.1	59.5 ± 20.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	200.1 ± 40.8	46.2 ± 24.0	185.4 ± 36.7	0.0 ± 0.0	1.9 ± 1.9	1.9 ± 1.9
		CWD	73.7 ± 22.6	10.1 ± 10.1	73.7 ± 22.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	921.1 ± 81.4	123.4 ± 24.7	300.0 ± 40.2	79.3 ± 17.9	45.3 ± 15.3	124.5 ± 20.9
	#39 B H 6 + 250 25	Live	759.7 ± 114.7	123.5 ± 80.4	164.7 ± 55.5	59.6 ± 33.6	38.8 ± 19.4	98.4 ± 37.2
	n = 3	Dead standing	145.0 ± 76.2	0.0 ± 0.0	58.8 ± 58.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	50.2 ± 50.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	50.2 ± 50.2	50.2 ± 50.2
		Total dead	195.2 ± 118.5	0.0 ± 0.0	58.8 ± 58.8	0.0 ± 0.0	50.2 ± 50.2	50.2 ± 50.2
		CWD	50.2 ± 50.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	50.2 ± 50.2	50.2 ± 50.2
		Total	954.9 ± 155.4	123.5 ± 80.4	223.5 ± 64.2	59.6 ± 33.6	89.0 ± 62.9	148.7 ± 44.4
	#48 Y H 4 - 250 20	Live	579.7 ± 105.2	363.2 ± 75.3	422.7 ± 86.3	101.9 ± 67.2	2.3 ± 2.3	104.2 ± 69.2
	n = 5	Dead standing	43.7 ± 43.7	43.7 ± 43.7	43.7 ± 43.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	38.1 ± 38.1	38.1 ± 38.1	38.1 ± 38.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	81.8 ± 50.3	81.8 ± 50.3	81.8 ± 50.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	38.1 ± 38.1	38.1 ± 38.1	38.1 ± 38.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	661.5 ± 137.0	445.0 ± 108.1	504.4 ± 114.4	101.9 ± 67.2	2.3 ± 2.3	104.2 ± 69.2
	#50 Y H 6 + 250 25	Live	976.9 ± 112.2	248.3 ± 41.8	283.9 ± 45.2	135.6 ± 34.7	169.0 ± 35.8	304.6 ± 56.6
	n = 17	Dead standing	63.3 ± 25.8	10.4 ± 10.4	55.7 ± 25.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	36.6 ± 26.5	0.0 ± 0.0	27.1 ± 18.6	0.0 ± 0.0	9.4 ± 9.4	9.4 ± 9.4
		CWD Chunk	65.0 ± 32.1	7.1 ± 7.1	65.0 ± 32.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	164.8 ± 52.9	17.5 ± 12.2	147.8 ± 49.8	0.0 ± 0.0	9.4 ± 9.4	9.4 ± 9.4
		CWD	101.5 ± 37.8	7.1 ± 7.1	92.1 ± 34.0	0.0 ± 0.0	9.4 ± 9.4	9.4 ± 9.4
		Total	1141.6 ± 128.8	265.8 ± 40.5	431.6 ± 51.2	135.6 ± 34.7	178.5 ± 37.9	314.1 ± 59.6
Immature	# 1 F H 6 + 55 35	Live	105.8 ± 29.2	0.0 ± 0.0	5.7 ± 5.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 15	Dead standing	5.1 ± 5.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	5.1 ± 5.1	5.1 ± 5.1
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	77.7 ± 23.0	6.6 ± 6.6	77.7 ± 23.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	82.8 ± 24.8	6.6 ± 6.6	77.7 ± 23.0	0.0 ± 0.0	5.1 ± 5.1	5.1 ± 5.1
		CWD	77.7 ± 23.0	6.6 ± 6.6	77.7 ± 23.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	188.7 ± 37.3	6.6 ± 6.6	83.5 ± 22.3	0.0 ± 0.0	5.1 ± 5.1	5.1 ± 5.1
	# 2 F H 6 + 65 30	Live	193.5 ± 44.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 19	Dead standing	3.9 ± 3.9	3.9 ± 3.9	3.9 ± 3.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	3.0 ± 3.0	0.0 ± 0.0	3.0 ± 3.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	6.9 ± 4.8	3.9 ± 3.9	6.9 ± 4.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	3.0 ± 3.0	0.0 ± 0.0	3.0 ± 3.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	200.4 ± 45.8	3.9 ± 3.9	6.9 ± 4.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	# 3 F H 6 + 65 35	Live	236.4 ± 71.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 10	Dead standing	9.0 ± 9.0	0.0 ± 0.0	9.0 ± 9.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	37.3 ± 25.1	0.0 ± 0.0	20.8 ± 20.8	0.0 ± 0.0	16.5 ± 16.5	16.5 ± 16.5
		Total dead	46.3 ± 32.5	0.0 ± 0.0	29.8 ± 29.8	0.0 ± 0.0	16.5 ± 16.5	16.5 ± 16.5
		CWD	37.3 ± 25.1	0.0 ± 0.0	20.8 ± 20.8	0.0 ± 0.0	16.5 ± 16.5	16.5 ± 16.5
		Total	282.7 ± 70.0	0.0 ± 0.0	29.8 ± 29.8	0.0 ± 0.0	16.5 ± 16.5	16.5 ± 16.5
	# 4 F M P 6 + 65 35	Live	262.0 ± 123.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 2	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	137.6 ± 49.5	45.8 ± 45.8	137.6 ± 49.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	137.6 ± 49.5	45.8 ± 45.8	137.6 ± 49.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	137.6 ± 49.5	45.8 ± 45.8	137.6 ± 49.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	399.6 ± 173.2	45.8 ± 45.8	137.6 ± 49.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	# 5 F D 6 + 65 35	Live	391.2 ± 108.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 6	Dead standing	27.5 ± 27.5	0.0 ± 0.0	27.5 ± 27.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	18.2 ± 18.2	18.2 ± 18.2	18.2 ± 18.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	59.8 ± 45.1	0.0 ± 0.0	59.8 ± 45.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	105.5 ± 49.4	18.2 ± 18.2	105.5 ± 49.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	78.1 ± 50.5	18.2 ± 18.2	78.1 ± 50.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	496.7 ± 148.4	18.2 ± 18.2	105.5 ± 49.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	# 6 F 4 - 75 30	Live	190.0 ± 91.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 5	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	36.4 ± 22.3	0.0 ± 0.0	36.4 ± 22.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	36.4 ± 22.3	0.0 ± 0.0	36.4 ± 22.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	36.4 ± 22.3	0.0 ± 0.0	36.4 ± 22.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	226.4 ± 104.3	0.0 ± 0.0	36.4 ± 22.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

Table 22. (cont.) Timber types: total volume (m³/ha) of large dimensional wood (dib ≥ 50cm, length ≥ 8m) by grade and structure.

