SUPPORTING INFORMATION

Look down to see what's up: A review of treefall dynamics in forests

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Supporting Information S1 Synthesis of the global literature on dead-wood forest components.

Table S1. Studies of treefall and its legacy effects, categorised according to the four most commonly studied research themes; causes, characteristics of the trees that contribute to treefall, causes of treefall events, and management/modelling applications. The most highly cited studies within each three-year block from 1985 to 2016 were chosen. In cases where the categories were extremely broad, additional studies were included to provide a more representative sampling of the breadth of the literature on that subtopic.

Footnote:

^ Study type: field measurements (FM), field experiment (FE), review (R), modelling (M), glasshouse (GH), experiment in the field (EF), lab experiment (EL), management (MM).

* Impact: population (P), community (C), ecosystem (E), landscape (L), individual (I).

Date	Author(s)	Forest type	Topic of paper	Study type^	Impact*	Key development or finding	Cites	Terms used
CONSEQUENCES *Canopy gaps and gap dynamics*								
1985 1986 1987	[1]	Tropical forest	Gap-phase regeneration behaviour examined for three tree species in natural gaps during the first 8-9 years of growth.	FM	C	Diversity in growth, recruitment and gap-size requirements across different species, that maintains diversity within gaps; but some overlap in regeneration behaviours may favour coexistence among some species.	385	Gap-phase regeneration, gaps
1988 1989 1990	[2]	Tropical rainfore st	Exploring the potential differences in light and nutrient availability on growth, in treefall gaps.	E/GH	C	The amount of light available in treefall gaps is important for the persistence, and co-existence of species (esp. shade-intolerant sp.)	335	Treefall gap, gaps
1988 1989 1990	[3]	Temper ate and tropical forests	Assessment of light intensity /regimes beneath closed canopies and tree-fall gaps.	FM	C	Under intact canopies sun flecks contribute 37-68% of seasonal radiation and light is generally not vertical. Light can penetrate into gap-edges. As gap size increases the mean and range of light within gap increases, but even in large gaps the potential duration of direct sunlight is restricted to approx. <4h.	823	Tree-fall gaps, forest canopies, gaps, gap light regimes

1988 1989 1990	[4]	All forest types	Review of the role of gap size and succession within gaps for recruitment.	R	P	Our present knowledge of forest dynamics is highlighted by the existence of forest cycles, gaps and the division of tree species into two groups: climax and pioneer species (which is related to their persistence in varying light environments).	924	Canopy gaps, gap, gap size
1991 1992 1993	[5]	*Nothofagus* forest	Characterising the dynamics and regeneration strategies of the broad latitudinal-ranged *Nothofagus* species	FM	P	Regeneration in gaps appears to be adequate to maintain the structure and composition of the old-growth forests studied.	188	Tree-fall gap, tree-fall, gap-phase, regeneration
1994 1995 1996	[6]	Boreal forest	A review of gap disturbance, ground micro topography and regeneration dynamics in boreal forests.	R	E	Understanding of the ecological significance of small-scale gap disturbances in boreal forests is limited. Patch mosaic structure has been altered by forest management.	293	Gap disturbance, gap, treefall gap
1997 1998 1999	[7]	Tropical (wet) forest	Effect of variation in gap size on above- and below-ground light and nutrient processes.	EF&EL	C	Higher nutrient pools in gaps caused by decomposition and mineralisation of the woody debris. This increase effects the high-or light-demanding species much more than shade-tolerant.	285	Treefall gap, gaps, treefalls
2000 2001 2002	[8]	Tropical forest	Critique of the paradigm: 'Treefall gaps maintain species diversity'.	FM	C	Gaps did not appear to increase diversity of shade-tolerant tree species, but it did for liana and pioneer tree species diversity.	362	Treefall gaps, gaps
2003 2004 2005	[9]	Beech forest	Effect of gap formation (over time) on the physical environment (light, temperature and soil moisture)	EF&FM	C	Growth of regeneration of 'edge trees' (as a result of increased light, shading and water extraction by roots) may have modified the effects of the canopy gap as early as the second year of gap formation.	152	Gap dynamics, gap, canopy opening

