Dead Tree Management in British Columbia[1]

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Abstract

We highlight the historical development, current legislation, and operational practices regarding dead tree management in British Columbia (BC), Canada. BC's Forest Practices Code, which regulates forest management, enables resource managers to leave wildlife tree patches in harvested areas, and to consider the retention of coarse woody debris (CWD). At the same time, occupational health and safety regulations govern the retention of potentially dangerous trees in forestry operations, and current CWD policy enables the management of CWD only within harvesting utilization standards. Managing for the ecological values of dead trees without impacting timber supply is a challenge facing BC's forest managers.

Introduction

British Columbia (BC) is Canada's most ecologically and biologically diverse province, with areas of extensive alpine, rangeland, and forest. Ownership of the province's 95.2 million ha is predominantly public (94.7 percent). These lands are administered for many purposes including fish, wildlife, wilderness, recreation, heritage, water, minerals, range, and timber. The Ministry of Forests (MOF) manages, in cooperation with other provincial and Federal agencies, the timber, range, and recreation resources of the unreserved public forest land (about 59 million ha). From these lands about 65-70 million cubic meters of wood are harvested annually (Ministry of Forests 1998). The predominant (about 90 percent by area) silvicultural system is clearcutting or clearcutting with reserves of individual or clumps of trees.

The ecological values of dead trees are well recognized by the managers of BC's forests. Wildlife trees (standing dead trees and live defective trees) are a vital component of biodiversity, providing critical habitat for 80 species of birds,

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mammals and amphibians in BC, as well as habitat for a myriad of invertebrate and fungal organisms (Lofroth 1998, Machmer and Steeger 1995). Coarse woody debris (CWD; fallen dead trees) has similar critical roles for many species of plants (especially bryophytes and lichens), fungi, invertebrates, and small mammals (Harmon and others 1986, Stevens 1997). The value of dead wood, particularly for wildlife trees, is acknowledged in forest management in BC through regulations issued under legislative acts.

In this paper, we outline the history and status as of December 1999 of the legislation and management of dead wood on crown lands in BC.

History of Forest Management and the Dead Wood Resource

Forests provided important resources to the First Nations of BC in terms of housing, transportation, clothing, household goods, fuel, and food. Dead wood was valued for a variety of purposes. Turner (1998) identified specific uses of dead wood that include cottonwood *(Populus balsamifera* ssp. *trichocarpa)* for the hearth and drill for creating friction fires, rotten trembling aspen *(P. tremuloides)* as an absorbent material, decayed wood for smudge for tanning hides, and knots left in rotten western hemlock *(Tsuga heterophylla)* and spruce (*Picea* spp.) logs for curved fish hooks. Little has been summarized specifically on the management of dead wood by First Nations, whose population was likely between 200,000 and 300,000 in the mid-1700s (Muckle 1998). Undoubtedly forest management did occur, given the recognition of resource ownership by many First Nations. Prescribed burning was carried out for a number of purposes—primarily to create and/or maintain certain vegetative types and to clear the land around habitations. Single burns would add to the dead wood resource, while repeated burning would reduce levels of both standing and downed material.

Commercial forest harvesting in BC began in earnest in the late 1800s. It was concentrated in the valuable and easily-accessible timber of the west coast and at lower elevations of major valleys in the interior of BC. Impacts on the forest were generally low because only the more valuable and easily-transported trees were cut. Undesirable species may have been felled to provide a cushion and reduce breakage of valuable trees felled subsequently. A legacy of high stumps was left due to the use of springboards to cut above butt flares. Additionally, the lower portions of felled trees were sometimes too massive to move and so were left in place. This increased the proportion of large diameter, fresh CWD in forests.

The use of high-lead yarding and extensive railway logging networks began just before World War I, ushering in clearcutting as a harvesting system. At the same time, slashburning was promoted by the BC Forest Service to reduce the fire hazard on logged coastal sites. The application of fire was deemed appropriate to remove fuels and create a seedbed amenable to natural regeneration. Some CWD would be removed by these controlled burns, but given that partial cutting (essentially high-grading) was still common, a supply of fire-killed standing dead trees was created at the same time.