Age	Timber Type	Structure	All Grades m³/ha	Y Grade m³/ha	Y, Z Grades m³/ha	U Grade m³/ha	X Grade m³/ha	U, X Grades m³/ha
Immature	# 7 F H 6 + 75 35	Live	246.8 ± 29.6	2.4 ± 2.4	4.4 ± 3.1	0.7 ± 0.7	0.0 ± 0.0	0.7 ± 0.7
	n = 36	Dead standing	36.5 ± 15.0	7.8 ± 5.9	16.9 ± 8.4	4.0 ± 4.0	0.0 ± 0.0	4.0 ± 4.0
		Dead windfall	37.5 ± 13.1	21.1 ± 8.2	37.5 ± 13.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	52.4 ± 14.5	30.1 ± 12.5	52.4 ± 14.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	126.3 ± 23.7	59.0 ± 16.1	106.7 ± 19.5	4.0 ± 4.0	0.0 ± 0.0	4.0 ± 4.0
		CWD	89.8 ± 17.9	51.2 ± 14.8	89.8 ± 17.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	373.1 ± 47.2	61.4 ± 16.3	111.1 ± 19.8	4.7 ± 4.1	0.0 ± 0.0	4.7 ± 4.1
	# 8 H F 6 + 75 35	Live	171.9 ± 71.0	3.8 ± 3.8	3.8 ± 3.8	0.0 ± 0.0	11.7 ± 11.7	11.7 ± 11.7
	n = 4	Dead standing	25.3 ± 25.3	0.0 ± 0.0	25.3 ± 25.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	46.3 ± 46.3	46.3 ± 46.3	46.3 ± 46.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	103.8 ± 103.8	0.0 ± 0.0	103.8 ± 103.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	175.4 ± 121.7	46.3 ± 46.3	175.4 ± 121.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	150.1 ± 98.5	46.3 ± 46.3	150.1 ± 98.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	347.3 ± 133.3	50.1 ± 50.1	179.2 ± 121.9	0.0 ± 0.0	11.7 ± 11.7	11.7 ± 11.7
	# 9 H F 6 + 75 30	Live	215.0 ± 77.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead standing	16.6 ± 16.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	18.6 ± 18.6	0.0 ± 0.0	11.7 ± 11.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	10.3 ± 10.3	0.0 ± 0.0	10.3 ± 10.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	45.5 ± 35.6	0.0 ± 0.0	22.0 ± 14.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	28.8 ± 20.2	0.0 ± 0.0	22.0 ± 14.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	260.5 ± 76.5	0.0 ± 0.0	22.0 ± 14.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	#12 F H 6 + 85 25	Live	294.5 ± 294.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 2	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	294.5 ± 294.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	#13 F H 6 + 85 35	Live	403.2 ± 104.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 4	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	48.3 ± 48.3	0.0 ± 0.0	48.3 ± 48.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	48.3 ± 48.3	0.0 ± 0.0	48.3 ± 48.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	48.3 ± 48.3	0.0 ± 0.0	48.3 ± 48.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	451.5 ± 131.5	0.0 ± 0.0	48.3 ± 48.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	#14 H F 6 + 85 30	Live	369.8 ± 56.1	20.2 ± 15.1	20.2 ± 15.1	24.1 ± 14.2	0.0 ± 0.0	24.1 ± 14.2
	n = 23	Dead standing	19.4 ± 17.6	17.5 ± 17.5	19.4 ± 17.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	31.3 ± 13.5	0.0 ± 0.0	31.3 ± 13.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	99.6 ± 25.8	0.0 ± 0.0	99.6 ± 25.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	150.3 ± 34.4	17.5 ± 17.5	150.3 ± 34.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	130.9 ± 28.9	0.0 ± 0.0	130.9 ± 28.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	520.1 ± 66.0	37.7 ± 22.4	170.5 ± 33.7	24.1 ± 14.2	0.0 ± 0.0	24.1 ± 14.2
	#16 H D 6 + 85 35	Live	600.9 ± 142.8	0.0 ± 0.0	0.0 ± 0.0	42.1 ± 42.1	0.0 ± 0.0	42.1 ± 42.1
	n = 5	Dead standing	44.7 ± 44.7	44.7 ± 44.7	44.7 ± 44.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	20.7 ± 20.7	0.0 ± 0.0	20.7 ± 20.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	44.0 ± 27.0	0.0 ± 0.0	44.0 ± 27.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	109.4 ± 59.8	44.7 ± 44.7	109.4 ± 59.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	64.7 ± 26.5	0.0 ± 0.0	64.7 ± 26.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	710.3 ± 124.8	44.7 ± 44.7	109.4 ± 59.8	42.1 ± 42.1	0.0 ± 0.0	42.1 ± 42.1
	#17 F H 6 + 95 25	Live	482.4 ± 242.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 3	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	243.8 ± 72.6	170.6 ± 111.3	243.8 ± 72.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	145.3 ± 24.0	0.0 ± 0.0	111.3 ± 56.6	0.0 ± 0.0	34.1 ± 34.1	34.1 ± 34.1
		Total dead	389.1 ± 96.1	170.6 ± 111.3	355.0 ± 125.2	0.0 ± 0.0	34.1 ± 34.1	34.1 ± 34.1
		CWD	389.1 ± 96.1	170.6 ± 111.3	355.0 ± 125.2	0.0 ± 0.0	34.1 ± 34.1	34.1 ± 34.1
		Total	871.5 ± 164.6	170.6 ± 111.3	355.0 ± 125.2	0.0 ± 0.0	34.1 ± 34.1	34.1 ± 34.1
	#18 H 6 + 95 30	Live	468.6 ± 99.5	42.0 ± 30.5	42.0 ± 30.5	35.1 ± 20.7	0.0 ± 0.0	35.1 ± 20.7
	n = 12	Dead standing	16.4 ± 11.2	7.3 ± 7.3	16.4 ± 11.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	74.5 ± 32.5	22.1 ± 22.1	63.0 ± 28.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	27.9 ± 20.4	19.2 ± 19.2	27.9 ± 20.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	118.8 ± 35.4	48.6 ± 27.9	107.3 ± 33.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	102.4 ± 37.9	41.3 ± 27.9	90.9 ± 35.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	587.4 ± 94.9	90.7 ± 41.2	149.4 ± 46.7	35.1 ± 20.7	0.0 ± 0.0	35.1 ± 20.7
	#19 D H 6 + 75 30	Live	134.8 ± 93.7	0.0 ± 0.0	0.0 ± 0.0	39.3 ± 39.3	0.0 ± 0.0	39.3 ± 39.3
	n = 5	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	60.9 ± 37.4	0.0 ± 0.0	60.9 ± 37.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	60.9 ± 37.4	0.0 ± 0.0	60.9 ± 37.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	60.9 ± 37.4	0.0 ± 0.0	60.9 ± 37.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	195.7 ± 96.1	0.0 ± 0.0	60.9 ± 37.4	39.3 ± 39.3	0.0 ± 0.0	39.3 ± 39.3

