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The research programs of the National Council for Air and Stream Improvement (NCASI) often result in the publication of Technical Bulletins or Special Reports. NCASI has published more than 2,000 of these documents, representing a major contribution to the body of technical literature on environmental quality management and the forest products industry.

The following is a list of over 100 resources and peer-reviewed articles produced in the first 23 years of NCASI's Canadian Operations. Resources published by NCASI are available free of charge to NCASI Member Company personnel who log in to the NCASI website, www.ncasi.org. A limited number of reports are available to the public. Printed copies may be obtained by sending a request to publications@ncasi.org.



Technical Bulletins

[Technical Bulletin No. 1071: Particulate Matter Testing of Wood Handling Sources and Panel Presses](#)

(Published 2/21)

This report describes wood panel presses and miscellaneous wood handling sources and their relevant particulate matter (PM) emission control devices, summarizes stack testing methods for measuring PM and relevant emissions data in the context of the strict regulatory limit imposed by the Quebec government, and illustrates the challenges and practical sampling approaches associated with testing regulated sources. Testing challenges documented herein include unconfined or short vents exhausting older cyclones and baghouses, cyclonic flow, and contributions of emissions from nearby sources. Relevant NCASI testing experience shows that temporary enclosures, extended ductwork, induced draft fans, and flow straightening devices, alone or in combination, are probably necessary to render these sources testable for PM.

[Technical Bulletin No. 1068: Wood Products Air Quality Technical Information Document: 2020 Update](#)

(Published 9/20)

This report synthesizes environmental information related to operations associated with primary subcategories of the wood products industry: lumber, oriented strand board, plywood, medium density fiberboard, particleboard, hardboard, and wood pellets. Emission characterization and control option information is provided for the industry's various combustion and process unit operations. An overview of current knowledge related to the Canadian and US wood products industry is provided, including population and production statistics, process equipment information, emission estimates, and a summary of the existing regulatory platform. This report updates and replaces NCASI Special Report No. 08-01.

[Technical Bulletin No. 1035: Effects of Process Parameters on Emissions from Wood Products Dryers](#)

(Published 5/16)

This NCASI Technical Bulletin provides information on the effects of certain process parameters on emissions of certain pollutants from wood drying operations in the wood panel and lumber industries. The majority of the information provided is in relation to the effects of dryer temperature on emissions. However, the effects of wood moisture content, wood species, particulate matter control device type and, to a lesser degree, the effects of harvest season, storage time, knots in lumber, and other variables are evaluated or discussed. Pollutants evaluated include acetaldehyde, acrolein, formaldehyde, methanol, volatile organic compound (VOC) as carbon, filterable particulate matter, and condensable particulate matter. The information reviewed for this report came from a variety of sources, including the open literature, NCASI field studies, and an NCASI database. The database contains information primarily from industry test reports and NCASI field studies. The report contains several hundred rows of data in tables and over 80 charts or graphs.

[Technical Bulletin No. 987: Review of Air Emission Source Test Methods Used in Canada](#)

(Published 7/11)

This report synthesizes and compares nearly 70 extractive air emission source test methods approved by provincial jurisdictions across Canada. The synthesis includes a summary of essential concepts regarding extractive source testing and a review of methods pertaining to the sampling of exhaust gas streams as well as to the measurement of air emissions relevant to the Canadian forest products industry. These substances are particulate matter, nitrogen oxides, sulphur dioxide, volatile organic compounds (VOCs), total reduced sulphur (TRS), dioxins and furans, chlorine dioxide mercury (Hg), carbon monoxide (CO), and sulphuric acids. Each substance is discussed in terms of predominant sources at forest products manufacturing facilities and the test methods to measure that substance. The report includes conceptual schematics and/or tables to help the reader easily identify similarities and/or differences between methods. A summary table listing all the extractive test methods approved by each province, as well as hyperlinks to the respective full method write-ups, is provided at the end of the report.

Technical Bulletin No. 952: Formation, Release and Control of Reduced Sulphur Compounds from Kraft Pulp and Paper Facilities *(Published 7/08)*

This report provides an overview of the formation, release and control of reduced sulphur compounds at kraft pulp mills. It also serves as the sector-wide component of a Technology Benchmarking Report; to assist the Ontario Ministry of Environment (MOE) in effectively evaluating its new standards for total reduced sulphur (TRS). It would form a component of the MOE's Guide to Requesting an Alternative Standard; for kraft pulp mills in the province of Ontario. The report includes a discussion on the origins of reduced sulphur compounds in kraft pulp mills, an identification of all the sources that emit TRS at such mills, a compilation of summary emission data available to NCASI for all such sources, a discussion and analysis of the potential operating factors that might be expected to affect such emissions, and a discussion of the available control options, both traditional and emerging, for TRS emission reduction including process change and add-on controls. It also includes relevant U.S. regulatory coverage for various kraft pulp mill unit operations. The results of a brief survey of eleven Canadian kraft pulp mills (NCASI members) seeking relevant information on mill TRS emissions and non-condensable gas collection practices are also presented. The report is written to address sector-wide aspects of TRS emissions and control. Site-specific assessments of technology applicability or air emission modeling are not included.

Technical Bulletin No. 904: Odorous Emissions from Wood Products Facilities *(Published 9/05)*

As a result of changing community demographics and sensibilities, forest products industry facilities are increasingly faced with community concerns and questions about odorous emissions. This report characterizes odorous compounds found in wood products facility emissions and provides a brief discussion of the issues of odor, sensory irritation, potential health effects, and community concerns related to those emissions. In general, odorous compounds are characterized in two ways: by the concentration at which the odor will be detectable (odor threshold), and by the capacity for the compound to stimulate the trigeminal nerve and produce symptoms of sensory irritation. There are a number of substances reportedly present in wood products facility emissions that have odor thresholds of less than 10 ppb, so they will be detectable at relatively low ambient levels. There are also a number of compounds reportedly present in wood products facility emissions that can produce symptoms of sensory irritation, but three (acrolein, crotonaldehyde, and formaldehyde) have been reported to cause sensory irritation at relatively low levels. While this report does provide an overview of odor issues, it is important to recognize that in order to address questions about specific mills and communities, one must have information about the precise nature of citizen complaints as well as measurements or good estimates of ambient air levels of the various compounds of concern.

Special Reports

Special Report No. 18-02: Review of Ambient Air Monitoring Technology for PM_{2.5} and Associated Canadian Ambient Air Criteria *(Published 2/18)*

Most Canadian ambient air quality standards and criteria for PM_{2.5} were derived from epidemiological data collected during the 1980s and 1990s. Older ambient air PM_{2.5} monitors are known to yield biased measurements when compared to those obtained from the newer reference gravimetric-based instruments. Although it is conceivable that these biases may have affected the accuracy of the epidemiological associations reported in the literature, the available information summarized in this report suggests that other methodological and confounding factors may have more impact on health effect estimates, and thus on ambient air criteria derived from these estimates, than monitoring technology.

Special Report No. 10-01: Overview of Canadian Ambient Air Monitoring Programs

(Published 6/10)

As part of a national air quality monitoring program, Environment Canada operates several ambient air monitoring networks. The two primary components of this national monitoring program are the National Air Pollution Surveillance (NAPS) network and the Canadian Air and Precipitation Monitoring Network (CAPMoN). In 2006, NAPS and CAPMoN operated 805 continuous monitors measuring ground-level ozone, particulate matter (PM), sulphur dioxide, carbon monoxide, and nitrogen dioxide and 165 air samplers collecting samples used to measure components of PM, various volatile organic compounds (VOCs) and other substances. The provinces also operate a variety of ambient air monitoring networks, some as components of the NAPS network and others intended to monitor air quality around industrial sources and metropolitan or regional areas. Environment Canada provides technical oversight for the operation of most of these networks. Information on national and provincial ambient air monitoring networks is readily available to the public online via websites maintained by national, provincial, or local airshed agencies. Much of the data generated by the various ambient air monitoring networks are also available online, although there is typically a multi-year lag in publication of written reports. Data from continuous monitors are typically available in real-time, but rather than actual concentration measurements, data may be presented as a qualitative assessment of risk ranging from “low” to “very high.” This report provides descriptions of the various national and provincial ambient air monitoring networks as well as links to available online resources for information.