Fire prevention has been encouraged since 1905, when fire wardens were first appointed. Early controlled burning reduced logging slash loadings but escaped burns increased dead wood resources. Human-caused wildfires have done likewise. Effective fire suppression began in the late 1950s due to improved fire detection,

technological advancements, such as air tankers and lightweight fire pumps. While the number of wildfires has increased since the late 1950s (from an average of 1,583 per year in the 1940s and 1950s to 2,493 in the 1980s and 1990s), the area burned has dramatically declined. Total area burned for the respective periods was 3,000,462 ha and 1,265,573 ha, as average fire size decreased from 94 to 25 ha.

Artificial reforestation was initiated in coastal BC in 1939 and in the Interior in 1950. To reduce the fire hazard and improve safety for planting crews, snags were felled on parts of Vancouver Island as early as 1942. In 1946 the Forest Act was amended to make snag falling compulsory concurrent with logging operations in the Vancouver Forest District (Statutes of British Columbia 1946). All standing dead trees taller than 10 feet were felled, that being the height to which a man could apply dirt with a shovel to extinguish a burning snag.

By 1947, changing logging methods, closer utilization and salvage operations had reduced the amount of logging residue. A 1943 pulpwood salvage study found that salvable wood accounted for 19 percent of the total utilizable stand volume, the rest having been taken in the first pass for sawlog production (MacBean 1946). Slash burning became less common on the Coast and was replaced either by spot burning or no burning at all. This increased the amount of remaining medium-sized CWD. Snag falling continued, largely as a fire prevention and safety measure, resulting in most dead wood being on the ground and little left standing.

Environmental concerns became more prominent in the mid-1960s and early 1970s. Resource management guidelines dealt primarily with wildlife habitat, soil conservation, stream protection, riparian zone management, silvicultural systems, cutblock size and arrangement and road location. The general guidelines did not address site-specific issues such as CWD or wildlife trees, which had not yet been identified as items requiring consideration and management. Indeed, in 1978 the responsibility to "fall snags progressively with the felling of adjacent live timber" in all forest operations was entrenched in the Workers' Compensation Board (WCB) Industrial Health and Safety Regulations (Workers' Compensation Board of British Columbia 1998).

The Ministry of Forests Act of January 1, 1979 instructed the Ministry of Forests to integrate and coordinate the management of timber, range, fisheries, wildlife, water, outdoor recreation and other natural resource values (Revised Statutes of British Columbia 1979). Integrated use involved altering harvesting prescriptions to provide benefits to established resource users, mitigating the effects of harvesting, and facilitating change in forest conditions to support new uses. The main variables were dispersal of activities, size of cutblocks, time interval between the sequential removal of adjacent blocks and location of roads and other infrastructure (Ministry of Forests 1984). All of these are landscape level issues and no provisions specifically addressed the conservation of dead trees.

General recognition of the ecological importance of dead trees started to emerge in BC in 1979, following the lead of research and management in the U.S. Pacific Northwest. In February 1979, Kamloops Forest Ranger Jack Weinard initiated a process he called the "rule of thumb" for snag management in the Kamloops Ranger District (Stevenson 1999). In the 1980s, the Ministry of Forests and Ministry of Environment jointly developed a wildlife tree signing program. This involved placement of "Wildlife Tree: Do Not Disturb" signs on selected wildlife trees (Backhouse and Lousier 1991). In 1985 the BC Wildlife Tree Committee, a multi-

agency group, was formed to consider the conservation and management of wildlife trees—particularly as related to their safe maintenance within forest operations (Manning 1995). This committee was instrumental in raising awareness of the need for legislation, regulations, guidelines and the importance of management of the dead tree resource.