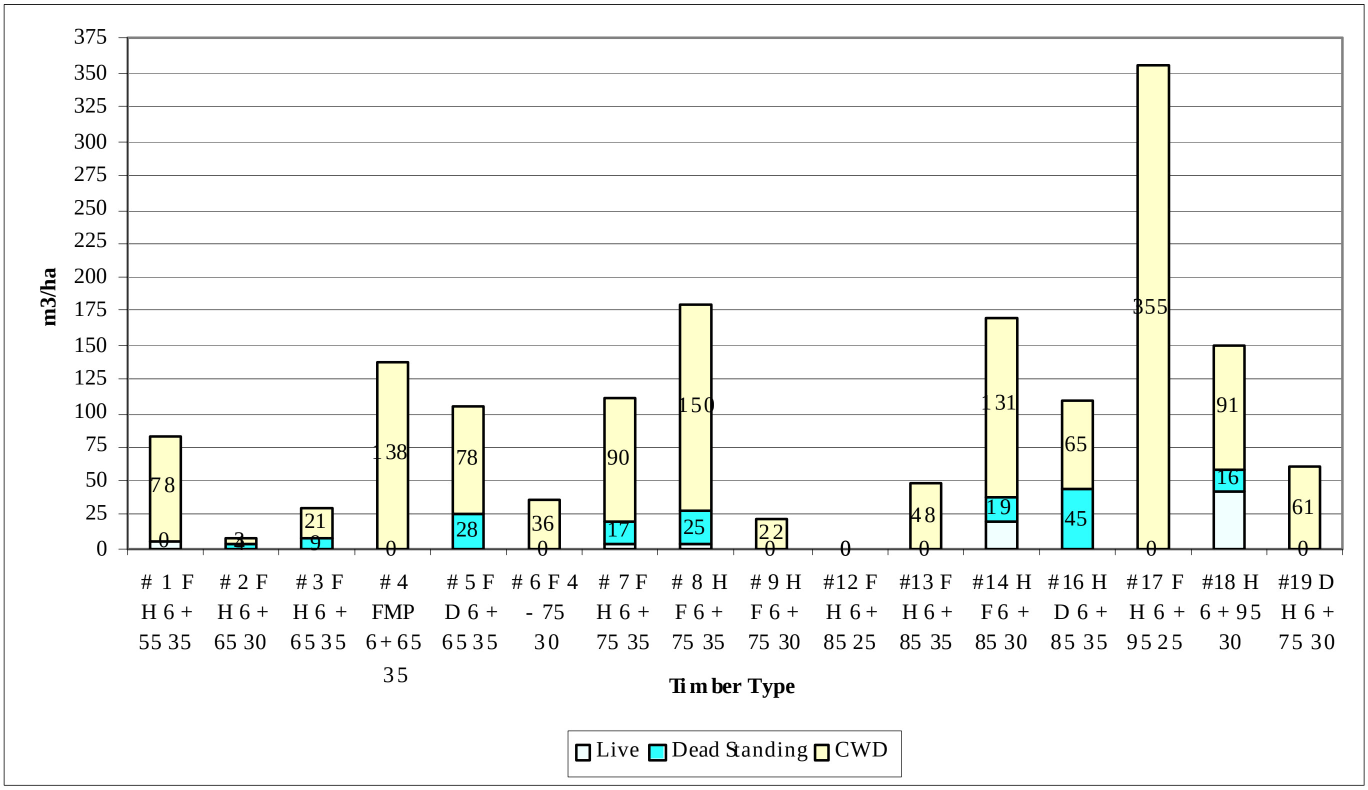

Figure 10. Immature timber types: total volume/ha of large dimensional Y+Z Grade wood (large-end dib ≥ 50 cm, length ≥ 8 m) partitioned by structure.

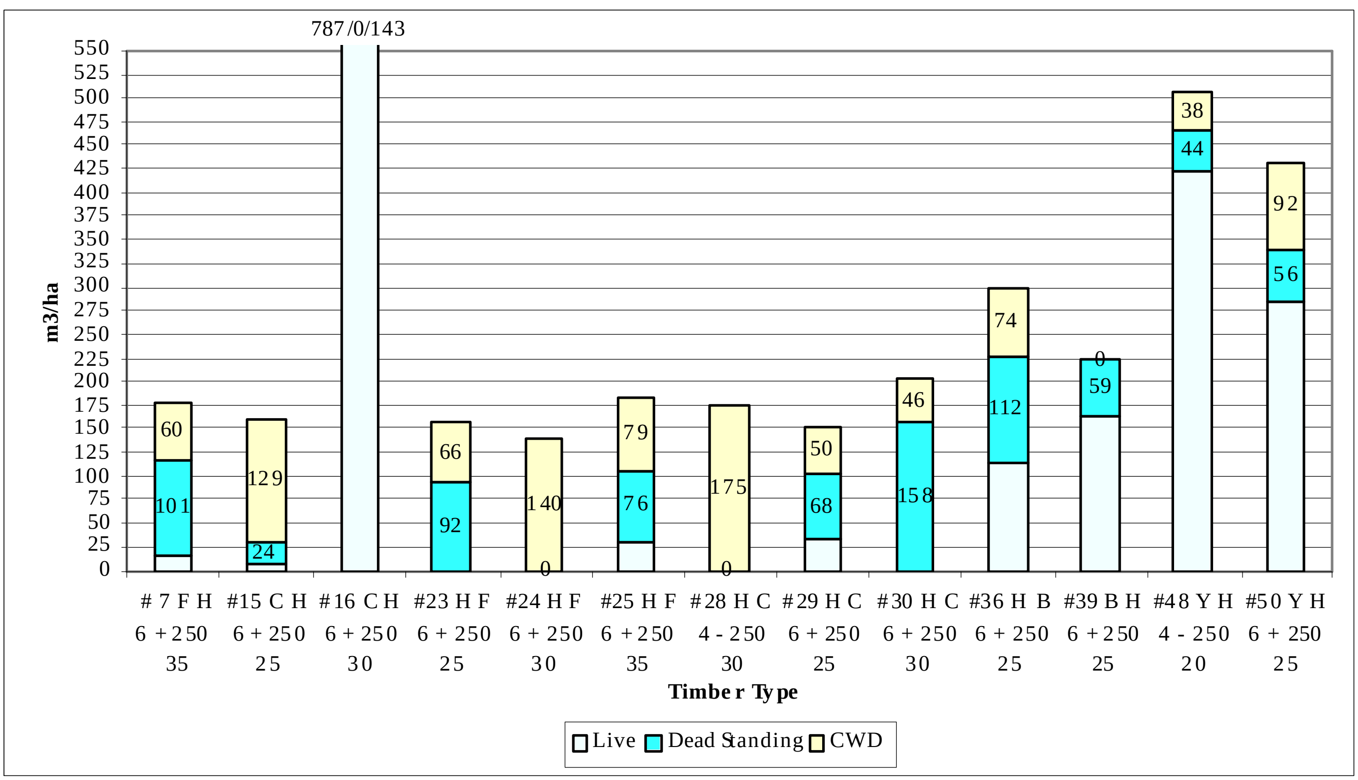

Figure 11. Mature timber types: total volume/ha of large dimensional Y+Z Grade wood (large-end dib ≥ 50 cm, length ≥ 8 m) partitioned by structure.

Table 23. Timber types: total density (no./ha) of large dimensional wood (large-end dib ≥ 50 cm, length ≥ 8 m), partitioned by grade and structure (mean ± SE).