Special Report No. 08-01: Wood Products Air Quality Technical Information Document *(Published 5/08)*

This report synthesizes environmental information related to operations associated with primary subcategories of the wood products industry: lumber, oriented strandboard, plywood, medium density fibreboard, particleboard, and hardboard. Emission characterization and control option information is provided for the industry’s various unit operations, both process- and combustion-related. Available emission test methods are also reviewed. An overview of current knowledge related to the Canadian and US wood products industry is provided, including population and production statistics, emission estimates, and a summary of the existing regulatory platform.

Special Report No. 07-08: Review of Available Technologies for Control of Air Quality Parameters Relevant to Pulp and Paper and Wood Products Facilities in Canada *(Published 10/07)*

The control options for air emissions of sulfur oxide (sulfur dioxide and trioxide/sulfuric acid), nitrogen oxide, VOCs, chlorine dioxide, particulate matter (PM), dioxins and furans, total reduced sulphur (TRS), greenhouse gases (carbon dioxide, nitrous oxide) and mercury, especially those relevant to the pulp and paper (P&P) and wood products (WP) industry in Canada, are summarized in this report. The predominant emission sources for these compounds are identified within a P&P or WP mill, followed by a discussion of the widely tested control technologies. A fair amount of the experience with technologies is from a lateral transfer from applications to boilers operating mainly in the electric utility industry. For sulfur dioxide emission control for boilers, besides substitution of low-er sulphur fuels and capture within the combustion process itself by alkaline constituents of the fuel, end-of-pipe control technologies involve several mature flue gas desulphurization technologies. Control of sulfuric acid aerosols from combustion is relatively difficult and limited experience has been gained with candle filters and wet electrostatic precipitators (ESPs). For nitrogen oxide emission control, besides switching to lower nitrogen fuels such as oils, control technologies applicable to fossil fuel-fired boilers are also fairly advanced and include both combustion modifications and end-of-pipe technologies like selective non-catalytic reduction and selective catalytic reduction. Nitrogen oxide control for wood-fired and combination wood-fired boilers is difficult to achieve since the wood nitrogen content governs the nitrogen oxide emissions, and post-combustion nitrogen oxide control is generally only effective on “base-loaded” boilers. Nitrogen oxide emission control for kraft recovery furnaces is mainly obtained by maximizing the principle of staged combustion, while nitrogen oxide emission control techniques for kraft lime kilns are still in their infancy.

Special Report No. 05-04: Development of National Emission Regulations for the Forest Products Sector - A Summary of Relevant U.S. Experience *(Published 11/05)*

In the United States, the Environmental Protection Agency (EPA) has the legal authority to set national emission regulations for industrial sources under two programs: New Source Performance Standards (NSPS) and Maximum Achievable Control Technology (MACT). As one of the major manufacturing sectors, the forest products industry has been subject to both of these EPA programs, NSPS in the 1970s and 1980s, and MACT from 1990 onwards. Development of NSPS and MACT regulations for a particular industry involves gathering extensive information to characterize the manufacturing processes, production equipment, emissions, air pollution control technologies, and costs for applying various control technologies. EPA turns to several sources to obtain this information, including other federal government agencies, state air pollution control agencies, equipment suppliers, control technology vendors, trade associations, research organizations, and individual companies and mills. This report describes the interaction between the forest products industry and EPA over four successive rulemakings—NSPS for chemical pulp mills, NSPS for plywood manufacturing, MACT for pulp and paper mills, and MACT for wood products plants—and examines how information provided by the industry affected the final emission rules promulgated by EPA. The influence of emissions sampling activities undertaken by the industry in the standards setting process is discussed in detail to show the critical importance of having a technically sound basis for regulation development.

Special Report No. 05-03: A Comprehensive Comparison of Canadian and U.S. Pulp and Paper Mill Air Emission Data *(Published 11/05)*

This report presents a detailed comparison of air emission data generated at Canadian pulp and paper mill facilities during the recent Forest Products Association of Canada's 20-mill study with similar data generated in the U.S. over the past decade or so. Included in the comparison are emissions for certain key speciated volatile organic compounds (including methanol, acetaldehyde, methyl ethyl ketone, and formaldehyde) from a range of pulp and paper mill sources. These sources include vacuum drum type brownstock washers, kraft bleach plants, oxygen delignification systems, direct contact evaporator (DCE) and non-direct contact evaporator (NDCE) kraft recovery furnaces, smelt dissolving tanks, lime kilns, thermomechanical pulping (TMP) and groundwood pulping operations, and paper machines processing mainly mechanical pulp. The individual mill source emissions and their medians for the Canadian mills were compared with median emissions for the corresponding U.S. mill sources and also with the median and range for the combined Canadian-U.S. data sets. Outliers arising from application of statistical treatment procedures to the combined data sets were identified. Besides VOCs, the comparison included criteria air pollutants such as total particulate matter (TPM), PM₁₀, PM_{2.5}, CO, sulfur dioxide and nitrogen oxide for DCE and NDCE furnaces; total reduced sulphur (TRS) for NDCE furnaces; TPM and TRS for smelt dissolving tanks; TPM, PM₁₀, PM_{2.5}, sulfur dioxide and TRS for lime kilns; sulfur dioxide, nitrogen oxide, CO and TRS for thermal oxidizers; TPM, sulfur dioxide and nitrogen oxide for sulphite recovery furnaces; and trace metals for DCE/NDCE recovery furnaces, smelt dissolving tanks and lime kilns.

White Papers

Overview of Particulate Matter Emissions From Forest Products Industry Sources (WP-24-07) *(Published 9/24)*

This report provides a comprehensive overview of particulate matter (PM) emissions from the forest products industry, highlighting sources, trends, control technologies, and associated health impacts. PM emissions, categorized as total PM and fine PM [lower than 10 microns (PM_{10}) or lower than 2.5 microns ($PM_{2.5}$)], can originate from both natural events and human activities, including forest product manufacturing facilities, and can be directly emitted or formed through atmospheric reactions. PM sources in the forest products industry vary by process and equipment efficiency. Key contributors include boilers using fossil fuels and wood residues, mechanical wood processing operations, and various pulp and paper manufacturing processes. Control technologies such as cyclonic collectors, electrostatic precipitators (ESPs), baghouses, wet scrubbers, and electrified filter beds are employed to mitigate these emissions, each with its advantages and limitations in terms of PM removal efficiency, capital and operational costs, and suitability for different gas stream conditions. Testing methods such as US EPA Methods 5, 201A, and 202 are used for accurate PM measurement, although challenges persist in measuring fine PM, particularly in wet environments or in the presence of ammonia and sulphur dioxide. Ongoing improvements and best testing practices are necessary to address biases and ensure the reliability of emission data. $PM_{2.5}$ emissions from manufacturing operations have decreased significantly in the US and Canada since 1990, largely due to improved emission controls and operational practices. Despite these advancements, the health implications of $PM_{2.5}$ remain a major concern given its ability to remain airborne longer and penetrate deep into the respiratory system. Long-term exposure to fine particles is linked to health issues such as cardiovascular and respiratory diseases. Various jurisdictions have established air quality standards to limit $PM_{2.5}$ exposure, though there is no universally accepted clear threshold below which it can be concluded with confidence that $PM_{2.5}$ -related health effects do not occur. To fully understand the risks, there is a need to account for methodological limitations and uncertainties associated with available evidence when interpreting findings on the adverse health effects of $PM_{2.5}$.