2006 2007 2008	[10]	Beech forest	Effect of gap size on light and soil moisture in the gap on abundance and distribution of herb layer species.	FE	C	Gap size had a profound effect on environmental variables but its effects were species-specific.	107	Gap, canopy gaps, gap size, gap formation
2009 2010 2011	[11]	All forest types	How does low light survival and high light growth allow coexistence - and what are the limitations.	R	P	Present/propose a theory of forest dynamics driven by small-scale disturbances as a species case of coexistence in variable environments. While low light survival/high light growth trade-off, while ubiquitous in forests, is unlikely to function as an important mechanism for stable coexistence of several tree species.	44	Gaps, canopy gaps, coexistence, canopy disturbance
2012 2013 2014	[12]	Hardwood forest	How the environmental conditions in gaps influence the decomposition and accumulation of coarse-woody debris.	FE	C	CWD in canopy gaps experience greater surface temperatures and decreased moisture conditions throughout most of the growing season. Annual C fluxes were higher in gaps	38	Coarse woody debris (CWD), canopy gaps, woody debris, gaps
2015 2016	[13]	Tropical forest	Propose a new definition of a forest gap based on precise measurements from airborne LIDAR.	FM	P	Dynamic gaps are "contiguous areas of significant growth, that correspond to areas >10cm2 with height <10m."	0	Gap-phase, gaps, gap dynamics
CAUSES **Small & Large scale** ***Disturbance (Extreme weather events [fire & wind], uprooting)***								
1988 1989 1990	[14]	All forest types	Review of tree uprooting (terminology) and its causes and consequences.	R	C	The term uprooting is distinct from treefall tree throw and blowdowns. This is because uprooting explicitly involves soil disturbance, and not 'bole snap'.	113	Uprooting, tree throw, treefall, blowdown, disturbance

1988 1989 1990	[15]	Hardwood forest	Assessed 3 hypotheses: 1) Does micro-site variation exist in pits and mounds; 2) do pit size and soil accumulation matter and 3) do the species that created the pit and mound matter?	FM	C	Pit and mound sizes were proportional to the size of the fallen tree but the identity of the tree did not matter (except in the intact soil microsite), large pits revegetated more slowly than small ones, 4 micro-sites were found in the pit.	173	Treefall pits and mounds & windthrow
1991 1992 1993	[16]	Hardwood forest	Frequency of uprooting versus bole snapping and the influence of these alternative treefalls on sprouting.	FM	C to P	Tree size was the most important factor in determining frequency of uproots vs. snapped trees. Uprooting occurs at a higher frequency in old-growth hardwood forests. Sprouting was determined to be of little importance for re-establishment, especially following a large windthrow event.	129	Uprooting & fallen tree
1991 1992 1993	[17]	Boreal spruce forest	Uprooted tree disturbance effect on the forest floor over a long time period (120 years)	FM	C	Uproot tree direction and frequency was strongly correlated to wind disturbance. There were large variations in disturbance rate, with higher rates in some years compared to others - this implies periods with low availability of exposed soil.	65	Uprooting & uprooted trees
1994 1995 1996	[18]	All forest types	A review of the damage and recovery of forests from catastrophic wind disturbance.	R	C to P	Measurement methods between studies can alter the results, leading to different conclusions regarding the severity of disturbance. Wind disturbance creates gaps of differing size, and recovery tends have been summarised here, to follow one of four pathways: regrowth, recruitment, release or repression.	445	Wind damage/disturbance, Treefalls