Age	Timber Type	Structure	All Grades no./ha	Y Grade no./ha	Y, Z Grades no./ha	U Grade no./ha	X Grade no./ha	U, X Grades no./ha
Mature	# 7 F H 6 + 250 35	Live	323.2 ± 40.1	9.5 ± 9.5	19.0 ± 19.0	27.0 ± 18.1	17.8 ± 8.1	44.8 ± 17.8
	n = 9 (plots)	Dead standing	51.2 ± 39.9	19.0 ± 13.8	38.0 ± 27.5	13.2 ± 13.2	0.0 ± 0.0	13.2 ± 13.2
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	51.2 ± 39.9	19.0 ± 13.8	38.0 ± 27.5	13.2 ± 13.2	0.0 ± 0.0	13.2 ± 13.2
		CWD[a]	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	374.4 ± 58.3	28.5 ± 15.3	57.0 ± 30.6	40.3 ± 20.3	17.8 ± 8.1	58.1 ± 18.6
	#15 C H 6 + 250 25	Live	114.9 ± 18.2	0.0 ± 0.0	0.0 ± 0.0	5.9 ± 4.0	0.2 ± 0.2	6.1 ± 4.0
	n = 18	Dead standing	13.0 ± 6.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	35.4 ± 13.1	5.2 ± 4.5	10.4 ± 9.1	0.0 ± 0.0	0.3 ± 0.3	0.3 ± 0.3
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	48.4 ± 13.7	5.2 ± 4.5	10.4 ± 9.1	0.0 ± 0.0	0.3 ± 0.3	0.3 ± 0.3
		CWD	35.4 ± 13.1	5.2 ± 4.5	10.4 ± 9.1	0.0 ± 0.0	0.3 ± 0.3	0.3 ± 0.3
		Total	163.3 ± 22.9	5.2 ± 4.5	10.4 ± 9.1	5.9 ± 4.0	0.5 ± 0.4	6.5 ± 4.0
	#16 C H 6 + 250 30	Live	263.6 ± .	55.5 ± .	111.1 ± .	26.3 ± .	0.0 ± .	26.3 ± .
	n = 1	Dead standing	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		Dead windfall	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		CWD Chunk	254.6 ± .	127.3 ± .	254.6 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		Total dead	254.6 ± .	127.3 ± .	254.6 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		CWD	254.6 ± .	127.3 ± .	254.6 ± .	0.0 ± .	0.0 ± .	0.0 ± .
		Total	518.2 ± .	182.9 ± .	365.7 ± .	26.3 ± .	0.0 ± .	26.3 ± .
	#23 H F 6 + 250 25	Live	324.4 ± 27.9	0.0 ± 0.0	0.0 ± 0.0	34.4 ± 13.9	8.4 ± 5.5	42.8 ± 13.5
	n = 14	Dead standing	16.0 ± 16.0	8.0 ± 8.0	16.0 ± 16.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	16.0 ± 16.0	8.0 ± 8.0	16.0 ± 16.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	340.3 ± 34.5	8.0 ± 8.0	16.0 ± 16.0	34.4 ± 13.9	8.4 ± 5.5	42.8 ± 13.5
	#24 H F 6 + 250 30	Live	318.9 ± 36.2	0.0 ± 0.0	0.0 ± 0.0	48.7 ± 20.7	7.5 ± 7.5	56.2 ± 17.3
	n = 5	Dead standing	38.0 ± 38.0	0.0 ± 0.0	0.0 ± 0.0	16.4 ± 16.4	0.0 ± 0.0	16.4 ± 16.4
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	14.3 ± 14.3	7.1 ± 7.1	14.3 ± 14.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	52.3 ± 37.1	7.1 ± 7.1	14.3 ± 14.3	16.4 ± 16.4	0.0 ± 0.0	16.4 ± 16.4
		CWD	14.3 ± 14.3	7.1 ± 7.1	14.3 ± 14.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	371.2 ± 19.3	7.1 ± 7.1	14.3 ± 14.3	65.0 ± 17.2	7.5 ± 7.5	72.6 ± 20.4
	#25 H F 6 + 250 35	Live	334.1 ± 31.1	7.0 ± 3.8	14.0 ± 7.7	23.0 ± 9.5	8.5 ± 3.7	31.4 ± 10.1
	n = 16	Dead standing	16.4 ± 13.2	6.6 ± 6.6	13.2 ± 13.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	18.8 ± 12.9	9.4 ± 6.5	18.8 ± 12.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	35.3 ± 17.3	16.0 ± 8.8	32.0 ± 17.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	18.8 ± 12.9	9.4 ± 6.5	18.8 ± 12.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	369.3 ± 33.6	23.0 ± 9.7	45.9 ± 19.5	23.0 ± 9.5	8.5 ± 3.7	31.4 ± 10.1
	#28 H C 4 - 250 30	Live	107.8 ± 61.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 2	Dead standing	14.9 ± 14.9	0.0 ± 0.0	0.0 ± 0.0	14.9 ± 14.9	0.0 ± 0.0	14.9 ± 14.9
		Dead windfall	24.1 ± 24.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	39.0 ± 39.0	0.0 ± 0.0	0.0 ± 0.0	14.9 ± 14.9	0.0 ± 0.0	14.9 ± 14.9
		CWD	24.1 ± 24.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	146.8 ± 100.2	0.0 ± 0.0	0.0 ± 0.0	14.9 ± 14.9	0.0 ± 0.0	14.9 ± 14.9
	#29 H C 6 + 250 25	Live	131.5 ± 60.1	5.0 ± 5.0	10.0 ± 10.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 3	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	26.7 ± 23.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	26.7 ± 23.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	26.7 ± 23.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	158.2 ± 56.0	5.0 ± 5.0	10.0 ± 10.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	#30 H C 6 + 250 30	Live	135.8 ± 31.6	0.0 ± 0.0	0.0 ± 0.0	1.3 ± 1.3	3.9 ± 3.9	5.2 ± 5.2
	n = 11	Dead standing	72.5 ± 38.4	34.3 ± 19.0	68.6 ± 37.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	28.7 ± 18.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	101.2 ± 46.3	34.3 ± 19.0	68.6 ± 37.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	28.7 ± 18.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	237.0 ± 38.0	34.3 ± 19.0	68.6 ± 37.9	1.3 ± 1.3	3.9 ± 3.9	5.2 ± 5.2

[a] Total CWD = Dead windfall + CWD chunks.

Table 23. (cont.) Timber types: total density (no./ha) of large dimensional wood, partitioned by grade and structure (mean ± SE).