Technical Bulletins

[Technical Bulletin No. 1087: Characteristics and Management of Lumber Kiln Condensates](#) *(Published 4/24)*

This report offers an overview of lumber kiln condensate, a byproduct of the lumber drying process. It begins with an introduction to the lumber drying process, highlighting the challenges sawmills face with increasing kiln condensate amounts. The report discusses the chemical composition of condensates and why they require adequate management strategies. Subsequently, it delves into the technical aspects of kiln drying and the various types of kilns, including batch, continuous dry kilns, dehumidification, and vacuum kilns. Finally, the report presents data from an industry survey that provides insights into the composition of kiln condensates generated at North American wood products facilities and outlines the most common condensate management options reported by those facilities.

[Technical Bulletin No. 1084: Wastewater Management in the North American Pulp and Paper Industry](#) *(Published 10/23)*

This report summarizes federal and provincial/state legislation and regulation pertaining to the management of pulp and paper mill effluents in North America, as well as this industry's efforts over recent decades to reduce organic releases from wastewater treatment systems through in-mill process modifications, secondary treatment optimization, and minimization of residual nutrients through improved wastewater treatment management practices. Seasonal and long-term biological monitoring of pulp and paper mill effluent-receiving streams, at various sites both upstream and downstream of mill effluent discharges, has shown the positive impact of process and wastewater treatment changes on the compatibility of treated effluents with fish and benthic macroinvertebrate communities, while highlighting the greater influence of habitat conditions, natural variations, and anthropogenic activities on downstream population and community structures.

The report also provides a review of relevant tertiary treatment approaches used at a small number of pulp and paper mills to further reduce COD, colour, and nutrient effluent releases, focusing on treatment principle, configuration, performance, and limitations. The tertiary treatment processes covered include flocculation and precipitation, membrane filtration, adsorption, advanced oxidation, ion-exchange, and biological technologies such as engineered wetlands or fungal treatments. The information gathered and organized in this report suggests that most tertiary treatment for colour or COD reduction, in biotreated final pulp and paper mill effluents, appears unjustified from an economic and sustainability standpoint or, in some cases, due to embryonic technological development. Although most mills applying tertiary treatment use coagulation/flocculation principles for phosphorus removal, and occasionally for colour reduction, the necessary chemical dosage and management of large amounts of residual sludge generated during treatment typically result in very high operational costs and increase the environmental footprint of the treatment system. Existing tertiary treatment applications often operate on an as-needed basis and are viable only when applied to wastewater streams with flowrates that are low relative to industry norms. Most of these processes also require significant capital investment, pre-treatment, increased chemical and energy inputs, and additional residuals management. A more sustainable and cost-effective approach to lowering organic and nutrient releases from pulp and paper mills in response to site-specific environmental concerns is often to implement in-mill process changes, where applicable, and management practices to reduce process-related organic losses, coupled with effective nutrient management to optimize biological treatment.

Technical Bulletin No. 1076: Review of Stormwater Runoff Management Approaches of Relevance to Canadian Forest Products Facilities *(Published 12/21)*

This report characterizes effective approaches for managing stormwater runoff generated at forest products facilities in Canada. In this regard, it provides a jurisdictional review of relevant legislation and permitting; discusses specific stormwater runoff management principles and their effectiveness; compiles preventive best management practices recommended by existing guidance; summarizes case studies for treating log yard runoff and wood leachate; and characterizes best management practices currently implemented at Canadian wood products facilities for stormwater runoff discharges. Commonly implemented stormwater management practices include good housekeeping, water recycling, and implementation of vegetated swales and filter strips, sedimentation traps and basins, retention ponds, and constructed wetlands. The quality of stormwater runoff discharges from Canadian forest products facilities is typically controlled through permit limits, primarily for total suspended solids (TSS), biochemical oxygen demand (BOD), and pH. Depending on the province, other parameters may be regulated and monitored, including total phenols, petroleum hydrocarbons, acute toxicity, resin and fatty acids, and selected metals. Recent data suggest that stormwater runoff discharges from Canadian forest products facilities respect the most stringent provincial limits for BOD, TSS, petroleum hydrocarbons, total phenols, and pH.

Technical Bulletin No. 1054: Compilation of Canadian Provincial and Federal Regulations Relevant to Pulp and Paper and Wood Products Facilities: 2019 Update *(Published 6/19)*

Forest products facilities in Canada face a complex and highly variable regulatory context depending on the province in which they are located. This report provides an updated overview of the applicable federal and provincial legislation, regulation, guidelines and standards, for both pulp and paper mills and wood products facilities. The focus of the review is on legislation and regulatory guidelines associated with forest products industry releases to air, water, and land; residuals and spill management; chemicals and toxic substances management; ozone-depleting and halocarbon substances; storage of petroleum products; mill practices; transportation and handling of dangerous goods; climate change and renewable energy; water resources conservation and protection; and approval or permitting procedures. This report is accompanied by an Excel workbook (CReST) that summarizes all legislative acts, regulations, codes of practice and guidelines described in the report, and compiles specific standards and limits prescribed by relevant regulations. Earlier versions of this compilation were published as Special Report No. 11-01 (2011) and Special Report No. 07-04 (2007).

Technical Bulletin No. 1007: The Effect of pH on the Toxicity of Substances Present in Pulp and Paper Mill Effluents: A Literature Review *(Published 1/13)*

In aquatic systems, total ammonia concentration is comprised of ionized (NH_4^+) and un-ionized (NH_3) forms, with NH_3 being more toxic to fish than NH_4^+ . The relative concentration of these two forms depends on water temperature and pH, with the relative concentration of NH_3 increasing as temperature and pH increase. This has implications for regulatory compliance because pH shifts during bioassay testing may indicate effluent toxicity when, in fact, a pH-associated increase in the fraction of un-ionized ammonia, and not the presence of some other toxic compound(s), was responsible for the bioassay response. Environment Canada does not currently allow the use of pH stabilization techniques during the acute lethality testing of pulp and paper mill effluents. This restriction is based on EC's concern that the use of such techniques could mask the toxicity of certain constituents of these effluents. The available literature, however, suggests that pH stabilization is necessary (a) to avoid inadvertent toxicity resulting from the formation of artefact un-ionized ammonia, and (b) to reduce the risk of masking the toxicity of compounds whose acute effects in fish decrease as a result of a pH change. This report summarizes published research addressing the relationship between pH and the acute lethality of substances typically found in pulp and paper mill effluents. Results from this review suggest that the acute toxicity of substances like resin acids, hydrogen sulphide, polychlorinated phenolics, and certain metals (e.g., chromium, lead, mercury, copper, and zinc) may be masked if pH is not stabilized during acute bioassay tests of pulp and paper mill effluents.

Technical Bulletin No. 975: Water Profile of the Canadian Forest Products Industry *(Published 5/10)*

Runoff from managed forest watersheds yields approximately one-fifth of Canada's freshwater resource. The effects of harvesting activities on water quality and forest hydrology are effectively controlled by the application of provincial regulations and forestry best management practices. Managed forestlands in Canada receive 1.35 trillion m³/yr of precipitation and produce roughly 0.67 trillion m³/yr of streamflow and groundwater. The forest products industry's manufacturing operations draw about 0.3% of these surface and subsurface sources. Approximately 88% of the water used by manufacturing processes is returned directly to surface waters following treatment; nearly 11% is evaporated during manufacturing and wastewater treatment; and about 1% is imparted to products or solid residuals. Federal pulp and paper mill effluent standards, in conjunction with process improvements and advanced biological treatment systems, have resulted in declining trends in discharge loads of biochemical oxygen demand (BOD), total suspended solids (TSS), adsorbable organic halides (AOX), and dioxins and furans. Laboratory testing and artificial stream assessment of aquatic organisms exposed to these effluents at different concentrations have shown variable effects on organism survival, growth or reproductive capacity. In contrast, extensive in-stream studies carried out to date suggest that treated pulp and paper mill effluents have little effect on aquatic community structure.