1997 1998 1999	[19]	All forest types	A review of the reasons why wind disturbance may be better considered as an ecological factor.	R	P	Studying the mechanical effects of wind (acclimation/adaptation of trees) may be a more important direction to take, as its effects may be greater than the acute effects of destructive storms.	159	Windthrow, treefall, wind
2000 2001 2002	[20]	Coastal tempera te rainfore st	Investigation of the abiotic factors controlling patterns of long-term windthrow, and how well they can be predicted using spatial information.	FM/M	I to P	Large-scale stand-replacement disturbance processes are common in areas most prone to windthrow, where small-scale disturbance processes are more common in areas least prone to windthrow.	122	Windthrow, gap-phase disturbances
2003 2004 2005	[21]	Conifer forests	Effects of prescribed fire on tree structure over 6 years - and its implications for forest restoration.	FM	C	The ecological outcomes of a prescribed burn in these forests were not in-line with the restoration goals for this ecosystem type: a reduction in tree density, reduction of woody debris and the death of old-growth trees resulted.	94	Fire, trees, coarse woody debris (CWD), forest floor fuels, burning
2006 2007 2008	[22]	Boreal forest	Assessment of tree mortality patterns contrasting: differences across tree sizes, wind intensity and stand age.	FM	P	Larger sized trees and old stands were more susceptible to wind-driven mortality. Likewise, early successional and shade intolerant were also more at-risk.	93	Wind-throw, blowdown, wind disturbance
2006 2007 2008	[23]	Ouachit a Mountai ns	Studied the biomechanical effects of stump-rot depression and infilling (contrasts to uprooting).	FM	C	Highlights that two other processes are significant to forest disturbance dynamics that should be considered alongside other uprooting effects: the physical displacement of soil by root and trunk growth and the infilling of depressions created by stump rot.	46	Tree throw, uprooting

2009 2010 2011	[24]	Fir-beech forest	Development of methods to quantify the age of windthrow events using field measurements and modelling.	FM/M	C	Age explained 34% of the variability in the measured windthrow associated variables: thickness of soil (on both mounds and pits), presence of new trees recruiting in windthrow areas, and the dimensions of the effect.	56	Windthrow, uprooted trees
2012 2013 2014	[25]	All forest types	Synthesis of the impact of wind-caused disturbance at multiple scales for application in forest management.	R	I to P	Windthrow is more than just a catastrophic phenomenon, with reoccurring effects on ecosystem process and pattern. They also call for a more interdisciplinary view on nature and occurrence of wind damage.	50	Windthrow
2015 2016	[26]	Mixed pine-broadleaf forest	Experimentally examine how tree size, species, fire history and failure mode influence tree stability.	FM	I	Tree stability increased with tree size. Their findings suggest that interspecific differences in reported tree damage may be more due to variation in wind load than to innate interspecific differences in tree stability.	0	Wind disturbance, snapping, uprooting, fire, tree stability
CAUSES ***Tree mortality & standing dead/dead wood (CWD)***								
1985 1986 1987	[27]	Tropical forest	Determining causes and rates of mortality over a 13-year period.	FM	P	Mortality was independent of size among individuals. Of those that died over the 13 years, most had decomposed entirely, or had fallen - a net loss of 1.7% stems across 13 years.	280	Treefall gap, treefalls, mortality
1988 1989 1990	[28]	Spruce-fir forest	Evaluation of the number of (standing) dead trees in Northern spruce-fir forests.	FM	P	Across the 46 datasets, dead trees were determined to account for 3-43% of total basal area and 5-36% of total density - the wide range reflects the complexity and interactions in forests.	32	Standing dead trees, mortality, dead trees

1991 1992 1993	[29]	*Tsuga heterophylla* forest	Factors that influence growth and mortality of trees.	FM	C	Rates of tree mortality are high in this forest - it is frequently exposed to severe wind events (disturbance is considered important in this system).	31	Blowdown, mortality, wind, gap
1994 1995 1996	[30]	Swiss forests	Quantitative assessment of the volume and decay stage of CWD and standing dead trees across sites in the Alps at different elevations.	FM	C	Differences in the volume of dead wood across sites, but high sampling variability. Most of the dead wood = young decay classes. Management of dead wood is paramount, and to fully understand how to manage it, more qualitative and quantitative assessments of CWD must be done across ecosystems and differing environmental conditions.	85	Coarse woody debris (CWD), standing dead trees, dead wood
1994 1995 1996	[31]	Old-growth conifer forest	Comparison of the structure of fragmented and non-fragmented forests to understand their ecology.	FM	P	Found an increase in mortality following a wind event, but this mortality differed with fragment size - 30% 1ha fragment, 98% in 1/16ha. Of this mortality, uprooting was the most common, followed by stem breakage).	156	Tree mortality, blowdown, uprooting
1997 1998 1999	[32]	Temperate forests	Quantifying the amount of dead wood in various forests in Britain, Europe and North America.	FM	C	Managed forests contained much less fallen dead wood than unmanaged. In British forests, it is unclear whether increasing the amount of dead wood will increase the diversity of these forests.	184	Fallen dead wood, fallen logs, standing dead trees
2000 2001 2002	[33]	Douglas Fir (Df) & Red cedar (Rc) forest	Investigations of density-dependence and mortality with two different component species.	FM	P	Mortality changed the spatial associations between species. Non-random mortality of Df and Rc such that survivors were more strongly aggregated than expected. Found some evidence of density-related effects on tree survival in this study.	242	Density-dependent, dead trees, mortality