Age	Timber Type	Structure	All Grades no./ha	Y Grade no./ha	Y, Z Grades no./ha	U Grade no./ha	X Grade no./ha	U, X Grades no./ha
Mature	#36 H B 6 + 250 25	Live	198.0 ± 20.4	15.2 ± 3.4	30.4 ± 6.9	21.5 ± 3.7	8.4 ± 2.9	29.8 ± 4.6
	n = 29	Dead standing	23.4 ± 15.0	11.1 ± 7.5	22.1 ± 15.0	0.0 ± 0.0	0.4 ± 0.4	0.4 ± 0.4
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	2.3 ± 2.3	1.1 ± 1.1	2.3 ± 2.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	25.7 ± 15.4	12.2 ± 7.7	24.4 ± 15.4	0.0 ± 0.0	0.4 ± 0.4	0.4 ± 0.4
		CWD	2.3 ± 2.3	1.1 ± 1.1	2.3 ± 2.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	223.7 ± 29.2	27.4 ± 7.6	54.8 ± 15.2	21.5 ± 3.7	8.8 ± 2.9	30.3 ± 4.6
	#39 B H 6 + 250 25	Live	237.2 ± 55.9	27.3 ± 14.4	54.7 ± 28.7	17.5 ± 10.9	9.4 ± 4.7	26.9 ± 7.3
	n = 3	Dead standing	14.6 ± 14.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	28.1 ± 28.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	28.1 ± 28.1	28.1 ± 28.1
		Total dead	42.7 ± 42.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	28.1 ± 28.1	28.1 ± 28.1
		CWD	28.1 ± 28.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	28.1 ± 28.1	28.1 ± 28.1
		Total	279.9 ± 22.5	27.3 ± 14.4	54.7 ± 28.7	17.5 ± 10.9	37.4 ± 30.2	54.9 ± 21.2
	#48 Y H 4 - 250 20	Live	245.9 ± 37.7	94.2 ± 9.9	188.4 ± 19.8	25.2 ± 16.8	1.7 ± 1.7	26.9 ± 17.3
	n = 5	Dead standing	20.2 ± 20.2	10.1 ± 10.1	20.2 ± 20.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	50.9 ± 50.9	25.5 ± 25.5	50.9 ± 50.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	71.1 ± 49.9	35.6 ± 24.9	71.1 ± 49.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	50.9 ± 50.9	25.5 ± 25.5	50.9 ± 50.9	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	317.1 ± 40.8	129.8 ± 18.9	259.5 ± 37.8	25.2 ± 16.8	1.7 ± 1.7	26.9 ± 17.3
	#50 Y H 6 + 250 25	Live	281.5 ± 29.4	38.2 ± 7.5	76.4 ± 15.0	35.6 ± 8.9	33.8 ± 7.4	69.4 ± 13.0
	n = 17	Dead standing	4.6 ± 3.2	1.2 ± 1.2	2.5 ± 2.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	2.3 ± 2.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	2.3 ± 2.3	2.3 ± 2.3
		CWD Chunk	4.7 ± 4.7	2.4 ± 2.4	4.7 ± 4.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	11.7 ± 5.7	3.6 ± 2.6	7.2 ± 5.2	0.0 ± 0.0	2.3 ± 2.3	2.3 ± 2.3
		CWD	7.1 ± 5.1	2.4 ± 2.4	4.7 ± 4.7	0.0 ± 0.0	2.3 ± 2.3	2.3 ± 2.3
		Total	293.2 ± 30.8	41.8 ± 7.8	83.6 ± 15.7	35.6 ± 8.9	36.2 ± 7.7	71.8 ± 13.9
Immature	# 1 F H 6 + 55 35	Live	67.6 ± 20.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 15	Dead standing	3.6 ± 3.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	3.6 ± 3.6	3.6 ± 3.6
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	5.8 ± 5.8	2.9 ± 2.9	5.8 ± 5.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	9.4 ± 6.6	2.9 ± 2.9	5.8 ± 5.8	0.0 ± 0.0	3.6 ± 3.6	3.6 ± 3.6
		CWD	5.8 ± 5.8	2.9 ± 2.9	5.8 ± 5.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	77.0 ± 20.0	2.9 ± 2.9	5.8 ± 5.8	0.0 ± 0.0	3.6 ± 3.6	3.6 ± 3.6
	# 2 F H 6 + 65 30	Live	106.2 ± 22.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 19	Dead standing	8.1 ± 8.1	4.1 ± 4.1	8.1 ± 8.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	8.1 ± 8.1	4.1 ± 4.1	8.1 ± 8.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	114.3 ± 24.9	4.1 ± 4.1	8.1 ± 8.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	# 3 F H 6 + 65 35	Live	111.9 ± 26.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 10	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	9.6 ± 9.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	9.6 ± 9.6	9.6 ± 9.6
		Total dead	9.6 ± 9.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	9.6 ± 9.6	9.6 ± 9.6
		CWD	9.6 ± 9.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	9.6 ± 9.6	9.6 ± 9.6
		Total	121.6 ± 29.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	9.6 ± 9.6	9.6 ± 9.6
	# 4 F M P 6 + 65 35	Live	134.5 ± 63.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	81.5 ± 81.5	40.7 ± 40.7	81.5 ± 81.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	81.5 ± 81.5	40.7 ± 40.7	81.5 ± 81.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	81.5 ± 81.5	40.7 ± 40.7	81.5 ± 81.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	216.0 ± 144.8	40.7 ± 40.7	81.5 ± 81.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	# 5 F D 6 + 65 35	Live	108.5 ± 29.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 6	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	22.4 ± 22.4	11.2 ± 11.2	22.4 ± 22.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	22.4 ± 22.4	11.2 ± 11.2	22.4 ± 22.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	22.4 ± 22.4	11.2 ± 11.2	22.4 ± 22.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	131.0 ± 32.7	11.2 ± 11.2	22.4 ± 22.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	# 6 F 4 - 75 30	Live	86.0 ± 44.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 5	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	86.0 ± 44.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

Table 23. (cont.) Timber types: total density (no./ha) of large dimensional wood, partitioned by grade and structure (mean ± SE).

Age	Timber Type	Structure	All Grades no./ha	Y Grade no./ha	Y, Z Grades no./ha	U Grade no./ha	X Grade no./ha	U, X Grades no./ha
Immature	# 7 F H 6 + 75 35	Live	97.8 ± 12.2	0.3 ± 0.3	0.6 ± 0.6	0.3 ± 0.3	0.0 ± 0.0	0.3 ± 0.3
	n = 36	Dead standing	7.9 ± 3.6	1.2 ± 1.0	2.5 ± 2.0	0.4 ± 0.4	0.0 ± 0.0	0.4 ± 0.4
		Dead windfall	18.6 ± 8.0	9.3 ± 4.0	18.6 ± 8.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	14.1 ± 5.6	7.1 ± 2.8	14.1 ± 5.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	40.6 ± 9.2	17.6 ± 4.5	35.2 ± 9.1	0.4 ± 0.4	0.0 ± 0.0	0.4 ± 0.4
		CWD	32.7 ± 9.0	16.4 ± 4.5	32.7 ± 9.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	138.4 ± 17.1	17.9 ± 4.6	35.8 ± 9.2	0.7 ± 0.5	0.0 ± 0.0	0.7 ± 0.5
	# 8 H F 6 + 75 35	Live	47.8 ± 18.9	2.2 ± 2.2	4.3 ± 4.3	0.0 ± 0.0	2.2 ± 2.2	2.2 ± 2.2
	n = 4	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	11.1 ± 11.1	5.5 ± 5.5	11.1 ± 11.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	11.1 ± 11.1	5.5 ± 5.5	11.1 ± 11.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	11.1 ± 11.1	5.5 ± 5.5	11.1 ± 11.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	58.8 ± 24.7	7.7 ± 7.7	15.4 ± 15.4	0.0 ± 0.0	2.2 ± 2.2	2.2 ± 2.2
	# 9 H F 6 + 75 30	Live	103.9 ± 36.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead standing	13.7 ± 13.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	5.6 ± 5.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	19.3 ± 19.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	5.6 ± 5.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	123.2 ± 35.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	#12 F H 6 + 85 25	Live	162.5 ± 162.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 2	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	162.5 ± 162.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	#13 F H 6 + 85 35	Live	180.9 ± 56.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 4	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	180.9 ± 56.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	#14 H F 6 + 85 30	Live	159.8 ± 23.2	9.0 ± 6.4	18.0 ± 12.9	14.9 ± 8.5	0.0 ± 0.0	14.9 ± 8.5
	n = 23	Dead standing	10.8 ± 10.8	5.4 ± 5.4	10.8 ± 10.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	10.8 ± 10.8	5.4 ± 5.4	10.8 ± 10.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	170.6 ± 24.8	14.4 ± 8.1	28.8 ± 16.3	14.9 ± 8.5	0.0 ± 0.0	14.9 ± 8.5
	#16 H D 6 + 85 35	Live	212.0 ± 53.3	0.0 ± 0.0	0.0 ± 0.0	8.9 ± 8.9	0.0 ± 0.0	8.9 ± 8.9
	n = 5	Dead standing	40.8 ± 40.8	20.4 ± 20.4	40.8 ± 40.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	40.8 ± 40.8	20.4 ± 20.4	40.8 ± 40.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	252.8 ± 58.2	20.4 ± 20.4	40.8 ± 40.8	8.9 ± 8.9	0.0 ± 0.0	8.9 ± 8.9
	#17 F H 6 + 95 25	Live	144.8 ± 86.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	n = 3	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	44.8 ± 29.6	22.4 ± 14.8	44.8 ± 29.6	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	6.8 ± 6.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	6.8 ± 6.8	6.8 ± 6.8
		Total dead	51.5 ± 29.1	22.4 ± 14.8	44.8 ± 29.6	0.0 ± 0.0	6.8 ± 6.8	6.8 ± 6.8
		CWD	51.5 ± 29.1	22.4 ± 14.8	44.8 ± 29.6	0.0 ± 0.0	6.8 ± 6.8	6.8 ± 6.8
		Total	196.4 ± 57.3	22.4 ± 14.8	44.8 ± 29.6	0.0 ± 0.0	6.8 ± 6.8	6.8 ± 6.8
	#18 H 6 + 95 30	Live	189.1 ± 47.6	17.7 ± 11.8	35.3 ± 23.6	5.9 ± 3.6	0.0 ± 0.0	5.9 ± 3.6
	n = 12	Dead standing	1.4 ± 1.4	0.7 ± 0.7	1.4 ± 1.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	11.9 ± 10.1	5.0 ± 5.0	10.0 ± 10.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	3.8 ± 3.8	1.9 ± 1.9	3.8 ± 3.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	17.2 ± 10.3	7.6 ± 5.2	15.3 ± 10.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	15.8 ± 10.4	6.9 ± 5.2	13.9 ± 10.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	206.3 ± 52.0	25.3 ± 13.3	50.6 ± 26.7	5.9 ± 3.6	0.0 ± 0.0	5.9 ± 3.6
	#19 D H 6 + 75 30	Live	50.1 ± 38.5	0.0 ± 0.0	0.0 ± 0.0	10.4 ± 10.4	0.0 ± 0.0	10.4 ± 10.4
	n = 5	Dead standing	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Dead windfall	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD Chunk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total dead	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		CWD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		Total	50.1 ± 38.5	0.0 ± 0.0	0.0 ± 0.0	10.4 ± 10.4	0.0 ± 0.0	10.4 ± 10.4