In the 1990s the importance of dead trees was recognized through significant policy, management, and legislative change. A problem analysis by Backhouse and Lousier (1991) highlighted the importance of wildlife trees and the need for changes in wildlife tree management. The initiatives of the multi-agency BC Wildlife Tree Committee began to take root. Through interpretation of the term "hazardous," the WCB began to recognize that not all standing dead trees were dangerous and that standing dead trees had ecological value. Wildlife/danger tree assessment procedures and training programs were initiated (Manning 2002). Management for wildlife trees began to appear in regional and provincial guidelines.

Initiatives for CWD have lagged behind those of wildlife trees in BC. In fact, the Ministry of Forests initiated and still has in place a strict residue and waste policy as part of its utilization standards (Caza 1993). This policy requires licensees to remove all wood above certain size and soundness limits while harvesting and penalizes them if they do not.

Current Legislation and Regulations

In 1995, BC introduced major changes to the legislation affecting forest resource management with the implementation of the Forest Practices Code of British Columbia Act. The Forest Practices Code establishes mandatory requirements for planning and forest practices, sets enforcement and penalty provisions, and specifies administrative arrangements. The regulations under the act lay out the forest practices that apply province-wide, including the planning framework. This act applies to all crown lands outside of protected areas, or about 80 percent of the land base in BC (Fenger 1995).

Guidance for planning is provided in a number of ways, including forest practices guidebooks and various levels of policy. This guidance is not normally binding until it is written into a higher level plan or operational plan (see http://www.for.gov.bc.ca/tasb/legsregs/fpc/hilevel/hlp-toc.htm for a detailed outline of the hierarchy under the Forest Practices Code). Landscape Unit Planning is the higher level process that sets the legal requirements for wildlife tree retention and old-growth management. Landscape Units usually cover a watershed or a series of watersheds and average about 70,000 ha. Other higher level plans (e.g., Local Resource Management Plans that address a region with many landscape units) may also provide direction on dead tree management. Further guidance for wildlife trees and CWD is found in Forest Practices Code documents, such as the *Biodiversity Guidebook*, *Riparian Management Area Guidebook*, and the *Identified Wildlife Management Strategy* (Ministry of Forests and BC Environment 1995a, 1995b, 1999).

The importance of wildlife trees is well recognized within Forest Practices Code regulations and guidelines. The Forest Practices Code of British Columbia Act and associated regulations provide the framework for wildlife tree management by ensuring that wildlife tree objectives are stated, that wildlife tree and other reserves

are clearly mapped within operational plans and marked in the field, and that penalties for non-compliance are in place *(table 1)*. Further, changes made in April 1998 to the WCB Occupational Health and Safety Regulations now enable greater retention of standing dead trees that do not pose a safety hazard *(table 2)*.

Table 1—*Forest Practices Code of British Columbia Act and associated regulations that relate to dead trees (the act and regulations are available at http://www.for.gov.bc.ca/tasb/legsregs/comptoc.htm).*