Technical Bulletin No. 944: Minimization of Nutrients in Biologically Treated Effluents from Pulp and Paper Mills *(Published 12/07)*

A common impairment cited for water bodies is excessive nutrients, and a growing number of pulp and paper mills in North America have received or are expected to receive stringent discharge limits for total phosphorus and/or total nitrogen. A mill contending with a tight nutrient limit has the often difficult task of minimizing nutrient addition while simultaneously maintaining a level of nutrients sufficient for good BOD removal and biomass settleability. This report covers several topics concerning nutrient management at mill treatment plants. These include a) current and proposed permit limits for nutrients at North American mills, b) nutrient concentrations in discharges from mills with minimization practices, c) treatment plant design and operational factors which may contribute to low levels of nutrients in discharged effluent, and d) possible alternative treatment technologies. A concise review of nutrient fundamentals is also provided.

Technical Bulletin No. 937: Synthesis of NCASI Information on the Management of Nutrients for Biological Treatment of Pulp and Paper Mill Wastewaters *(Published 7/07)*

This report is a synopsis of previously published NCASI works related to the management of nutrients used to support biological treatment of wastewaters. It is intended as a reference for mill personnel interested in improving the management of supplemental nutrients and/or reducing concentrations of residual nutrients in treated effluents. The material presented summarizes more detailed works on the fundamental requirements for nutrients in biological treatment; analytical methods for nitrogen and phosphorus species in wastewater; sources of nitrogen and phosphorus in process wastewaters; supplemental addition of nitrogen and phosphorus to treatment systems; minimization of residual concentrations in effluents; nitrogen and phosphorus removal practices; and the bioavailability of organic nitrogen and phosphorus forms in biologically treated wastewaters. Considerable additional detail on these topics may be found in related NCASI publications.

Technical Bulletin No. 902: Material Substitution to Reduce Mercury Concentrations in Pulp and Paper Industry Final Effluents *(Published 8/05)*

State and federal guidance on developing and implementing mercury-specific pollutant minimization plans (PMPs) are reviewed. Examples of state-approved mill-specific mercury PMPs are provided, and the impacts of implementing these PMPs on mercury concentrations in final effluents are summarized. In addition, data on the levels of mercury and other metals in a variety of pulp and paper industry feedstocks used throughout North America are presented. These data show that essentially all raw materials and chemicals imported to mill sites contain measurable mercury and that the major imports are associated with (in alphabetical order) calcium carbonate, caustic, clay, furnish, starch, and sulfuric acid. To date, the experiences of bleached kraft (BK) mills indicate that sulfuric acid and, to a lesser extent, caustic are the major contributors to final effluent mercury. Because the levels of mercury in sulfuric acid and caustic from different sources vary widely, some BK mills have been able to effect significant reductions in effluent mercury by substituting new supplies with lower mercury concentrations. Depending on the relative concentrations of mercury in the different supplies, final effluent concentrations have been reduced 70 to 90%. Based on work done at these mills, the dominant vectors for this final effluent mercury are bleach plant filtrates, and evidence suggests that very little of the mercury in final effluents originate from paper mills at integrated BK mills. Furnish contributed the vast majority of the mercury imported to the secondary fiber mills examined, with other raw materials, chemicals, or additives accounting for <1% of known imports at these mills. In all cases, the masses of mercury exported with mill-specific final effluents were greater than those imported in all non-furnish raw materials, chemicals, or additives.

Technical Bulletin No. 874: Canadian Environmental Protection Act Aldehydes and the Forest Products Industry *(Published 4/04)*

Formaldehyde, acetaldehyde, and acrolein have been declared toxic under the Canadian Environmental Protection Act (CEPA). This report summarises information related to these compounds that will provide valuable context as Environment Canada undertakes its obligations under CEPA, as well as what is known about the use and unintentional formation of these compounds by the forest products industry. It updates and expands on earlier inventories of total sources of the compounds. The environmental fate and significance of the compounds are reviewed. Their toxicologies are briefly reviewed and discussed in the context of the bases for their determinations as CEPA toxic. Analytical methods are summarised, and information on emission factors are reviewed or tabulated.

Special Reports

Special Report No. 12-02: Approaches for In-Plant Reduction of Spent Pulping Liquor Losses *(Published 5/12)*

Effective management of losses of organic material derived from pulp manufacturing is an important aspect of environmental management at chemical pulp mills. While the recovery of pulping chemicals is a central component of virtually all chemical pulping facilities, there are ongoing routine losses of these chemicals due to the nature of the processing systems, and these are either recovered back into the process or are sent to wastewater treatment. Reducing and recovering losses of spent pulping liquors can result in better performance of wastewater treatment systems, decreased “pass through” of substances that may resist biological degradation, and incremental benefits to the mill’s energy generation and chemical cost profiles. This report has been designed as a tool to provide a proposed framework that may be useful to individual facilities in helping to identify and minimize “background” low-concentration and/or low-flow spent liquor losses, thus reducing the challenges inherent in managing wastewater treatment and effluent quality. This approach may also be useful for facilities currently working to address residual effects measured through the EEM program or to address local receiving environment initiatives, depending on site-specific circumstances. The report includes example mill programs for managing spent liquor losses.

Special Report No. 08-04: Investigation of the Main Sources of PCBs at a TMP/Recycle Pulp Mill and a Bleached Kraft Pulp Mill *(Published 8/08)*

A screening-level study was conducted to identify the main sources of PCBs to the final effluent of one thermo-mechanical (TMP)/recycle pulp mill and one bleached kraft mill in Québec. The high-resolution gas chromatography/high resolution mass spectrometry method, US EPA Method 1668, Revision A, was used to quantify congener-specific PCB concentrations in composite samples of process waters, pulps, and solids collected during representative operating conditions at carefully selected mill locations. Samples were analyzed sequentially to maximize the cost-effectiveness of the analyses. Data on total PCB concentrations and mass transport and on PCB congener composition were evaluated. Numerous sources of sampling and analytical uncertainty in the data exist, and many of the samples presented significant challenges to Method 1668A. Despite these problems, the data provide some insight on PCB sources at both mills. At the TMP/recycle mill, the most important source of PCBs to the treated effluent is likely the recycled paper (newspaper and magazines) used as a source of fibre in papermaking. The primary source or sources of PCBs are less clear at the kraft mill; however, this study indicates that PCBs are present at measurable levels at many sampling locations in the mill and waste treatment areas, the PCB composition of nearly all samples resembles an Aroclor 1254 standard, and pulp bleaching was judged to be an unlikely contributor to the PCB content of the mill final effluent.

Special Report No. 07-03: Evaluation of Analytical Approaches for the Measurement of Formaldehyde in Pulp Mill Treated Effluents *(Published 4/07)*

Quebec mills were instructed to have effluent samples tested for formaldehyde using either Standard Method 6252B or MA 403–SP.03 1.0 in order to fulfill formaldehyde monitoring requirements of the attestations d'assainissement provincial effluent permitting program. Because neither of these methods have been validated for applicability to pulp and paper industry effluents, NCASI undertook studies to evaluate whether the methods produce reliable results suitable for use in making regulatory decisions. The results of the studies, reported herein, show that when methanol is added to samples, as specified in both methods for the introduction of surrogate spikes, a unique interaction between constituents in pulp mill effluents and the pentafluorobenzylhydroxylamine (PFBHA) derivatization chemistry converts some of the methanol to formaldehyde and results in a positive bias. The magnitude of this bias varied from mill to mill and, in some instances, over time. Limited efforts to resolve the problem using antioxidants failed to mitigate the bias. Although the bias can be substantially reduced by specifying the use of acetonitrile as the surrogate spike solution solvent, these studies show that application of either of the subject methods will produce a biased result if the effluent contains any residual methanol. Thus, the PFBHA derivatization chemistry should not be used in pulp mill effluents unless it can be documented that the samples contain no methanol. Comparison of the subject methods to other analytical approaches suggests that there may be yet another source of bias, but a full understanding of this phenomenon would require additional research.