APPENDIX E: COMPARISON OF CRUISE TO CHECK SURVEY DATA

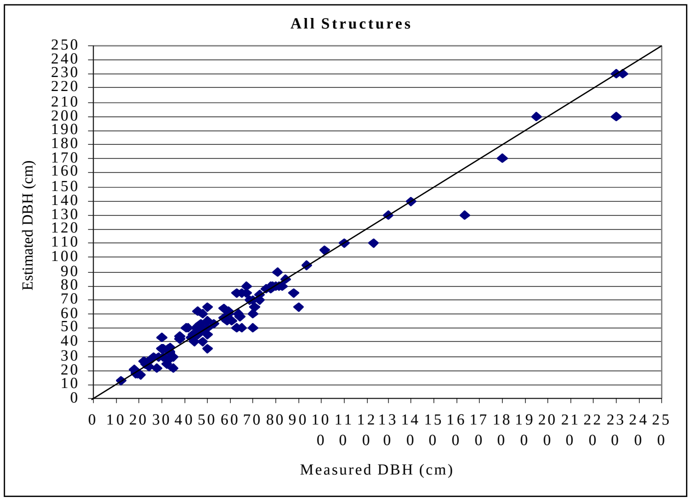

Figure 12. Comparison of measured to estimated dbh: all structures.

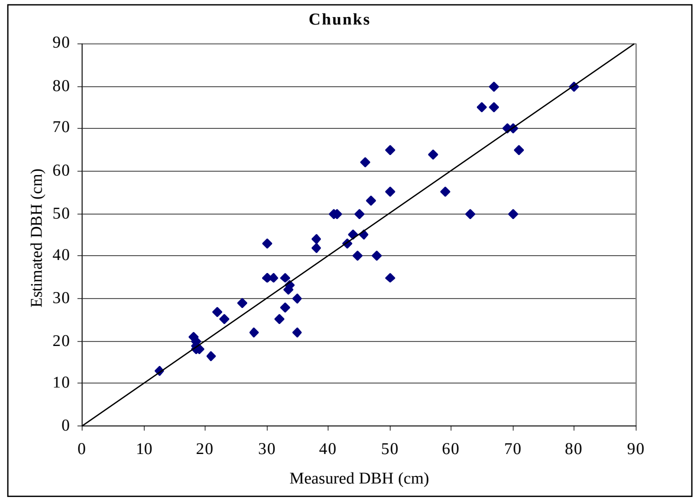

Figure 13. Comparison of measured to estimated dbh: chunks.

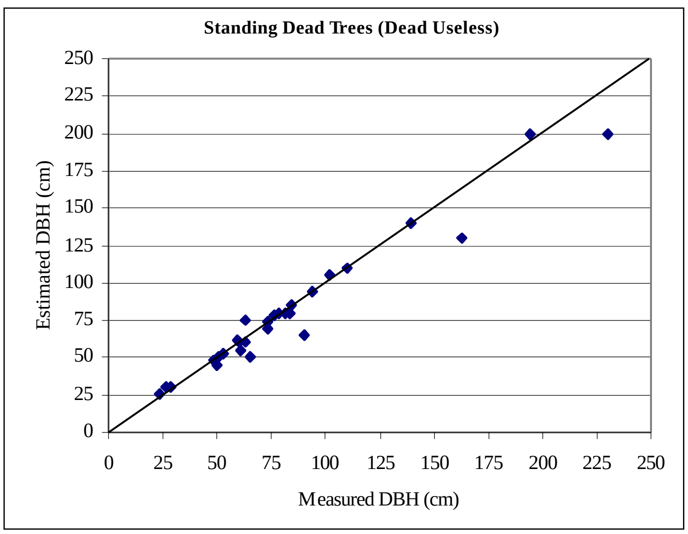

Figure 14. Comparison of measured to estimated dbh: dead standing.

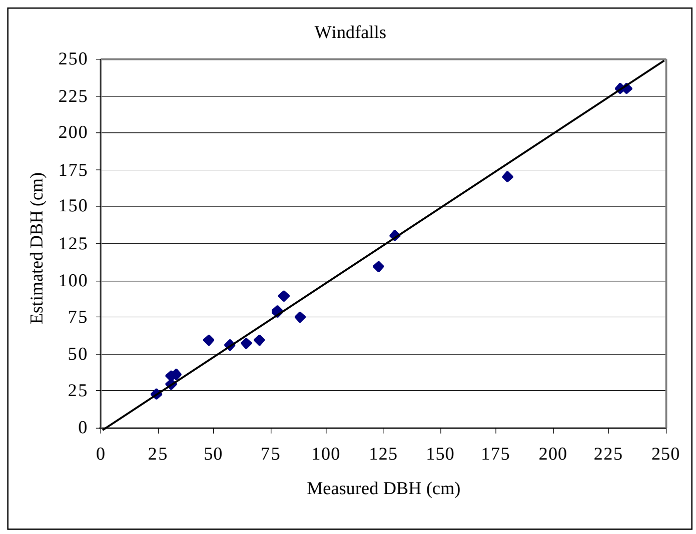

Figure 15. Comparison of measured to estimated dbh: windfalls.

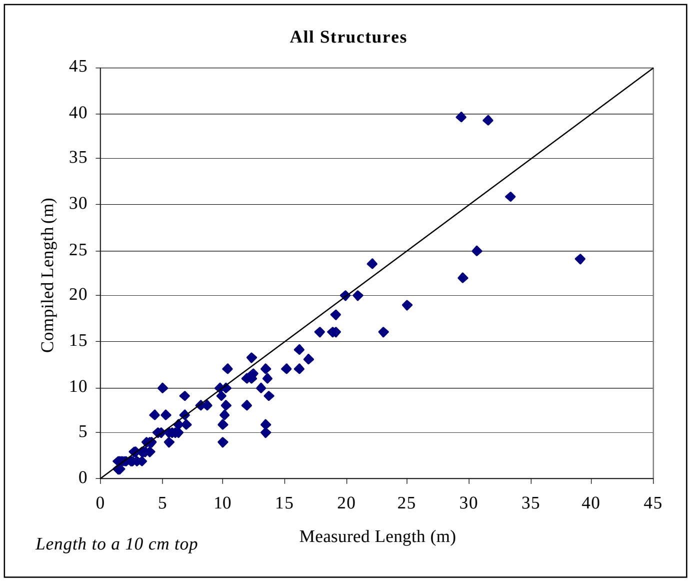

Figure 16. Comparison of compiled and measured length (to a 10 cm top diameter): all structures.

