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Analysis of the Newfoundland Forest Service Permanent Sample Plot Dead Wood Transect Dataset

M.T. Moroni and D.D. Harris

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NRCan, Canadian Forest Service - Atlantic Forestry Centre
C.P. 4000
Fredericton (N.-B.) Canada E3B 5P7
Tel.: (506) 452-3500
Fax: (506) 452-3525

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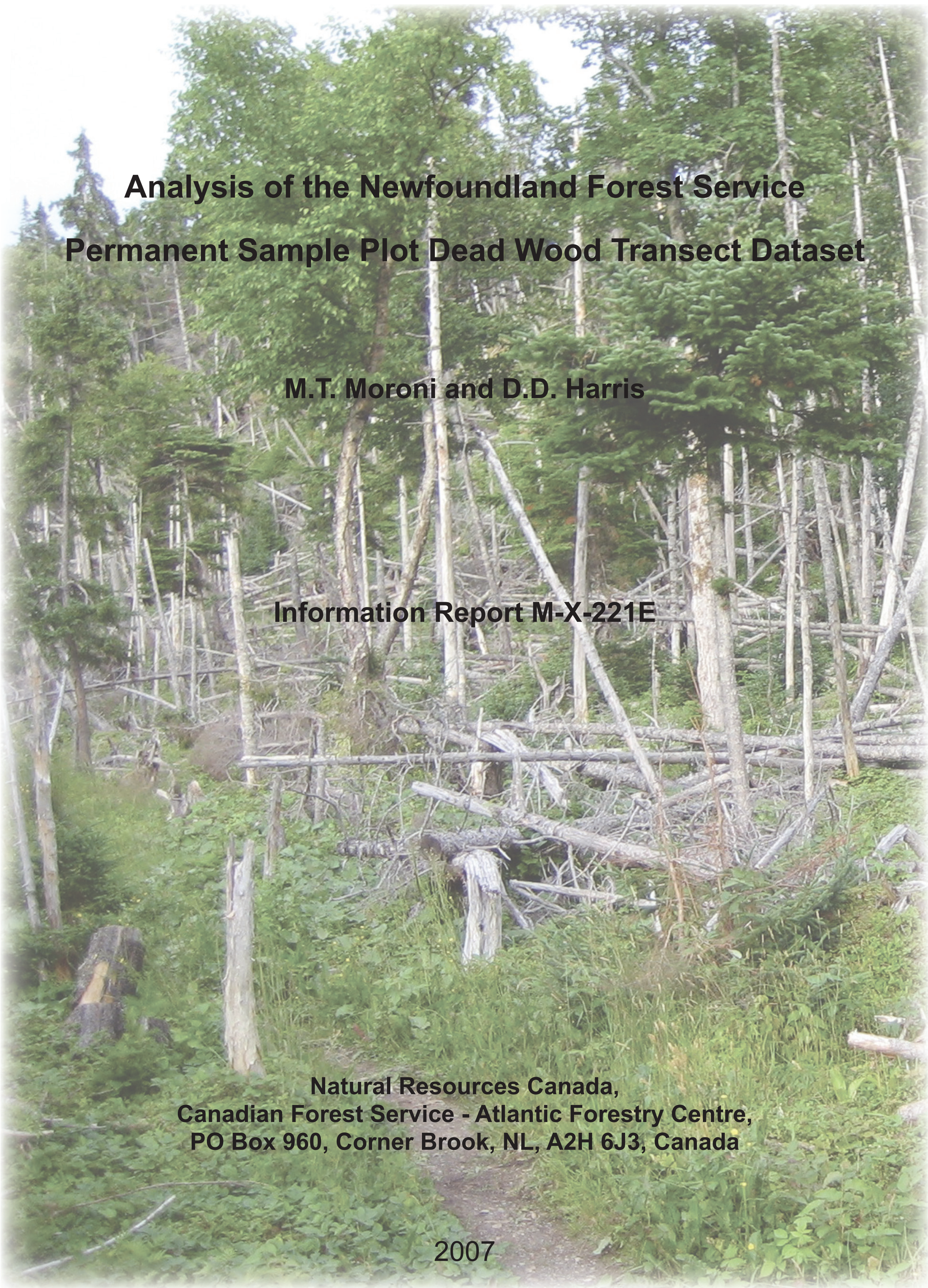