Act or Regulation	What
Forest Practices Code of British Columbia Act	12. A silviculture prescription must comply with the following: (a) it must include, for the area under the prescription, (i) long term management objectives set out (A) in a Forest Development Plan… (ii) a description of the silvicultural system and post harvesting stand structure and site condition 41(1)(b) "the district manager is satisfied that the plan or amendment will adequately manage and conserve the forest resources of the area to which it applies." 41(2) before approving a plan or amendment the district manager may require the holder to submit information that the district manager reasonably requires in order to determine if the plan or amendment meets the requirements of subsection (1)
Operational Planning Regulation	Section 1 - Definitions: "wildlife tree" means a tree or group of trees that are identified in an operational plan to provide present or future wildlife habitat 18(1) A person must ensure that a forest development plan includes the following information for the area under the plan: … (u) the general objectives respecting the target levels of retention for coarse woody debris and wildlife trees 32. A person must ensure that a logging plan contains a map of the area under the plan illustrating the topography and … (b) the approximate location of (i) mappable reserves including wildlife trees and wildlife tree patches 39(2) A person must ensure, for the area under the silviculture prescription, that the silviculture prescription describes the location of the following: … (d) mappable reserves, including wildlife tree patches and riparian reserve zones 39(3) A person must ensure, for the area under the silvicultural system, that the prescription does the following … (c) describes the silvicultural system to be used, including the species and function of any trees left standing. … (m) describes (i) the volume and range of piece sizes of coarse woody debris, if any, necessary or required to accommodate any objectives for coarse woody debris established in a forest development plan and that are applicable to the area under the prescription 50(2) A stand management prescription must … (b) contain a map illustrating … (ii) for the area under and adjacent to the prescription, the following items: … (D) the approximate location of mappable reserve areas, including wildlife tree patches
Timber Harvesting Practices Regulation	3(1) A person carrying out harvesting must mark in the field, before commencement of harvesting, the location of all wildlife trees or wildlife tree patches that are (a) 0.25 hectares or more, unless exempted by the district manager, and (b) less that 0.25 hectares, if required by the district manager (2) A person required to mark a wildlife tree or wildlife tree patch, under subsection (1) must ensure that the marking is visible during harvesting and is marked in a manner that will remain visible for at least 6 months after the completion of harvesting 28. A person must not carry out a minor salvage operation in any of the following areas unless harvesting the area has been approved in a silviculture prescription or the person has received in writing from the district manager the terms and conditions that apply to the carrying out of the minor salvage operation: … (c) wildlife tree patches;
Timber Harvesting Practices Regulation (Administrative Remedies Regulations Schedule)	Harvesting or damaging trees that are required by the silviculture prescription to be left standing or undamaged—$5000. Failure to mark in the field the location of wildlife trees or wildlife tree patches, before commencement of harvesting operations—$5000

Table 2—*Workers' Compensation Board Occupational Health and Safety Regulation as related to dead trees (these regulations can be viewed at http://www.worksafebc.com/policy/regs/contents.asp).*

Act or Regulation	What
Workers' Compensation Board Occupational Health and Safety Regulation	26.11(1) If work in a forestry operation will expose a worker to a dangerous tree, the tree must be removed. (2) Trees that will interfere with rig-up, the movement of lines and equipment, or that could be pushed or pulled into the work area must be removed. (3) Saplings over 6 m (20 ft) tall, in an area where cable logging is being done, must be removed before yarding commences. (4) If it is not practicable to comply with subsection (3), such as during partial cutting operations, alternative work methods or procedures which minimize the risk to workers may be used, and the work must be directed by a supervisor who has, as far as practicable, controlled the danger to any worker. (5) Any dangerous tree, regardless of height, located within an active hand falling or cable logging operation must not interfere with safe falling or yarding practices, and if it does interfere, it must be removed. (6) A dangerous tree in a forestry operation may be left standing during operations other than construction or harvesting if (a) no significant ground vibrations are likely to be produced, (b) no work will be done within reach of the tree when wind speed exceeds 20 km/h (12mph), and (c) tree assessor who has completed a training program acceptable to the board determines that the tree will not be dangerous to workers during the planned activity (7) If tree planting is to be done in an area that has more than 500 dangerous trees per hectare, the board may approve a request to work without removing all the dangerous trees if, before work commences, (a) a representative sample of the dangerous trees is assessed by a tree assessor who has completed a training program acceptable to the board, (b) any findings of the assessment as to the removal of dangerous trees or other trees are implemented, and (c) no silviculture is done within reach of dangerous trees when wind speed exceeds 20km/h (12 mph).

The importance of CWD is also clearly recognized within the Forest Practices Code regulations but, unlike wildlife trees, detailed provincial CWD management guidelines are lacking. References to CWD management within the *Biodiversity Guidebook* and the *Managing Identified Wildlife Guidebook* are less specific than references to wildlife trees. Several interim CWD guidelines have been drafted, but consensus has not been reached (see http://www.for.gov.bc.ca/research/deadwood/Dtgui.htm#BC for the current short-term strategy). Concerns not only also exist where specific CWD volume retention targets may conflict with present timber utilization standards as expressed in Ministry of Forests policy, but volume retention targets also conflict with wood below the standards that the forest licensees consider economical to harvest (Ministry of Forests Policy 8.1—Timber utilization—coastal and interior available at http://for.gov.bc.ca/tasb/manuals/policy/resmngmt/rm8-1.htm).