2003 2004 2005	[34]	European Beech forest	Quantitative assessments of dead wood volume (standing vs. fallen dead wood) between two contrasting (disturbance regime) forests.	FM	P	Dead wood is largely driven by disturbance (and thus varies over time). Fallen dead wood contributed more to total dead wood than standing dead wood. Windstorm damage is a large contributing factor to standing dead wood volume, but this also depends on topographic heterogeneity.	237	Dead wood, standing dead wood, fallen dead wood
2006 2007 2008	[35]	Old-growth boreal forest	Exploring the spatial, temporal and frequency of standing tree mortality.	FM/M	C	Mortality of standing dead trees (excluding catastrophic disturbance events) is an important process in forest structural complexity and diversity. Standing dead trees in *Pinus* stands were predominately clustered, large dead = random, small dead = clustered.	51	Standing-tree mortality, living and dead trees
2009 2010 2011	[36]	Boreal forest	Assessing snag degradation pathways (survival curves) of the main boreal species in North America	FM	C	Diameter of trees did not influence fall probability. Differential degradation pathways were determined for the four species examined that translate individualistic responses that are related to species autecology.	49	Deadwood, snags, logs
2012 2013 2014	[37]	Mixed-deciduous beech forest	Prescribing mortality patterns into different processes (i.e., modes of death) to determine how mortality varies among and between species for testing mechanistic models.	M	P	Survival/mortality varied with life-history stage (time); small trees = died standing or crushed, medium-sized trees = lower mortality, large trees = very high mortality rates mostly due to snapping and uprooting.	29	Standing dead, tree mortality, uprooting
2015 2016	[38]	Many forest types	Reconciling the spatial aspects of tree mortality in old-growth forests (successional stage).	FM	C	Spatial aspects of tree mortality change over time, particularly in latter successional stages.	3	Tree mortality, density-dependence

CONSEQUENCES ***Decay & nurse logs (recruitment)***								
1985 1986 1987	[39]	Many forest types	Differences in log attributes (structure, chemistry, microbial activity) across three forests.	FM	P	Western hemlock and red cedar logs decayed faster than Douglas fir (which had logs that had persisted 200 yrs). It took 90 yrs for N, P and Mg to exceed initial amounts. Other elements (Ca, K, Na) remained constant throughout the 200 yrs studied.	199	Fallen boles, logs
1988 1989 1990	[40]	*Picea-Tsuga* forest	Causes of close seedling-log associations (how logs facilitate seedling recruitment).	FM	I to C	Competition with herbs and mosses on the forest floor appears to be responsible for the disproportionate number of tree seedlings found on logs. Recently fallen logs represent sites where competition is low enough to facilitate seedling recruitment.	351	Logs, fallen logs, nurse logs, fallen dead tree
1991 1992 1993	[41]	Deciduous & conifer forests	Comparison of the amount of CWD and processes that influence CWD accumulation in two different forest systems.	FM/R	P	Lower input and faster decay rates means that there is less CWD in deciduous forest than conifer (there are three-times the number of logs in conifer forest). During gradual mortality, CWD adds fewer nutrients than fine litter at both sites because nutrients are released at slower rates from CWD than litter.	234	Coarse woody debris (CWD), dead trees, logs
1994 1995 1996	[42]	Boreal forest	Dynamics of dead wood in different successional stage forests that also vary in disturbance.	FM	C	Thinning and wood salvage (through forest management) reduces dead wood C stores drastically lower than their potential levels found in undisturbed forests. Natural disturbance increases dead wood C pool by a factor of 2-4.	204	Dead wood, windthrow, logs, snags, stumps