Special Report No. 04-04: Evaluating Analytical Methods and Quebec Water Quality Objectives for Aluminum, Arsenic, Copper, Lead, and Mercury *(Published 9/04)*

The Quebec Ministry of Environment (MENV) is requiring pulp and paper mills in the province to undertake one year of monthly effluent sampling for a number of compounds, including mercury, aluminum, arsenic, copper, and lead. Results from this sampling campaign are compared to the capacity of the receiving water bodies and are then being used for permitting purposes. This report compares the water quality criteria (WQC) used by MENV for calculating the capacity of the receiving environment for these five metals, to those used in jurisdictions geographically relevant to the province of Quebec. Analytical methods commonly available for the determination of these metals in aqueous samples are also evaluated and compared with the method recommended by MENV. Their suitability for use in pulp and paper effluent matrices is specifically assessed.

Tools & Handbooks

[NCASI Tool for Searching Substance-specific Aquatic Toxicity Data \(SATDat\)](#) *(Published 7/24)*

NCASI maintains a database of effluent analytes and test species to support Member Companies in activities related to whole effluent toxicity (WET) outcomes, such as quickly assessing potential bioassay responses based on analyte concentrations in effluent samples. While Member Companies can contact NCASI staff for general toxicity information regarding specific toxicants relevant to pulp and paper mill effluents, some have expressed interest in accessing this information directly. Many Members have found that conducting toxicity data searches using publicly available resources can be overwhelming. SATDat summarizes currently available substance-specific aquatic toxicity data and offers a user-friendly interface for querying this information. The backend of this tool contains data sourced from the ECOTOX database, peer-reviewed literature, and safety data sheets. The frontend features a 'Search' tab where users can query toxicity data by chemical and test species, and a 'Glossary' tab that provides definitions and concepts to aid in interpreting query results. It is worthwhile noting that this tool does not include toxicity data for sum-parameter measures (e.g., BOD, COD, conductivity), which can also affect toxicity responses in WET tests. Nonetheless, the tool has been designed to easily incorporate additional or new toxicity data as needed.

CHEMICAL MANAGEMENT

Technical Bulletins

[Technical Bulletin No. 1049: Systematic Statistical Procedures for Emission Factor Development](#) *(Published 9/18)*

This report describes a systematic statistical approach developed by NCASI to estimate emission factors from quality assured emissions and process data generated at forest products manufacturing facilities. The approach is designed to treat run-by-run data as well as data consisting of individual source averages. Key methodological steps implemented in the approach include the removal of suspiciously high non-detects (data below the reporting detection level), the identification and removal of potential statistical outliers, and the generation of summary statistics using a variety of robust estimators tailored to handle data sets containing a significant fraction of non-detects. The approach has been fully automated using a computer program that relies on Microsoft Access® to handle thousands of data sets and the R software to perform advanced statistical calculations.

[Technical Bulletin No. 930: Total Reduced Sulphur, Hydrogen Sulphide, Chlorine, Chlorine Dioxide, Chloroform and Methanol and the Forest Products Industry](#) *(Published 4/07)*

Total reduced sulphur (TRS), hydrogen sulphide, chlorine, chlorine dioxide, chloroform, and methanol are six candidate substances or substance groups under review for potential classification as “toxic”; under the Canadian Environmental Protection Act (CEPA). In addition, TRS, H₂S, chlorine, chlorine dioxide, chloroform, and volatile organic compounds (VOCs, of which methanol is the most relevant for pulp and paper facilities) have been recently reviewed by the national Pulp and Paper Air Quality Forum for potential release reduction. This report is a summary of information related to these six substances (or substance groups) that should provide valuable context as Environment Canada undertakes its obligations under CEPA, as well as document what is known about their use and/or unintentional formation within the forest products industry. It updates and expands on earlier inventories of total sources of these compounds. The environmental fate and significance of the compounds are reviewed. Their toxicological characteristics are briefly reviewed and discussed in the context of the bases for their potential determination as “CEPA toxic.” Finally, analytical methods are summarized, and information on emission factors is reviewed or tabulated.

Special Reports

[Special Report No. 17-03: Detailed Review of National Pollutant Release Inventory \(NPRI\) Data Reported by Forest Products Manufacturing Facilities up to 2015](#) *(Published 11/17)*

Forest products manufacturing facilities may at times file inaccurate reports to the National Pollutant Release Inventory (NPRI) for a variety of reasons (e.g., transcription error in the report, unit conversion error, etc.). If undetected, these errors can lead to significant distortions of industry-wide reporting trends. Conventional data quality assurance can become a highly resource-intensive activity, especially if it involves the scrutiny of reports made by hundreds of facilities over extended reporting periods. The approach presented in this report is intended to serve as an exploratory tool to analyze the NPRI database in search of unusual reports that have the potential to significantly affect forest products industry reporting trends. This potential is evaluated by comparing actual reports, as filed by individual facilities, with plausible reports calculated using a procedure that combines statistical outlier identification and a data substitution algorithm. The approach has been implemented using a computer program that generates graphical and tabular information for nearly 90 different NPRI substances of relevance to the forest products industry. Results show that less than 2% of all quantities ever reported by the industry are flagged as unusual reports, and nearly 50% of these correspond to quantities reported as releases to air. Results also suggest that verifying the validity of these unusual reports could result in the adjustment or removal of existing reporting trends or in the creation of trends where none existed originally. Interestingly, data quality assurance is not expected to significantly affect the trends associated with the reporting of criteria air contaminants, or forest products industry-relevant substances such as formaldehyde, methanol, dioxins and furans, total polycyclic aromatic hydrocarbons (PAHs), total reduced sulphur (TRS), chlorine dioxide, or ammonia.

Special Report No. 15-03: Synthesis and Analysis of Forest Products Industry NPRI Data Reported Up to 2012

(Published 4/15)

This report provides a detailed portrayal of how the reporting of relevant releases from forest products manufacturing mills has changed since the inception of the National Pollutant Release Inventory (NPRI) in 1993. Specifically, the tabular and graphical information presented allow the identification of historical trends and potential outliers or suspect data. A systematic computer-based approach has been developed to generate this information. A significant finding from this analysis suggests that the majority of the releases shows a declining trend. This is particularly true in the case of most criteria air contaminants. Also, a non-trivial amount of data has been statistically flagged as being potentially inaccurate and requiring further investigation.

Tools & Handbooks

NPRI Handbook for Pulp & Paper Facilities (both English & French versions) *(Updated 4/19)*

The Handbook of Substance-Specific Information for NPRI Reporting contains extensive substance-specific information (SSI) sheets for compounds that have some likelihood of exceeding NPRI reporting thresholds at pulp and paper mills in Canada. The quantitative information included in the SSI sheets consists of summary statistics (min, max, averages) of emissions from major process units and concentrations in mill effluents, raw and process materials, fuels, and solid residues. In addition, we have included a new Appendix C containing guidance for the reporting of criteria air contaminants and mercury emissions from electricity generation units. These updates were made in response to the NPRI reporting requirements published by ECCC for 2018 and 2019. Facilities should report their releases for the 2018 and 2019 calendar years no later than June 1, 2019, and June 1, 2020, respectively.

NPRI Handbook for Wood Product Facilities (both English & French versions) *(Updated 4/19)*

The Handbook of Substance-Specific Information for NPRI Reporting contains extensive substance-specific information (SSI) sheets for compounds that have some likelihood of exceeding NPRI reporting thresholds at wood products facilities in Canada. The quantitative information included in the SSI sheets consists of summary statistics (min, max, averages) of emissions from major process units and concentrations in raw and process materials, fuels, and solid residues. In addition, we have included a new Appendix C containing guidance for the reporting of criteria air contaminants and mercury emissions from electricity generation units. These updates were made in response to the NPRI reporting requirements published by ECCC for 2018 and 2019. Facilities should report their releases for the 2018 and 2019 calendar years no later than June 1, 2019, and June 1, 2020, respectively.