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PO Box 960, Corner Brook, NL, A2H 6J3, Canada

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Abstract

The Newfoundland Forest Service (NFS) and the Canadian Forest Service cooperated to review the NFS permanent sample plot (PSP) dead wood data and data collection procedures. Dead tree (snag) frequency and diameter at breast height (dbh) data from the dead wood transect, when combined with the same data from the greater PSP plot, should be sufficient to estimate dead tree frequency by dbh class, and provide coarse estimates of dead tree volume for all Newfoundland PSPs. In addition, the frequency and diameters at what would have been breast height for downed dead wood (or woody debris (WD)), when combined with the same data from the greater PSP should be sufficient to estimate WD frequency separated by dbh across PSPs. However, only untagged trees within the PSP are recorded. Tagged dead trees that met PSP tagging criteria, that were either tagged when dead or tagged live trees that subsequently died, are not included in the dead wood transect. As such, other attributes recorded in the dead wood transect that were not also recorded for tagged dead trees in the greater PSP plot are incompletely measured. Changes to the PSP data collection procedures are recommended in order to make the dead wood data more complete and useful.

Résumé

Le Newfoundland Forest Service (NFS - Service des forêts de Terre-Neuve) et le Service canadien des forêts (SCF) ont collaboré à l'examen des données sur le bois mort des placettes d'échantillonnage permanentes (PEP) du NFS ainsi que des procédures de collecte de ces données. Les données sur la fréquence et le diamètre à hauteur de poitrine (DHP) des arbres morts (chicots) des transects de bois mort, lorsque combinées avec les mêmes données des grandes PEP, devraient être suffisantes pour estimer la fréquence des arbres morts en fonction de la classe de DHP et pour obtenir des estimations grossières du volume d'arbres morts pour toutes les PEP de Terre-Neuve. En outre, la fréquence et les diamètres à ce qui aurait été la hauteur de poitrine pour le bois mort au sol (ou débris ligneux), lorsque combinés avec les mêmes données des grandes PEP, devraient être suffisants pour estimer la fréquence des débris ligneux en fonction du DHP dans l'ensemble des PEP. Cependant, seules les mesures des arbres non marqués situés dans les PEP sont consignées. Les arbres morts marqués qui satisfaisaient aux critères de marquage des PEP et qui ont été marqués vivants ou une fois morts ne sont pas inclus dans les transects de bois mort. Par conséquent, les autres attributs consignés dans les transects de bois mort, mais non consignés pour les arbres morts marqués dans les grandes PEP, ont été mesurés de façon incomplète. Des changements aux procédures de collecte de données dans les PEP sont recommandés afin de faire en sorte que les données sur le bois mort soient plus complètes et plus utiles.

Introduction

Dead wood is an important yet poorly documented component of forest structure. Dead wood is important to carbon and nutrient cycling (Kurz and Apps 1993, Lambert et al. 1980), habitat (e.g., Newfoundland birds (Thompson et al. 2003, Smith et al. submitted), and mammals (Thompson and Curran 1995)), and is fuel for forest fires (van Wagner 1968). Dead wood dynamics are affected by disturbance history, forest type, growth, rates of snag fall, and rates of decay. Forest dead wood dynamics are poorly understood and require further investigation.