1997 1998 1999	[43]	All forest types	Comparison of quantity, decay stage and turnover of dead wood in three contrasting forest types (separated by climatic and physical zones).	FM	C	Dead wood quantity differed across the three climatic zones; lowest = dry, peak = moist, decreased slightly = wet. Decay stage in all three was mostly rotten or intermediate - very little woody debris was recent and intact. Overall no clear trend in turnover across the three climatic zones.	194	Dead wood, woody debris, downed wood, standing dead
2000 2001 2002	[44]	Tropical forest	Providing carbon cycling models with useful parameterisation and validation information for coarse litter. Decomposition of boles.	FM	C	Uprooting and dead standing = the most common causes of tree mortality. Decomposition rate constants for trees killed by other falling trees were higher because trees killed by treefalls were on average smaller than trees that died from other causes.	279	Boles, coarse surface litter, dead trees
2003 2004 2005	[45]	Conifer forest	The role of coarse woody debris in nutrient cycling.	R	P	Although CWD accounts for over 50% of organic matter, it contributes substantially small amounts of nutrients (N, P, K, Ca, Mg). CWD is of minor importance in the nutrient cycles of these forests.	225	Coarse woody debris (CWD)
2006 2007 2008	[46]	Sub-alpine spruce forest	Determined how long it took for a stem/fallen debris to be used as a substrate for recruitment.	FM	C	Although CWD covered only 4% of the forest floor, it accounted for over 40% of sapling stems. Highest recruitment on a log is generally between 30-60yrs which represents a decay state of between 4 & 7. But early colonisation is possible, but the slow decay can sometimes lead to slower growth of seedlings.	74	Dead wood, decaying wood, coarse woody debris (CWD), logs

2009 2010 2011	[47]	European forests	Examining dead wood thresholds in forests for sustainable forest management.	R	P	Thresholds vary among studies with different species, habitats and regions. Provides baseline CWD thresholds for management decisions.	162	Dead wood, management, threshold
2012 2013 2014	[48]	Mixed conifer forests	Assessing the hypothesis that snags decay slower than logs, making the long term dynamics of seral forests dependent on snag fall decay and breakage.	FM	C	Confirmed hypothesis = reduced decay rates in stags and variation among species. Found variation in fall, breakage and decay among species and size = suggests increased diversity of snag species in number and size would meet the ecological needs of this forest type.	12	Coarse wood, coarse woody detritus (CWD), snags, logs
2015 2016	[49]	Mixed deciduous forest	Importance of deadwood as a habitat for organisms and plants.	FM	C	49 vascular plant species colonised downed wood and these species were mostly small-seeded rather than heavier seeded plants. Abundance of species and organisms increased with greater logs sizes and decomposition. Deadwood served as a seed filter, capturing small seeds in cracks, where bigger seeds generally tended to roll off.	1	Coarse woody debris (CWD), deadwood, downed logs, logs
CHARACTERISTICS ***Non-living & Structural Elements***								
1985 1986 1987	[50]	Maple forest	Investigation of the attributes that contribute to the susceptibility of *Acer saccharum* to wind damage.	FM	C	Larger trees are more susceptible to wind effects due to the loss of trunk/stem flexibility - this is also compounded by their increased exposure to wind as they grow taller (out of canopy).	169	Trees, trunk, canopy gaps
1988 1989 1990	[51]	Pacific Northw	How does the living and dead forest interact, what we know about the large trees that fall,	R	P	Snags are important structural components of a forest, and when fall, can cause different effects than a green tree that falls. Future	181	Fallen trees, coarse woody debris (CWD)