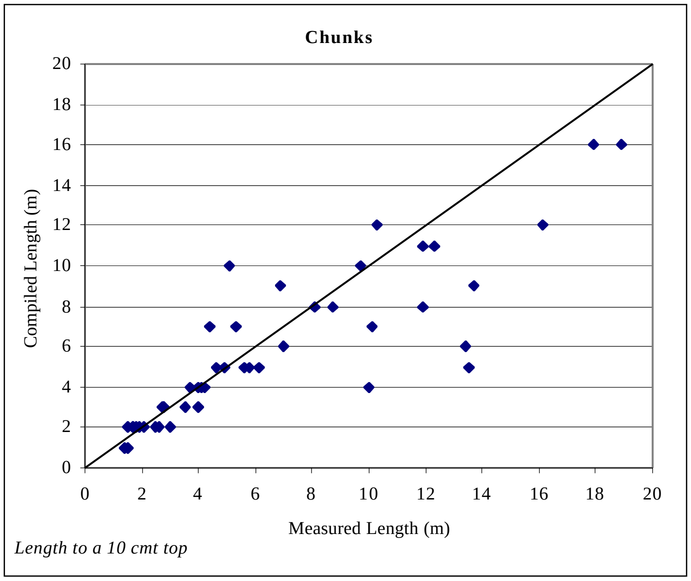

Figure 17. Comparison of compiled and measured length (to a 10 cm top diameter): chunks.

Figure 18. Comparison of compiled and measured length (to a 10 cm top diameter): standing dead.

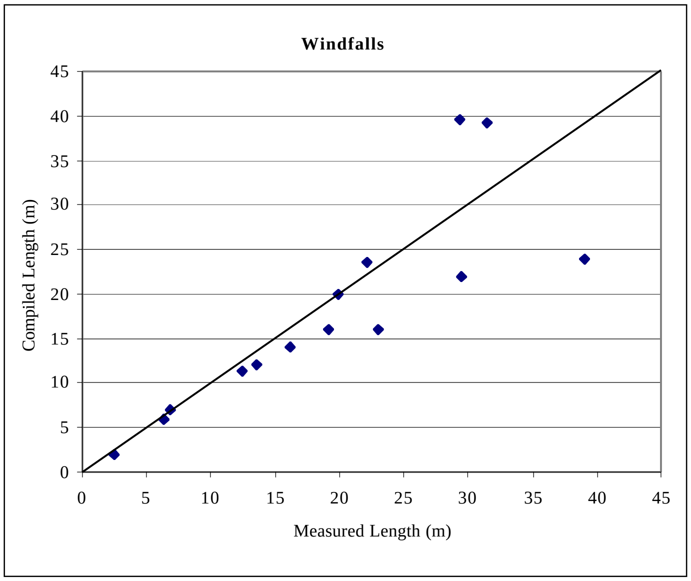

Figure 19. Comparison of compiled and measured length (to a 10 cm top diameter): windfalls.

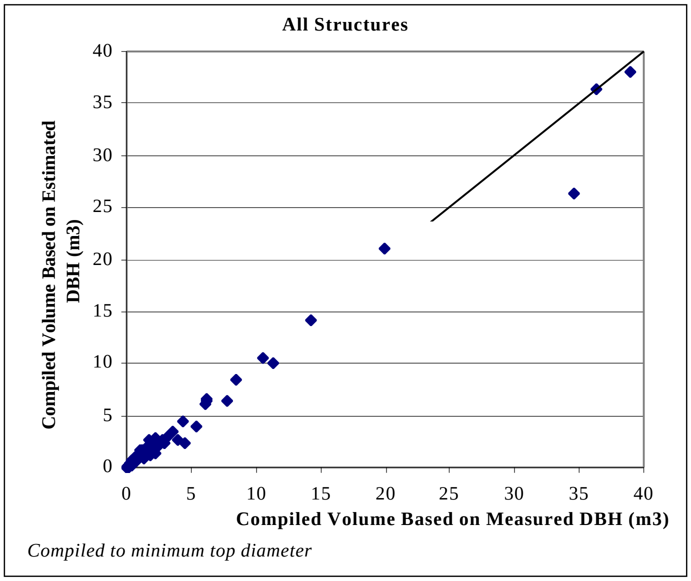

Figure 20. Comparison of compiled taper volumes based on measured and estimated dbh (to minimum top diameter): all structures.

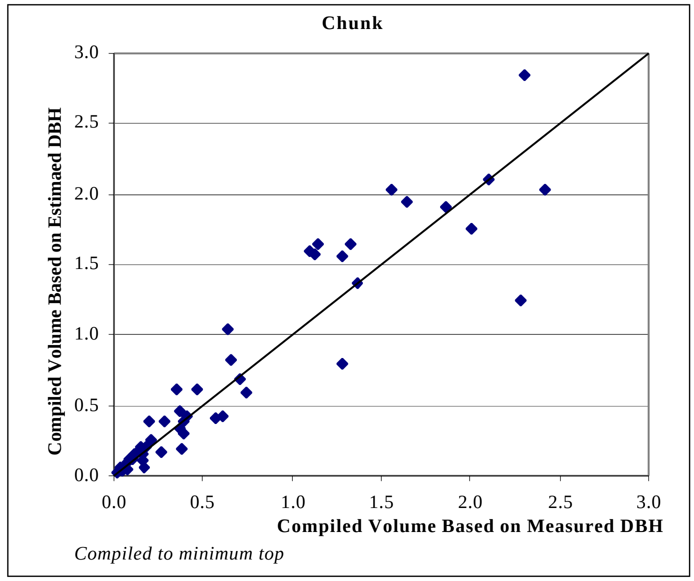

Figure 21. Comparison of compiled taper volumes based on measured and estimated dbh (to minimum top diameter): chunks.

Figure 22. Mean absolute difference in dbh by decay class: CWD.

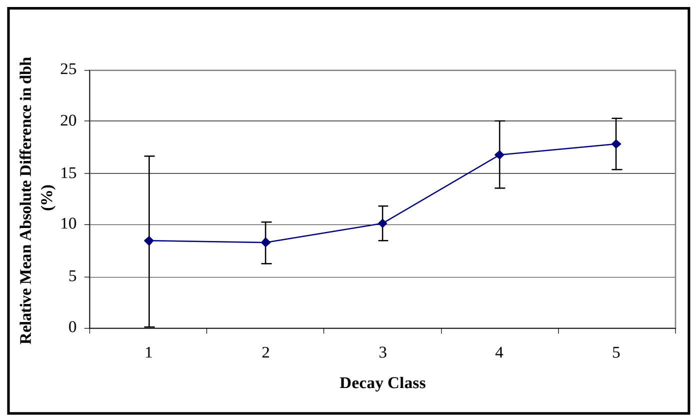

Figure 23. Relative mean absolute difference in dbh by decay class: CWD.

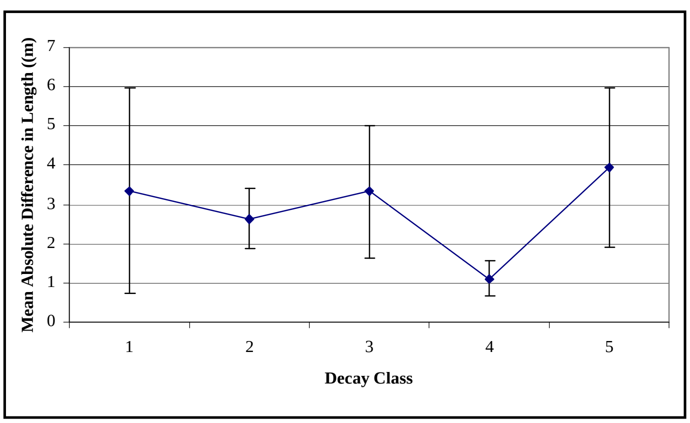

Figure 24. Mean absolute difference in length by decay class: CWD.