The Newfoundland boreal forest is dominated by balsam fir (*Abies balsamea* (L.) Mill.) and black spruce (*Picea mariana* (Mill.) B.S.P.). Harvesting is the major anthropogenic disturbance in Newfoundland, where ~17 500 ha/year are clearcut, roughly half in balsam fir and half in black spruce (Newfoundland Department of Forest Resources and Agrifoods 1998). The major natural disturbances in Newfoundland forests are fire in black spruce (Wilton and Evans 1974) and insect outbreaks in balsam fir (Hudak 1996, Hudak and Raske 1981). Newfoundland has been divided into ten ecoregions with 18 sub-ecoregions containing 33 ecologically based forest types (Meades and Moores 1994). In addition, the Newfoundland Forest Service (NFS) divided Newfoundland's forests into productivity types based on characteristics identifiable from aerial photographs (Newfoundland and Labrador Department of Natural Resources. 2004, 2005). It is unknown if there is an effect of ecoregion, sub-ecoregion, ecological forest type, or forest productivity on dead wood dynamics. Studies of dead wood in Newfoundland are limited to examinations of old-growth balsam fir (Thompson et al. 2003), harvest chronosequences in balsam fir-dominated forests (Sturtevant et al. 1997), and comparisons of naturally and anthropogenically disturbed balsam fir and black spruce (Moroni 2006) within a limited range of forest productivity types, and with no comparison of forest types based on ecoregions, sub-ecoregions, ecological forest type, or forest productivity. Studies of snags in boreal systems have focused on the impacts of a single disturbance such as fire (Bond-Lamberty et al. 2003) or harvesting (Sturtevant et al. 1997).

The NFS has been recording dead wood characteristics in the NFS Permanent Sample Plot (PSP) Program since 1996. Permanent sample plot measurements cover several 4- to 6-year remeasurement periods at ~1000 sites located throughout the commercial forest. Dead wood measurements were collected to estimate the abundance and condition of snags, fallen logs, and stumps to help develop harvesting and silviculture strategies to meet the needs of wildlife dependent on dead wood (Newfoundland and Labrador PSP manual, unpublished). The dead wood dataset has yet to be analyzed to determine whether it addresses the issues for which it was designed, or whether it has any other potential value or application.

This report examines the Newfoundland and Labrador PSP dead wood dataset to determine the usefulness of the collected data and provide recommendations for future collections and application of the dataset.

Materials and Methods

Site selection and description

In 1985, the NFS implemented a PSP program for Newfoundland to provide growth data for calibration and validation of stand growth-projection models. The initial focus was predominantly on immature stand types in natural and managed forests throughout Newfoundland. In 1996, the program was expanded to include stands in all development stages (i.e., regenerating, immature, semi-mature, mature, and overmature), resulting in approximately 1000 PSPs established in natural and managed stands of all development stages and scheduled for remeasurement every 4–5 years.

The expanded PSP program was designed to examine the eight major softwood-producing stand types in Newfoundland. Each stand type was ranked for sampling based on relative importance to commercial timber supply and level of financial investment. For example, precommercially thinned stands received a very high sampling priority because they contribute significantly to wood supply and have received significant financial investment.

The eight major stand types were stratified into sampling units, based on variables related to stand development, by summarizing forest inventory and silviculture stand records. Allocation of plots within sampling units was based on two main criteria: the sampling priority assigned to the stand type, and the inherent variability within each sampling unit. Stands were selected from a list of potential PSP locations to ensure they were: characteristic of the targeted stand type, well distributed across the ecoregion(s) (Meads and Moores 1994), and not scheduled for management treatment in the near term (Vanguard Forest Management Services 1992). Selected stands were verified by field crews, and if suitable, plots were established, ensuring that they fell wholly within the targeted forest type.