Current Management

Wildlife tree management includes both the retention of suitable trees at the time of harvest and during silviculture activities, and provision for recruitment of suitable replacement wildlife trees over the harvest rotation period. Operationally, there are three types of wildlife tree management strategies. These are wildlife tree patches (WTPs), individual live tree retention, and artificially created wildlife trees. Potentially, all three approaches can be applied in a single harvest area, although WTPs are generally the most operationally feasible (i.e., easier to accommodate various block layouts, topographic considerations, and harvesting methods) and the safest method for forest workers to retain wildlife trees. If selected carefully, WTPs can incorporate all or some of the habitat attributes commonly associated with the conservation of biodiversity at the stand level. These attributes include horizontal and vertical stand structure, wildlife trees, CWD, intact forest floor, and various special habitats, such as riparian areas, wetlands, gullies and rock outcrops. However, given our understanding of the ecological values of wildlife trees, it is prudent to also retain dispersed single trees within the landscape.

In 1995 the Biodiversity Guidebook brought forward a tabular approach to determining wildlife tree retention requirements for a particular area. Two variables must be known to allow determination of wildlife tree retention:

- Percent of the area available for harvest (i.e., percent of the total area deemed to be operable).
- Percent of the operable area already harvested without wildlife tree retention.

Knowing these numbers, an area retention objective ranging from 1 percent (where most of the area is inoperable and very little harvesting without wildlife tree retention has occurred) to 15 percent (where the area is highly operable and a large portion has been harvested without wildlife tree retention) is determined. These retention objectives can be applied as area-based WTPs or as a basal area equivalency for individual tree retention.

To date, Ministry of Forests district managers have generally provided policy as per the retention objectives and communicated them to licensees for incorporation into their silviculture prescriptions (an operational plan required prior to harvesting). With the recent issuance of the Landscape Unit Planning Guide, these will now be incorporated as landscape unit objectives (Ministry of Forests and Ministry of Environment, Lands and Parks 1999).

A silviculture prescription map must show the location of the WTPs that make up the retention objective and state the basal area equivalence for single tree management. A significant proportion of this retention will come from inoperable areas, such as riparian reserves. In addition, placement of wildlife tree patches should consider:

- Worker safety; only wildlife trees which are assessed as safe may be left outside of a patch within the work area.
- Location of good wildlife tree attributes, e.g., center a patch around a well-used wildlife tree or group of wildlife trees.
- Areas of tree species that are potentially valuable as wildlife trees and relatively uncommon.

- Stability of chosen patch, e.g., it may be advisable to locate patches adjacent to standing timber of a riparian reserve if there is concern regarding windthrow.

The decision to retain individual trees as wildlife trees in a harvest block will depend on the characteristics and condition of those trees (e.g., species, size, evidence of wildlife use, branching structure, decay, wind firmness, and safety considerations), and other management objectives (e.g., type of silvicultural system, harvesting method, and rotation length). In most cases, individual trees must be retained through the rotation in order to receive credit as wildlife trees in the management prescription. However, except for initial layout and considerations for wind firmness, no long-term management prescriptions for wildlife tree patches have usually been expressed.

In BC, hazard/danger tree assessment procedures developed by the Wildlife Tree Committee of BC are in place, along with appropriate training, concerning the management and retention of wildlife trees (Manning 2002). These guidelines are intended to provide information and technical procedures for assessing and safely retaining trees (some of which are potentially dangerous) in all types of forestry operations.

In some circumstances, trees are artificially modified to create or enhance wildlife tree habitat values. Methods used in BC include tree-topping, fungal inoculation, girdling, "planting snags" with an excavator, or cutting stems at 3 to 6 metres in height ("stubbing") with a mechanical harvester (Deal 1995, Harris 1995). The practice of modifying trees is usually only undertaken to remove specific safety hazards, or to augment other methods of habitat retention.