Environmental Release Estimation Tool for Pulp and Paper Facilities (ENREST) *(Published 12/14)*

The Environmental Release Estimation Tool for Pulp and Paper Facilities (ENREST for P&P) is a generic calculation tool developed by NCASI to help facilities determine the plausible range of annual releases for several substances of relevance to the pulp and paper sector. ENREST uses basic mill-specific information and NCASI's environmental database to estimate annual environmental releases. The user inputs mill-specific information such as annual production rates, raw material and fuel consumption, solid residue generation, and final effluent flow rates. The tool then utilizes NCASI's environmental database to generate estimates. The database contains emission factors, as well as wastewater, process material and fuel concentrations for more than 130 substances. All substances for which NCASI has prepared an NPRI pulp and paper substance-specific information sheet have been incorporated into this tool.



SUSTAINABILITY

Technical Bulletins

[Technical Bulletin No. 1092: Beneficial Use of Wood Ash for Road Stabilization](#) *(Published 11/24)*

Forest products manufacturing facilities generate fly ash and bottom ash from woody biomass combustion. Landfilling wood ash is costly and environmentally challenging, making wood ash application in road stabilization an attractive and sustainable ash management solution for the forest products industry. The available literature documents several applications where wood ash has successfully stabilized various road types, including forest, gravel, and landfill roads. This report provides an overview of the potential use of wood ash for road stabilization. It includes wood ash handling, physical and chemical characteristics, and utility as a construction material, as well as the benefits, limitations, and concerns associated with its application in forest road stabilization. Wood ash tends to exhibit variable characteristics depending on wood species, combustion conditions, and handling practices. Its high calcium content and pozzolanic oxides can provide cementitious properties with reasonable hardening ability when it reacts with water. Wood fly ash with finer particles and a higher reactive surface area is a suitable filler in road stabilization. Bottom ash with better compaction potential may be useful as an aggregate. While wood ash also contains variable amounts of trace metals and salts that can potentially leach into the surrounding environment, especially in acidic soils, their contribution to concentrations in soil generally decrease over time and return to background levels within a few years. With appropriate precautions and best practices, the economic and environmental benefits of using wood ash as a road stabilizer can be maximized while minimizing potential adverse environmental effects.

[Technical Bulletin No. 1067: Land Application of Wood Ash in North America: A Case Study Review](#)

(Published 6/20)

Several regulatory agencies have published guidelines discussing the use of wood ash as liming material for agricultural land and as a soil amendment and fertilizer. However, no information summarizing the experience of applying wood ash on agricultural land is available in the literature. This report provides a review of several forest products facility-sponsored agricultural application programs across North America. Each program is described as a case study, in terms of required wood ash quality, approval requirements, recommended best management practices, agricultural benefits of wood ash, and challenges confronted by ash generators and farmers during storage, handling, and land application of wood ash. A summary of the common and distinctive aspects of these land application programs is presented at the end of the report.

[Technical Bulletin No. 1015: A Review of Biomass Carbon Accounting Methods and Implications](#) *(Published 7/13)*

When performing greenhouse gas inventories, product carbon footprints, company carbon footprints, and policy studies, it is important to select a carbon accounting approach that is appropriate for the intended use. This report examines the available forest carbon accounting options and the factors to consider in selecting among them. It finds that the “carbon neutrality” debate involves carbon accounting questions related to system boundaries, the greenhouse gases to include, baselines, attribution, and a number of other factors. Because trees require decades to grow, it is especially important that spatial and temporal boundaries are established correctly in studies of forest carbon. Otherwise, the results of the analysis may not properly reflect the renewability of forest biomass and the removals of CO₂ from the atmosphere during forest growth. Also important, especially in policy studies, is addressing market responses to increased demand for forest biomass. Studies that use accounting methods that ignore these forces produce results that understate the benefits of using forest biomass. Much of the current debate about the benefits of forest-derived materials and fuels is not about whether these benefits exist but whether the benefits are delayed (the so-called “carbon debt”). Where the benefits are delayed, the estimated delay is reduced by using accounting methods that reflect market responses. The significance of a delay in delivering greenhouse gas mitigation benefits, however, cannot be assessed by carbon accounting alone.

Technical Bulletin No. 994: Beneficial Use of Woody Biomass for Energy and Other Purposes (Published 12/11)

This report synthesizes published information on current inventories of wood residue in Canada and beneficial use options for these residues. Wood residue sources accounted for in these inventories include mill residues from forest products manufacturing, existing bark/hog fuel piles, urban wood residue, wood residue from harvesting and thinning operations, and wood killed by natural disturbances. The inventory data compiled in this report suggest that the wood residue availability varies with geographical location and that current and future beneficial use opportunities will rely both on harvest residues and dead wood. Energy use constitutes the most developed beneficial use for wood residues, and thus it has been fully explored in this report in terms of process principles and technology, potential by-products, economic costs, potential environmental releases, regulatory landscape, and wood residue quality requirements. The number of information sources documenting non-energy applications (e.g., soil amendment, wood-composites, animal bedding) is limited if compared with the available literature on energy uses. These latter applications are primarily discussed in terms of type of wood residue used and the principle or context of the application.

Technical Bulletin No. 985: Summary of the Literature on the Treatment of Paper and Paper Packaging Products Recycling in Life Cycle Assessment (Published 5/11)

A review was undertaken of methodologies used in the literature for dealing with paper recycling in life cycle assessment (LCA) studies, to provide perspective as to their strengths and weaknesses in accurately reflecting the life cycle-related characteristics of the use of recycled fibre within the overall wood fibre system. The review also incorporated an examination of the factors (e.g., energy type) that have a significant effect on the LCA results. Of the 99 candidate studies, 41 were retained for further analyses, having met several selection criteria. A series of seven overarching issues were identified, which either drive the results of recycled fibre-related LCAs, or for which there is still too much uncertainty to fully understand their potential effect on LCA results. These included 1) impact of land use and alternative usage of the forest area; 2) type of energy used during virgin and recovered fibre processing; 3) type and amount of energy displaced when burning used paper at end-of-life; 4) accuracy of modelling toxicity-related impacts; 5) assumption regarding the degree of paper degradation in landfills and the approach used for modelling of biogenic carbon dioxide; 6) selected allocation procedure for recycling, in cases where virgin and recycled fibre are compared; and 7) recycled-to-virgin fibre substitution ratio. Based on the literature reviewed in this study, the existing knowledge on LCA and paper recycling does not allow for general conclusions to be made regarding the overall environmental superiority of the use of recycled or virgin fibre for paper production.

Technical Bulletin No. 974: Characterization, Toxicology, and Management and Treatment Options for Wood Pile Leachates and Runoff - Part II: Case Studies (Published 5/10)

A number of Canadian provinces have developed or are developing codes of practice and guidelines to control the discharge of leachate or stormwater runoff from log storage areas, bark piles or related wood processing activities. These management practices alone might not sufficiently attenuate the environmental effect of large volumes of concentrated stormwater runoff and leachate. In those cases, treatment can be considered as a potential alternative or as a supplemental measure. Available information on the efficiency of these treatments at an industrial scale is, however, limited. Using a case study approach, this report examines the viability of a number of full-scale options to treat leachate and stormwater runoff. Nine facilities participated in this study. Treatments include aerated ponds, irrigation, wetlands, sand filtration, biological trickling filtration, and natural attenuation. Each facility is described in terms of site and climatic conditions, relevant permitting issues, treatment principle, operation and performance, final effluent effect on the receiving environment, and when available, capital and operating costs. Most of the information used in this report comes from relevant monitoring data, technical reports provided by facilities, notes from site visits, and discussions with consultants, site operators, and environmental managers.