Site description and sampling

Following site validation, a transect was marked from the selected stand to an easily located landmark. Permanent sample plots form a rectangle, with four corner posts labelled A–D (Fig. 1). Corner A is established at the stand end of the transect. Facing into the plot from Corner A in the direction of the transect, Corner D is located 14 m on a bearing 90° to the right of Corner A. Corners B and C are located on the bearing of the transect from Corners A and D, respectively, at a distance, or plot length, depending on the examined stand type and density. Plot length of mature and overmature stands was 28.57 m, creating 0.10-ha plots. Immature and semimature stand plot length was determined by the plot length required to tag a minimum of 75 trees that met minimum tagging criteria, however, plot size was restricted to seven standard plot sizes ranging from 0.002 to 0.004 ha. Minimum tagging criteria varied by stand development stage. For mature and overmature stands, trees with dbh ≥8.0 cm were tagged. The dbh of tagged trees drops with stand age until the stand contains the smallest taggable trees, which simply exceed 1.3 m in height. Permanent sample plots contain a dead wood subplot, which is rectangular with a length

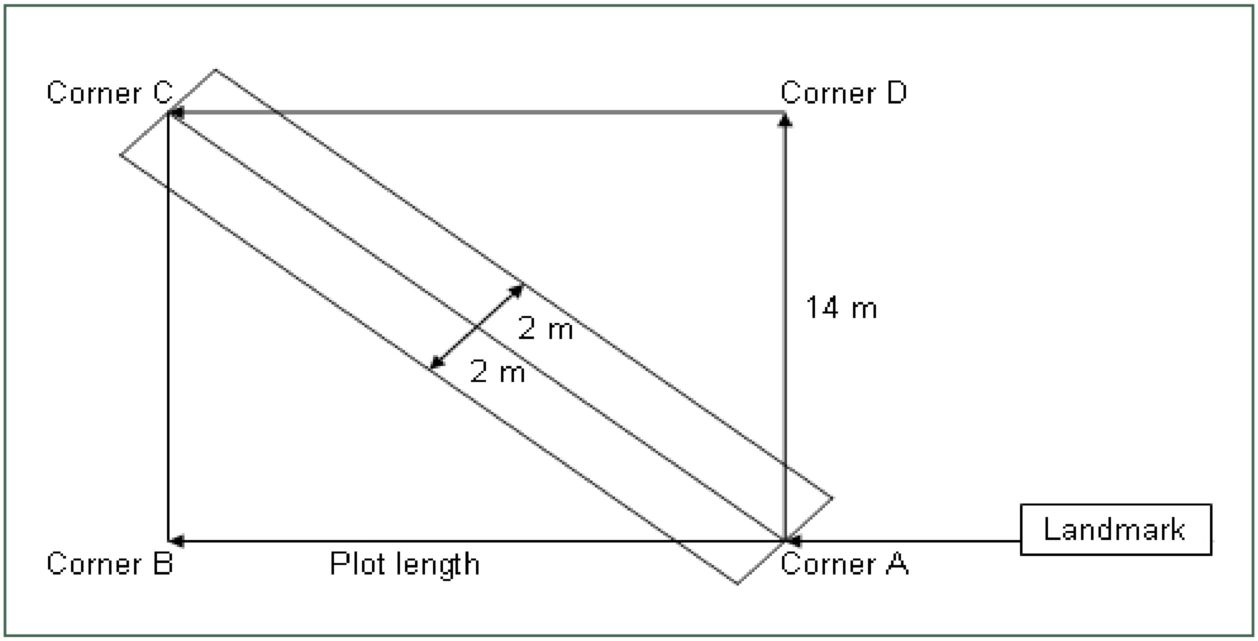

Figure 1. PSP plot layout.

equivalent to the center line between Corners A and C; it is 4 m wide, 2 m either side of the center line (Fig. 1). Slash from harvesting or silviculture activities within the PSP dead wood transect were noted, and a comment on slash decay state was recorded.