Figure 25. Relative mean absolute difference in length by decay class: CWD.

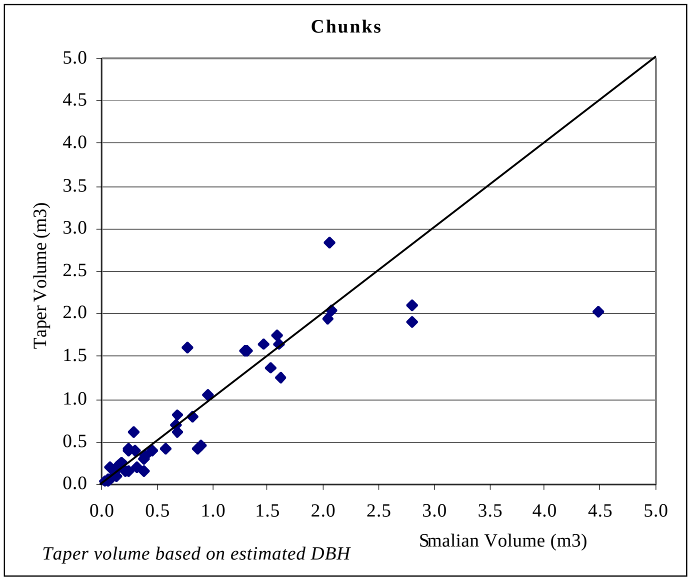

Figure 26. Comparison of Smalian and taper volumes (to a 10 cm top): chunks.

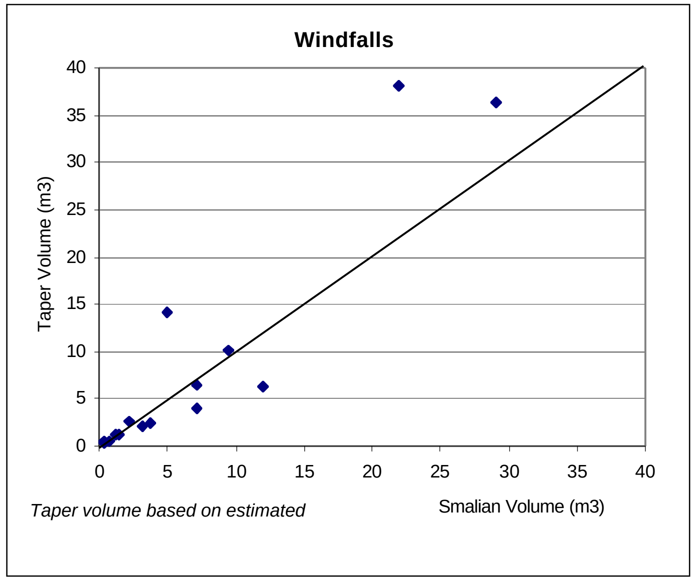

Figure 27. Comparison of Smalian and taper volumes (to a 10 cm top): windfalls.

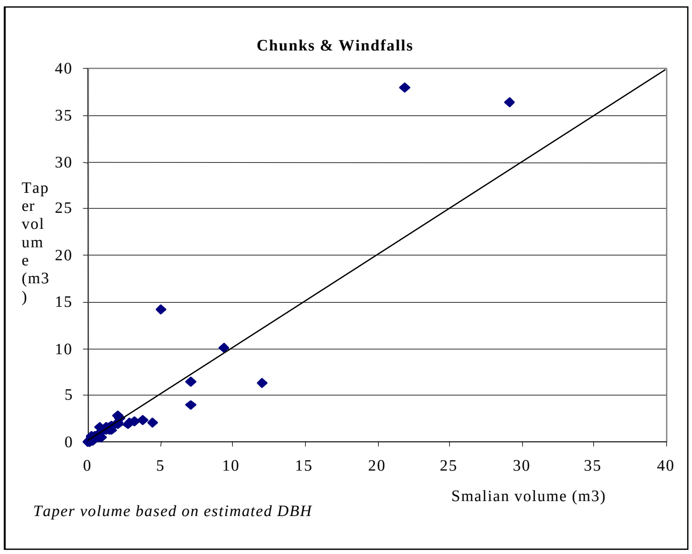

Figure 28. Comparison of Smalian and taper volumes (to a 10 cm top): chunks and windfalls.

APPENDIX F: SENSITIVITY ANALYSIS OF PLOT-LEVEL PARAMETERS BASED ON CRUISE AND CHECK DATA (PLOT TOTALS)

Subset (mean/Sem)		**1**	**2**	**3**	**4**	**5**	**6**
Total volume (m^3/ha)	Cruise	426.9 ± 87.6	360.6 ± 51.2	447.4 ± 106.5	428.7 ± 103.4	452.9 ± 107.6	445.0 ± 109.3
	Check	445.2 ± 89.7	396.3 ± 56.8	452.7 ± 109.1	442.4 ± 104.0	475.3 ± 110.0	459.4 ± 111.8
CWD volume (m^3/ha)	Cruise	265.1 ± 67.6	204.8 ± 32.3	291.6 ± 82.3	286.8 ± 82.4	270.2 ± 83.5	272.2 ± 83.9
	Check	289.0 ± 67.9	244.4 ± 37.3	306.1 ± 83.1	307.9 ± 81.5	293.5 ± 82.8	293.2 ± 84.4
Volume of Y- and Z-Grade	Cruise	202.7 ± 35.2	176.5 ± 25.2	205.3 ± 43.0	194.6 ± 41.2	223.1 ± 41.8	214.0 ± 42.6
wood (m^3/ha)	Check	215.3 ± 39.3	186.9 ± 31.5	214.2 ± 47.9	199.0 ± 44.1	240.8 ± 46.9	235.5 ± 47.4
Large CWD volume (m^3/ha)	Cruise	105.5 ± 56.9	43.7 ± 13.2	115.6 ± 71.0	118.7 ± 70.8	126.2 ± 70.6	123.4 ± 70.8
	Check	110.0 ± 57.1	49.6 ± 16.1	121.4 ± 71.1	124.1 ± 70.9	125.8 ± 70.4	128.9 ± 70.9
Subset (mean/Sem)		**1**	**2**	**3**	**4**	**5**	**6**
Total density (no./ha)	Cruise	716.4 ± 145.0	650.8 ± 121.4	787.1 ± 176.6	748.9 ± 175.6	662.9 ± 153.4	732.2 ± 178.2
	Check	1073.4 ± 138.7	1095.3 ± 157.2	1106.3 ± 163.8	1063.3 ± 153.3	1078.8 ± 139.2	1023.2 ± 163.2
CWD density (no./ha)	Cruise	562.2 ± 147.0	500.9 ± 120.9	640.0 ± 179.1	589.0 ± 179.5	482.5 ± 155.1	598.5 ± 180.0
	Check	752.2 ± 123.1	736.4 ± 133.0	807.4 ± 148.7	743.4 ± 141.7	687.6 ± 110.2	786.2 ± 152.2
Density of Y- and Z-Grade	Cruise	190.9 ± 36.6	214.9 ± 43.7	200.7 ± 43.6	167.8 ± 35.8	207.1 ± 44.7	164.0 ± 35.4
wood (no./ha)	Check	372.3 ± 80.7	442.2 ± 95.6	371.2 ± 95.8	350.9 ± 92.6	432.7 ± 97.0	264.3 ± 62.5
Density of Large CWD (no./ha)	Cruise	25.1 ± 7.1	22.1 ± 6.9	23.3 ± 8.1	25.0 ± 8.0	27.5 ± 8.0	27.7 ± 8.5
	Check	24.7 ± 7.0	22.3 ± 7.0	24.0 ± 8.2	23.5 ± 7.6	26.9 ± 7.9	26.7 ± 8.4