		est forests	and what are the implications of our management practices.			forests will contain less CWD, and that CWD will be substantially smaller than we see today. Fallen trees add a different dimension to forests.		
1991 1992 1993	[52]	Tropical riparian forests	Comparison of tree species distribution in two different areas that are especially prone to fire and tree fall.	FM	C	Tree fall was concentrated on upper valley slopes and tended to fall down slope. Fire-scarred trees were predominately found on gentler slopes. Both disturbances were determined to be important role in promoting species co-existence; providing a varied micro-climate for establishment, but patchy enough to ensure the disturbance-sensitive species continue to persist.	56	Tree falls, tree death
1994 1995 1996	[53]	Hardwood forest	Investigated how management influences the distribution and abundance of CWD in the central Appalachians.	FM	C	Young stands had the highest density, volume and biomass of CWD. Following clear-cutting most CWD existed as relatively labile, low decay state, small-diameter. Crushed logs do not function ecologically in the same capacity as large intact logs.	153	Coarse woody debris (CWD), Standing snags, logs, stumps
1997 1998 1999	[54]	Boreal forest	Assessment of CWD abundance and structure for the purpose of comparing the differences across stand age & developing a model that predicts CWD availability, specifically for wildlife.	FM	C	Wind and insect defoliation strongly influence CWD accumulation. Size and relative density of standing trees are related to the susceptibility of individual trees to windthrow - and larger more isolated trees are increasingly vulnerable. Older stands are more prone to insect defoliation. CWD size is a function of standing tree size - CWD is influenced by site quality.	287	Coarse woody debris (CWD), fallen tree boles, downed wood, snag (standing dead wood)

2000 2001 2002	[55]	Multiple forest types	Information on CWD is in-demand for wildlife biologists, fire specialists and ecologists most especially as an indicator of forest health - this paper explores the methods used to estimate CWD structural attributes.	R	P	Define an attribute of CWD as "any item or characteristic of the CWD population that a researcher or manager is interested in estimating…" This may include volume, log number, biomass and carbon. At a population level, these attributes are important for forest process and function including decomposition rates, accumulation, disturbance indicators.	152	Down wood, dead wood, coarse woody debris (CWD)
2003 2004 2005	[56]	Multiple forest types	Review of the literature that has been associated with forest and woodland structural attributes and complexity.	R	P	No definitive suite of structural attributes for forests. Most common structural attributes that are presented in the literature: foliage arrangement, canopy cover, tree diameter, height, tree spacing, species, stand biomass understory vegetation and deadwood. To quantify logs the most useful attributes were abundance of large logs and variation in log number and size.	333	Logs, stags, standing dead trees, dead wood
2006 2007 2008	[57]	Boreal forest	Characterisation of the volume and attributes of CWD in managed and unmanaged boreal forests.	FM	C	Following a fire disturbance stand age matters for CWD accumulation. Further, CWD dynamics differed with stand origin (logging).	56	Snags, coarse woody debris (CWD)
2009 2010 2011	[58]	Tropical forest	The role of topography, soil, tree growth and mortality in explaining variability in forest biomass at local scales.	FM	C	Along a topographic gradient there were higher rates of treefall, which decreased total stand basal area and favoured allocation to height growth and recruitment of light-demanding species with low density. Highlights importance of including site characteristics in biomass measurements.	71	Treefall, woody biomass, topography, mortality, wood density

2012 2013 2014	[59]	Savanna	Influence of herbivores (elephants) on treefall.	FM	P	Elephants were revealed to be the primary agent of treefall, regardless of savanna condition.	50	herbivores, treefall dynamics, turnover
2015 2016	[60]	Mixed-conifer & pine forests	Assessments of log and snag density to inform policy and development of predictive models - comparing across two forest types.	FM/M	C	Human access to forests and management history has a large influence on large snag density - this is not accounted for in the management guidelines.	1	Snags, standing dead trees, fallen logs, logs, management
APPLICATION ***Modelling & Forest Management***								
1985 1986 1987	[61]	*Picea-Pinus* forest	Using a simulation model (FORSKA) to test the hypothesis that height and diameter distributions of the trees are the outcome of storm-felling.	M	C	The simulation generated a stand description similar to the real forest stand including the essential characteristics. Gap-models are important for simulating forest dynamics - the one used here is just one example.	107	Gap model, storm-felling
1988 1989 1990	[62]	Douglas -fir forest	Modelling the long term mortality of trees as a function of morphological variables such as diameter at breast height, season burnt, scorch height etc.	M	C	The best predictor of mortality was the number of quadrats with dead cambium. Percentage of crown volume scorched was a better predictor of mortality than lethal scorch height.	111	Models, Mortality, fire, bole damage, cambium
1991 1992 1993	[63]	All forest types	Comparisons between explanatory and descriptive models for forest dynamics.	M	C	Recent software developments have increased our ability to use explanatory (simulation) models to examine forest dynamics - these enable us to cope with, and better predict changing environmental and management conditions.	89	Modelling, gaps, wood biomass