Dead wood—comprising all dead trees (snags), both standing and fallen, that were never tagged and measured as live trees, and stumps generated following harvesting only—was measured within a subplot of the PSP. Stems or stumps were counted if the midpoint of the stem was within the subplot. Untagged stems originating outside the subplot that fell into the subplot were not recorded, but untagged stems originating from within the subplot that fell out of the subplot were recorded. For standing or fallen untagged snags, the dbh— or what would have been dbh—was recorded. Stump diameter and height were recorded. All debris was tallied by diameter class (i.e., 0–9, 9.1–18, 18.1–24, and >24 cm). Untagged standing snags were further subdivided into standing vertical, standing leaning, stem intact or <2/3 crown remaining, and presence or absence of bird cavities was noted. Fallen snags were further subdivided into “not moss covered” and “moss covered.” Dead wood attributes have been measured on all PSPs, with most remeasured once and some twice.

In addition to the dead wood transect, all dead trees within the mature and overmature PSPs at the time of plot establishment that met minimum tagging criteria, had no green cambium, and retained ≥2/3 of their original height with branches largely intact, were tagged and measured. Tagged dead trees are noted as standing, leaning, or downed, and with broken top or stem only (i.e., no data on cavities). Dead trees tagged at plot establishment and live tagged trees that subsequently died were not included in the PSP dead wood transect, whether standing or fallen. As a result, dead trees recorded within the PSP dead wood transect tended to be the smaller or most decayed dead trees present.

Results

Complementary data were collected for snag and woody debris (WD) in the dead wood transect and greater PSP plot that, when combined, should be sufficient to support an analysis of snag and WD dbh abundance by dbh, and a coarse estimate of snag volume. These data should be combined and analyzed elsewhere.

Tagged snags (whether standing or fallen) occurring in the PSP were not included in the dead wood transect. Tagged dead trees were not scored for cavity presence. Tagged WD was not scored for moss cover. Consequently these data are incomplete.

Discussion

To obtain useful dead wood data, dead wood attributes must be measured for all dead wood occurring within a study plot. This will require changes in the PSP measurement protocols to capture some of the dead wood attributes for both tagged and untagged trees. The variables of interest and intensity of sampling will depend on the value and objectives of the sampling. Below is a discussion related to measurement of the various dead wood attributes captured in the dead wood transect, and recommendations for future measurement and analysis.

Snags

Snag diameter and numbers per plot are consistently measured variables for both tagged and untagged trees. Thus, it should be possible to combine these snag data for snags within the dead wood transect and tagged dead trees from the greater PSP from all PSPs to i) create snag frequency and volume curves to match yield curves for the major forest type, and ii) determine if any PSP topographical or vegetation data are useful predictors of snag frequency or volume. However, for untagged snags, snag species and height are not recorded and diameters are tallied by size class rather than by individual snag measurements, limiting the accuracy of these data. Tagged snags are not measured for height either; however, an estimate can be obtained from the last measurement when the tagged tree was alive. When combining tagged and untagged tree data, the combined dataset will be limited by the data that is least precise. Where possible, tagged and untagged trees should be measured using the same protocols. The usefulness of the combined dataset can be improved by increasing the precision of untagged snag measurements to that of tagged trees and by measuring the same attributes to the same standard for both tagged and untagged snags.

If the activity of cavity-nesting birds, by species, is of interest, snag cavity dimension can be used to determine the species that excavated the cavity (Smith *et al.* submitted). Generally, larger snags are preferred by cavity-nesting birds (Smith *et al.* submitted), but large snags are tagged. Tagged trees are not included in the dead wood transect where cavities are recorded, thus the most desired snags for cavity-nesting birds were not measured. To complete snag cavity data collection, snag cavity data should be gathered from tagged trees.

Snag bole volume can be determined from a regression equation based on snag species, diameter, and unbroken height (e.g., for Newfoundland—Warren and Meades 1986, Page et al. 1971). Thus, if a snag has lost its top, an estimate of the original snag total height is required to accurately estimate broken snag volumes. Volume estimates will be improved if individual snags are classified by species and remeasurement heights and diameters. Snag biomass is estimated by assigning densities to snag volumes. Relationships between snag characteristics and measured snag density can be determined; however, the process is time and resource demanding. Alternatively, snag density can be estimated using an established procedure such as that of the National Forest Inventory Groundplot Protocol (NFIGP; Natural Resources Canada 2007), which the NFS has used to measure National Forest Inventory plots across Newfoundland and Labrador. If the measurement and decay class system of the NFIGP is adopted, snag volume equations and wood density by decay class and species can be obtained from the Federal National Forest Inventory, allowing estimation of snag biomass. Snag biomass is 50% carbon by mass (Moroni 2006), allowing snag carbon content to be estimated. Literature values for snag nutrient content may be used to estimate snag nutrient stores.