Technical Bulletin No. 928: A Review of Canadian Forest Products Industry Landfill Design, Construction, Operation and Closure *(Published 12/06)*

NCASI compiled information on the various types of residuals generated in the Canadian forest products industry and examined landfilling practices using data from the Forest Products Association of Canada and a survey distributed by NCASI-Canada. Data from the FPAC Survey indicate that wood residuals is the largest overall waste generated, followed by wastewater treatment plant residuals (residuals), followed by process residuals, ash, and other. While wood residuals may have at one time been considered by the industry to be “wood waste” destined for landfill disposal, the forest products industry in Canada currently utilized the majority of these materials for energy recovery. Management practices were reviewed for five individual types of wastes, including treatment plant residuals, process residuals (primarily causticizing materials and recycling wastes), wood residuals, combined boiler ash and incinerator ash, and other solid wastes. For each of the five solid waste streams (other than wood residuals), landfilling is used (often predominantly) for management. The NCASI-Canada survey resulted in 24 responses that were used to summarize current practices for the design, construction, operation, and closure of Canadian forest products industry landfills.

Technical Bulletin No. 911: Characterization, Toxicology, and Management and Treatment Options for Wood Pile Leachates and Runoff: Part I - Literature Review *(Published 12/05)*

A large number of documents have been published discussing the characterization, toxicology, and management and treatment options for wood yard leachates and stormwater runoff, but this information originates from very diverse sources, and has never been compiled or synthesized to present a clear picture of current understanding. This report provides a comprehensive summary of the literature available on this subject. First, a portrait of the quality and variability of leachate and stormwater runoff is provided. The toxicity of leachates and stormwater runoff from various studies is then presented, in addition to the potential sources of toxicity. Groundwater characteristics near wood waste landfills are discussed as well as the mechanisms for natural attenuation. Different technologies are presented that have either been tested at lab or pilot scale or implemented on a full scale, for the treatment of wood yard leachates and stormwater runoff. Finally, best management practices for dryland sorts, log yards, and sawmills are discussed.

Technical Bulletin No. 910: Improved Clean-Up Procedure for Canada-Wide Reference Method for Petroleum Hydrocarbons in Soil *(Published 12/05)*

In 2001, the Canadian Council of Ministers of the Environment (CCME) published a Canada-wide standard analytical protocol for the Tier 1 determination of petroleum hydrocarbons (PHC) in soil. As a screening procedure, it was designed to be quick and cost effective. As a result, however, it suffers from potential interference from natural bark and wood extractives. Representative literature was reviewed and summarized in order to characterize and document this potential. A potential for interference was clearly indicated. To better understand the potential problem, available or synthesized bark and wood extractives were analyzed to determine which extractives may co-elute in the target analyte fractions of the CCME PHC procedure. Finally, to quantify potential interferences, samples of bark and wood known to be free of petroleum contamination were analyzed using the CCME PHC procedure. Independent GC/MS (gas chromatography/mass spectrometry) analyses of the extracts further documented the presence of natural bark and wood extractives. NCASI developed a refined silica gel chromatography column to better separate petroleum hydrocarbons from natural bark and wood extractives. This cleanup is similar to others reported but is optimized for application to samples where woody debris is present. The efficacy of this procedure has been demonstrated through analysis of the same bark and wood samples analyzed by the CCME PHC procedure. The cleanup procedure was applied in two separate case studies. In the first, woody debris was analyzed using the CCME PHC method and then using the NCASI cleanup procedure. GC/MS analysis showed that the extract from the CCME PHC method contained known bark and wood extractives and did not show significant evidence of petroleum hydrocarbons. Comparing the CCME PHC results to the NCASI cleanup results, reductions of 20%, 62%, and 89% were observed for Fractions 2, 3, and 4, respectively. Thus, use of the NCASI cleanup can significantly reduce the potential for false positives or high bias from natural bark and wood constituents. The second case study involved a similar analysis of a soil amendment material produced from kraft mill waste treatment plant residuals. Using the same procedures, it was determined that the sample did appear to contain petroleum hydrocarbons. While the NCASI cleanup removed some bias, the subsequent analysis correctly identified and measured the presence of petroleum hydrocarbons. The NCASI cleanup provides an effective means of reducing or eliminating bias from natural components expected to be found in woody debris. Although it does add some time to the analysis, it can be effective in reducing the chance that woody debris will be incorrectly judged as contaminated with petroleum hydrocarbons.

Special Reports

Special Report No. 18-03: Review of Sustainability Reporting Indicators and Metrics Used by the Global Forest Products Industry *(Published 4/18)*

This report is to help companies in the forest products industry better understand the sustainability disclosure landscape and the range of expectations and requirements from both current and emerging disclosure initiatives. The report provides an overview of 11 voluntary disclosure initiatives [Global Reporting Initiative (GRI), Dow Jones Sustainability Index (DJSI), Carbon Disclosure Project (CDP), CDP Water, CDP Forests, Global Protocol on Packaging Sustainability (GPPS), The Sustainability Consortium (TSC), International Integrated Reporting Framework (IIRC), Extractives Industry Transparency Initiative (EITI), Ontario Securities Council (OSC) and Sustainability Accounting Standards Board (SASB)], along with a more detailed focus and analysis on the indicators and metrics associated with environmental issues. While the studied indicators are relevant to the sector, the manner in which some are quantified may lead to inconsistent results across companies and/or across disclosure initiative reporting. It is important to note that while the overall analysis in this report will be useful over time, the details in each of the disclosure initiatives will continue to evolve.

Special Report No. 16-02: Screening Life Cycle Assessment of Unconventional Use Pathways for Woody Mill Residues *(Published 8/16)*

In this study, life cycle assessment is used to assess the environmental attributes and trade-offs of different woody mill residue management options in North America. More specifically, this study documents the potential environmental impacts and benefits from disposing of woody mill residues in a landfill, or using them in five unconventional use pathways: heat production from value-added fuels (pellets, syngas, methane), combined heat and power (CHP) generation from these same value-added fuels, transport fuel, use in metallurgy, and use as horticultural growing media. The results indicate that, for most environmental indicators studied, the impact scores are lower for the unconventional uses than for landfill disposal. Scenarios involving the use of syngas in the combined heat and power pathway designed for high electricity output and displacing electricity on the North American electricity grid show the most environmental benefits for most impact categories. Scenarios involving the use of pellets and methane in these CHP systems also yield environmental benefits in a large number of impact categories. Production of heat using syngas is also interesting. In contrast, the scenarios in the transport pathway are among those with the most categories showing the worst relative environmental impact, scenarios in the metallurgy use pathway are relatively neutral (i.e., showing neither significant environmental benefits or impact), and the scenarios under the horticultural growing media pathway are also among those with the greatest number of categories showing a net environmental impact.

Special Report No. 09-04: Review of LCA Allocation Procedures for Open-Loop Recycling Used in the Pulp and Paper Industry *(Published 4/09)*

The North American pulp and paper industry is increasingly interested in using Life Cycle Assessment (LCA) to address the sustainability of its processes and products. One important characteristic of paper products is that they are usually recyclable. Some pulp and paper systems that involve recycling can be modeled as “closed-loop” recycling systems, meaning that all recovered product from the system is used in that same system and the only product leaving the system is headed for disposal after use. Using this approach, the recovered paper stays within a single process system, making it easier to model the related environmental impacts. However, in most cases, the recovered paper is used in a different system (e.g., used copy paper recycled into tissue products). In these cases (i.e., systems with “open-loop” recycling activities), the system being studied is essentially producing a raw material for a different system so one must decide on how much of the environmental burden from the system being studied should be transferred to the system using the recovered material (allocation). NCASI reviewed recent LCA studies of paper and paperboard products to assist the industry in understanding the types of approaches being used for deciding which portion should be transferred from one system to the other and how these are viewed by expert reviewers. The report also evaluates the different approaches in relation to their conformity with the International Organization for Standardization (ISO) requirements for LCA.