CWD management is less advanced than wildlife tree management, particularly due to the lack of CWD management guidelines. However, CWD objectives must be defined in forest development plans that guide individual silviculture prescriptions. CWD objectives must be balanced with other potentially competing stand management objectives such as fuel management.

CWD objectives defined in forest development plans range from general statements to more specific CWD volume retention targets. CWD volume targets are usually based on a volume that can be easily achieved within standard operational practice or a minimum of the range found in unmanaged primary forests (Stevens 1997). At present, forest companies are encouraged to leave behind as much CWD as possible provided it does not exceed the minimum utilization standards or interfere with other stand management objectives (i.e., forest health). This may be perceived as the status quo and often leads to the development of vague CWD management objectives, although it does not necessarily translate into low CWD retention.

In the case of general CWD management objectives—such as "within the requirements of normal utilization standards the licensee will try to maintain current levels of CWD on each cutblock providing post-treatment objectives, forest health, and fire hazard are not compromised"—the result on the ground depends greatly on the type of stand harvested, the pulpwood market, the harvesting and site preparation techniques, and the knowledge of the operators. For example, the whole-tree harvest of a 60-year old lodgepole pine (*Pinus contorta* var. *latifolia*) stand that has a history of underburn fires and, similarly, the harvest of coastal second-growth stands which were subjected to shake salvage will often result in very low post-harvest levels of CWD. On the other hand, clear-cut harvesting of a high elevation subalpine fir *(Abies*

lasiocarpa) stand with many standing dead trees will generally yield high levels of CWD.

Communication between on-the-ground operators, foresters, and ecologists is important to minimize the adverse impact on the CWD resource and to maximize timber use. However, such communication varies within BC. Through communication, the experience of the operators plays an important role in the retention of CWD. An experienced on-the-ground operator may be able to leave uneconomic wood at the stump rather than hauling it to the landing by identifying only economic grade logs that should be yarded to the roadside, bucking out unmerchantable sections on the site, and retaining full-length intact uneconomic logs (Arsenault 2002).

Regulations and guidelines not only direct on-the-ground decisions but are considered in higher level forest management decisions, such as the determination of the allowable annual cut (AAC). In British Columbia, the AAC is determined by the Chief Forester of BC every 5 years for each of the 70 forest management units administered by the Ministry of Forests. To assist the decision of the Chief Forester that is based on social, economic, and ecological considerations, a timber supply review is conducted. The timber supply review uses simulation models in which the timber flow (merchantable volume that excludes most endemic dead wood) of the unit is projected. The models use current forest cover inventory and constraint information that reflect existing management practices, such as cutblock adjacency and ungulate winter range requirements, to model current and future timber flows (although the AAC decision is only for the first 5-year period).

In the timber supply review, wildlife tree patch requirements are commonly modeled by reserving a percentage of forest within a biogeoclimatic subzone in a landscape unit. CWD has not been considered directly as operational practices do not directly influence the merchantable volumes attributable to the AAC. Current practice has only used uneconomic CWD below utilization levels, though recent relaxation of utilization accounting could enable the retention of small volumes of some lower grades of wood. Non-recoverable losses, such as those caused by pest or fire, are excluded from the timber flow projections.

Management Support

Forest management planning in BC is supported by a variety of inventories, surveys, and projection tools. In the 1990s, under the auspices of the multi-agency Resources Inventory Committee, BC initiated substantial standardization and updating of resource inventories. The new provincial Vegetation Resources Inventory, that is to replace an existing provincial forest cover inventory, includes provision for both wildlife tree and CWD sampling (Ministry of Forests 1999). However, the majority of ground-based samples are expected to have a timber emphasis and not include items such as CWD. Procedures for describing terrestrial ecosystems include wildlife tree and CWD sampling (Ministry of Forests and Ministry of Environment, Lands and Parks 1998). Pre-harvest timber cruises provide counts of standing dead trees but typically only those with >50 percent sound wood. Similarly, post-harvest residue and waste surveys only sample merchantable wood volumes. Standards for growth and yield permanent sample plots were modified in 1999 to include standing dead tree measures. This information will be used to enhance existing standing and down dead tree models incorporated in growth and

yield models used in forest management planning (Stone and others 2002). Although there is an expectation of improved dead tree information, these new sampling procedures need to be evaluated to ensure their usefulness.