Stumps

Stumps originating from harvest were measured, whereas stumps that result from the partial collapse of trees were not, removing a component of dead wood from measurement. Should a complete inventory of dead wood be desired, stump definition should include all dead stems with a height less than measured snags.

Woody Debris

Downed dead wood data collection involved measuring the stems of downed trees at what would have been breast height (dbh). Woody debris resulting from slash piling and litterfall or the partial collapse of snags or downed tagged trees was not captured in the WD transect. However, within the greater PSP plot, tagged snags are assigned a status code 2 if dead and leaning or down. A snag is commonly defined as a self-supporting dead tree, with non-self-supporting dead trees commonly defined as WD. Thus, dead tree code 2 snags encompass both snags and WD. Untagged snags are categorized as vertical or leaning, with leaning untagged snags encompassing self-supporting dead trees and non-self-supporting dead trees. However, the prevalence of leaning snags on the landscape is probably limited, and tagged code 2 snags and leaning untagged snags are likely to be dominated by WD. If we assume all tagged dead tree code 2 snags, and untagged leaning snags are WD, we can combine WD diameters at what would have been breast height for tagged and untagged fallen trees to i) estimate the abundance of WD with a dbh for all PSP plots and ii) determine if any PSP topographical of vegetation data is a useful predictor of WD dbh frequency. The above estimate of WD abundance will be a slight overestimate as it will include leaning self-supporting snags. Consequently, the above snag measurements will be slightly underestimated because self-supporting snags are assumed to be WD. Dead wood should be defined as self supporting or non self supporting to differentiate snags from WD. Snags and WD may further be defined as leaning or not leaning should this be a desired attribute.

Downed dead wood data for “moss covered” or “not moss covered” are incomplete. To complete this dataset, the same data are needed from downed tagged trees.

Data describing woody debris volume and biomass are used to provide estimates of fire fuel load and content, along with associated habitat requirements. To address these needs, dead wood volume and decay class are required for individual pieces. Several methods are available to estimate dead wood volume (Jordan et al. 2004). Of these, the Line Intersect Method used in the NFIGP should be considered because the NFS and Canadian Forest Service have some experience with the methodology. The line intersect method has been reviewed by Nemec and Davis (2002) and van Wagner (1982). If the decay class system of the NFIGP is adopted, wood density by decay class and species can be obtained from the National Forest Inventory, allowing estimation of dead wood volume and biomass. The Line Intersect method allows WD volume to be estimated by measuring individual WD diameters at the point of intersection with the transect. If the full range of diameters is of interest, smaller-diameter WD may be tallied by diameter class or measured within subplots of known area as in the NFIGP. Alternatively, smaller-diameter WD may be ignored. Recent studies have shown that a large amount of WD becomes buried in the organic layer in boreal ecosystems (Moroni 2006). Should an estimate of total WD volume or biomass be desired, buried wood can be measured using the procedures of the NFIGP.

Collection of dead wood data by species, size class, and decay class will allow dead wood abundance to be examined based on these variables, potentially increasing the usefulness of collected data. However, it may not be possible to collect all data described above for all PSP plots. Should additional data be required that are unattainable from all PSP plots, reducing the proportion of PSP plots where dead wood is measured should be considered, along with reducing the intensity of measurement within individual plots.

Conclusions

A component of WD and snag data, when combined with tagged snag data from the greater PSP plot, should prove useful in later analyses. The same methodology should be used for both tagged and untagged trees when collecting dead wood data.

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