1994 1995 1996	[64]	Dipterocarp forest	Examining the effect of different logging methods on carbon (biomass).	FM/MM	C	41% of unharvested trees were damaged due to felling (uprooted and crushed) using the conventional method. When using a reduced-impact method 15% of trees were damaged - this means more carbon retention. Mortality of damaged trees may contribute to net decreases in biomass many years after logging.	416	Mortality, damaged trees, logging, tree felling
1997 1998 1999	[65]	Boreal forest	Exploring what happens to nutrients during woody decay, and what is the role of CWD in different successional stages.	M	C	Nutrient stores declined with decay state, and the rate of these losses were related to patterns of bark loss. Modelling revealed that post-disturbance release of nutrients from woody detritus can potentially supply a large proportion of nutrient accumulation in living biomass.	136	Woody detritus, decomposition, dead trees, decay, coarse woody debris (CWD)
2000 2001 2002	[66]	All forest types	Provides a broad array of management recommendations.	R/MM	E	Lack of standing snags and fallen logs is the most obvious difference between planted and natural forests. Management is general and can apply to many regions. Suggests a new plantation forest paradigm based on the hypothesis that minor improvements in design and management can improve biodiversity outcomes while retaining economic benefit.	526	Plantations, harvesting, management, coarse woody debris (CWD)
2000 2001 2002	[67]	All forest types	Provide an overview of models designed for modelling tree dynamics, and review their suitability based on their intended use.	R/M	E	Suggest that in complex forest systems, tree-level models will be necessary to account for competition effects etc. These tree-to-tree interactions are necessary to provide reliable estimates of stand development.	269	Management, gap models, tree fall

2003 2004 2005	[68]	Fennoscandia forests	Review of the organisms that are dependent on dead wood, and identify the challenges of their management.	R/MM	L	New approaches to management are called for! Argue that it is necessary to counteract the current shortage of dead wood, minimise isolation and edge effects by planning at the landscape level, create a variety of dead wood types to maximise biodiversity and habitats.	292	Dead wood, management, coarse woody debris (CWD)
2006 2007 2008	[69]	Boreal forest	Parameterisation of CWD decay-class models to better represent decomposition-related changes in snags and downed woody debris (DWD) over time.	M	C	DWD from trees that fell at death was projected to advance through 4 decay classes over a 55-60yr period, but those originating from stags was modelled to persist for up to 90yrs after tree death because of slower decomposition while standing. Diameter has a strong effect on DWD transitions into decay classes 2 & 4 but not 3.	51	Snag, downed woody debris, coarse woody debris (CWD), management, decay
2006 2007 2008	[70]	All forest types	Rationale and context of a national inventory of downed woody material for guiding management and providing data census.	R/MM	E	The DWM indicator can provide a good indication of forest health, and can provide information on DWM attributes that can be used across multiple forest ecosystems.	138	Downed woody materials (DWM), fine and coarse woody debris
2009 2010 2011	[71]	Tropical forest	How life expectancy and time to reach canopy (growth) interact to influence forest turnover.	R/M	C	Characterising the light environment (using an index of crown illumination) in integral projection modelling & age-from-stand analysis is important in capturing tree life history axis of movement through the light environment.	40	Turnover, mortality, crown illumination, gap

2012 2013 2014	[72]	All forest types	Presentation of a new method for the quantification of deadwood in forests.	M	P	Full waveform airborne laser scanning can be used as an important tool to accompany manual quantification of deadwood. Using a digital height model you can depict downed stems as line-like features.	14	Fallen trees, dead wood, downed trees
2015 2016	[73]	All forest types	Critique of the methods used for quantifying dead wood with a predominate focus on biomass and carbon attributes.	R	E	A range of methods should be used when quantifying dead wood (C stores and fluxes) including detailed experiments that are region specific, to more general landscape protocol establishment. To date, there is no universal approach to determining the total amount of dead wood and its patterns of decomposition, but there are several approaches that will serve this purpose.	6	Dead wood, downed wood, coarse woody debris (CWD), standing dead

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