Research on dead trees and their ecological values is conducted by the many research organizations in BC: provincial and Federal governments, academia, industry, and consultants. Little research on CWD was conducted in BC prior to the 1990s (Candy and Swan 1995, Caza 1993), although as early as 1929 MOF researchers showed some interest in CWD dynamics (Stone and others 1998). The past decade has seen increased research on the roles and dynamics of dead trees in BC and limited investigation of the effects of current harvesting practices on dead wood volumes and attributes. Forest Renewal BC, a Crown corporation established in 1994 that derives monies from stumpage revenues, has funded a variety of recent research on dead wood, including experimental manipulation of CWD, snag dynamics, CWD dynamics, the ecology of dead wood dependent organisms, and forest productivity relationships (Feller 1977, Huggard 1999). However, we still lack knowledge of the specifics of many of the ecological roles and dynamics of dead trees in conjunction with forest stand development and management (Lofroth 1998).

Education about dead trees has occurred at many levels in BC. Legislation and guidelines have provided many incentives to learn about the value of dead trees. A variety of informational brochures and publications have been made available (Kremsater and Nicholson 1995; Machmer and Steeger 1995; Ministry of Environment, Lands and Parks, and Ministry of Forests 1999; Stevens 1997). Hundreds of forest workers and professionals have received formal training for wildlife/danger tree assessment and riparian management (Forestry Continuing Studies Network of British Columbia: http://www.fcsn.bc.ca). Wildlife trees have been included in public school education programs such as Project WILD (Post and others 1994). Students themselves have created informational software with a wildlife tree and CWD component (Neal and Taylor 1996).

Discussion

The abundance and distribution of dead wood is highly variable and depends largely on disturbance history, stand age, tree species composition, ecosystem type, and decomposition rates. Standing dead trees and CWD will vary in size and stages of decay, even within the same forest. Maintaining the natural variability of dead wood at both the stand and landscape levels needs to be an objective for sustainable forest management. However, there are many real and perceived constraints that make this challenging. Some of the constraints limiting the retention of dead wood in BC's forests are: worker safety (particularly with standing dead trees); logging costs; utilization policy; resistance to change; harvesting techniques; pulpwood markets; salvage initiatives; silvicultural objectives; fuel management; and forest health. Another challenge is defining the natural variability of dead wood, considering the dynamic nature of ecosystems over time and space.

BC's forest management is still mainly concerned with the harvesting of older primary (previously unlogged) forests. These primary forests provide opportunities for management of the dead tree resource that may not be present in second-growth forests established with little consideration for the ecological values of dead trees. Of special concern is the recruitment of large standing dead trees and fresh CWD in second-growth stands. In some instances, most CWD remaining on such sites

originated from the first harvest of the primary forest and is therefore large, but usually well-decayed. Where biodiversity is a management objective in second-growth stands, specific strategies, such as direct felling and retention of live stems, will need to be developed to provide for CWD and wildlife trees of all species, size, and decay classes.

Policy has separated the management of wildlife trees and CWD in BC. To a large extent this reflects a lack of specific CWD targets in terms of volume and dimensions. As CWD targets or clearer ecological objectives are developed, it will be important to evaluate how wildlife tree reserves will address long-term CWD input—a current assumption of forest managers. Three main challenges face us. The first is implementation and evaluation of no-cost opportunities for retaining CWD (e.g., minimizing piles). The second is collection of dead wood attributes on both natural and managed stands to provide the necessary background to establish defensible CWD targets that are fully integrated with wildlife tree reserve goals. The third is integration by resource managers of CWD ecological values and management with the traditional view of CWD as salvage, slash, fuel, and waste (Arsenault 2002).

The management and recognition of the dead tree resource in BC has improved since the time when dead trees were left standing only if we could cover their tops with dirt. However, the balancing of dead tree ecological values and timber supply is a challenge still facing BC's forest managers.

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