Special Report No. 07-09: The Greenhouse Gas and Carbon Profile of the Canadian Forest Products Industry

(Published 10/07)

The Canadian forest products industry's carbon and greenhouse gas profile, composed of emissions, sequestration, and avoided emissions, was characterized for two time periods (1990 and 2005). Emissions from the forest products value chain are comprised of direct emissions from manufacturing (20 million tonnes carbon dioxide equivalent (Mt CO₂ eq.) in 1990; 14 Mt CO₂ eq. in 2005) and a number of different types of indirect emissions, including those associated with electricity purchases (7.7 Mt CO₂ eq. in 1990; 12 Mt CO₂ eq. in 2005), transport (2 Mt CO₂ eq. in 1990; 3 Mt CO₂ eq. in 2005), and methane from discarded forest products in landfills (20.3 Mt CO₂ eq. in 1990; 24.4 Mt CO₂ eq. in 2005). Carbon is sequestered in forests used to supply fibre to the industry. The forest defined as "managed" for purposes of reporting under the United Nations Framework Convention on Climate Change is a net sink for carbon except during years when large areas of forest are impacted by fire. This managed forest includes land that is harvested and regenerated as well as land that is affected by other types of human interventions not related to the forest products industry. Some of the carbon in harvested wood is subsequently stored in forest products in use and in landfills. Carbon stocks in products were increasing at rates of 59.2 Mt CO₂ eq./yr. in 1990 and 80.4 Mt CO₂ eq./yr. in 2005. Avoided emissions, which further enhance the industry's profile, are associated with the industry's use of combined heat and power (~6.3 million tonnes CO₂ avoided per year), recycling (~17.3 million tonnes CO₂ equivalents avoided per year) and product substitution effects due to the use of Canadian wood-based building products in North America of 3.7 Mt CO₂ eq. per year.

Special Report No. 07-06: Comparative Review of Environmental Labeling Programs *(Published 8/07)*

A review was undertaken of a selection of multi-attribute environmental labeling programs. These thirteen programs, which include a mix of life cycle- and non-life cycle-based initiatives, include criteria specifically related to the forest products sector and are generally recognized as the programs available to the global industry for product-related environmental attribute comparisons. The coverage of environmental attributes by each program varies, and aspects such as data availability and assessment boundaries can influence comparability of products from different facilities. A relatively low uptake of these programs may be due to the amount of effort required and a historically weak connection between these programs and the marketplace, a connection that may be strengthening over time. The programs examined in this study vary greatly in their coverage of environmental issues, due in part to regional or national priorities. The issues most commonly addressed include recycling, the use of chlorine in bleaching, greenhouse gases, BOD/COD, and forest management. Many of the programs hold a company responsible for emissions or resource requirements that are, to a greater or lesser degree, beyond its control, which may raise questions about the equity of comparisons. Also, the programs included in this review would not be particularly useful for comparing the attributes of forest products with products made of different materials (nor were they designed to accomplish this). In situations where different materials are being compared, a metric addressing the use of renewable resources is needed. For a number of reasons, there is a relatively low participation rate in environmental declaration programs by paper companies outside of Europe. There are fewer perceived benefits for participating in many of the programs because the connection to the marketplace may be unclear.

Special Report No. 07-02: The Greenhouse Gas and Carbon Profile of the Global Forest Products Industry

(Published 2/07)

The global forest products industry's carbon and greenhouse gas profile is composed of emissions, sequestration, and avoided emissions. Emissions from the forest products value chain are comprised of direct emissions from manufacturing (~260 million tonnes CO₂ per year), as well as a number of different types of indirect emissions including those associated with electricity purchases (~190 million tonnes CO₂ per year), transport (~70 million tonnes CO₂ per year) and methane from discarded forest products in landfills (~250 million tonnes CO₂ equivalents per year). Carbon is sequestered in forests used to supply fiber to the industry (net sequestration of at least 60 million tonnes CO₂ per year) and in forest products (~540 million tonnes CO₂ per year). Avoided emissions, which further enhance the industry's global profile, are associated with the industry's use of biomass fuels (~175 million tonnes CO₂ avoided per year), combined heat and power (~95 million tonnes CO₂ avoided per year), recycling (~150 million tonnes CO₂ equivalents avoided per year) and product substitution effects (not possible to estimate on global basis). Although the estimates are subject to considerable uncertainty, they clearly indicate that the greenhouse gas emissions that occur along the forest products industry value chain are largely offset by sequestration. Net emissions from the global forest products industry value chain are expected to decline for several important reasons. First, the industry is expected to continue to reduce the carbon intensity of manufacturing. Second, landfill methane releases are expected to continue to decline because of efforts to control what is placed in landfills and the growth in the use of landfills designed and operated to minimize methane releases.

Tools & Handbooks

User-friendly Greenhouse Gas Emissions Trend Tool (NUGGETT) *(Released 4/18)*

The NCASI User-friendly Greenhouse Gas Emissions Trend Tool (NUGGETT) is a Microsoft Excel®-based tool designed to illustrate greenhouse gas (GHG) amounts reported by Canadian forest products facilities to the Federal GHG Emissions Reporting Program (GHGRP). The tool offers the user the ability to aggregate reported GHG data by jurisdiction and forest products subsector, and across all available reporting years since 2004. It also allows the user to drill through the aggregated data down to the individual GHG compounds reported by an individual mill. Dynamic maps and bar charts are used to display aggregated data, and line plots show reporting trends and the presence of potential statistical outliers. Please note that the data embedded in this tool only reflect the reporting of Canadian forest products industry mills with GHG emissions exceeding the Federal GHGRP's reporting threshold, which until 2016 was established at 50,000 tonnes per year of CO₂e.

Practical Guide for the Beneficial Use of Forest Products Residuals (GuBu) *(Published 8/16)*

Forest products manufacturing mills generate large amounts of solid residues from their processing and wastewater treatment plants. Disposing of these materials in landfills is costly because of the logistical and environmental requirements associated with landfill operation. Most benefits resulting from otherwise using these residues are well known and documented, and in recent years, several regulatory agencies have published guidelines and codes of practice discussing their reduction, recycling and beneficial use. NCASI staff and other investigators have also produced several reports and journal articles on residual management and beneficial use. This Practical Guide for the Beneficial Use of Forest Products Residuals ("GuBu") is a Microsoft Excel®-based tool intended to help NCASI member companies navigate through the vast literature on beneficial use of residuals. Over time, NCASI will develop modules to encompass the array of industry residuals for which alternative beneficial use opportunities are available. The current version of GuBu (Version 1.0, released August 2016) contains organized scientific and practical information primarily on wood ash, particularly on its characterization, beneficial use and management. This information was synthesized from technical reports, peer-reviewed journals, and Canadian guidelines and codes of practice.

Greenhouse Gas Calculation Tools for Pulp & Paper Facilities (Canadian Version) *(Updated 6/2022)*

The GHG calculation tool developed by NCASI consists of two parts. The first part is a report (PDF) that describes the approaches for estimating greenhouse gas emissions from pulp and paper mills. Initially released in 2002, it was last updated in July 2005 to conform to the updated WRI/WBCSD GHG Protocol. The second part of the calculation tool is an Excel spreadsheet to aid in the calculations. NCASI has developed several versions of the spreadsheet, as described below. It is intended that these industry-specific tools be used in conjunction with an accepted GHG accounting protocol such as the “Greenhouse Gas Protocol” issued by the World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) or other accepted protocols for corporate GHG inventories. These tools reflect many of the features of well-known and widely accepted protocols. In addition, they anticipate a number of questions that pulp and paper mills must address when preparing facility-level or company-level inventories. A special effort has been made to ensure that the tools are consistent with protocols issued by the Intergovernmental Panel on Climate Change (IPCC) and the WRI/WBCSD.

These tools estimate CO₂ emissions from fossil fuel combustion based on the carbon content of the fuel (or a comparable emission factor) and the amounts burned. Carbon dioxide emissions from biomass combustion are not counted as greenhouse gas emissions, a convention common to most of the protocols examined in this review but can be reported as “supporting information” as called for in the WRI/WBCSD GHG Protocol. Methane and nitrous oxide emissions from combustion processes, both fossil fuel and biomass, are estimated using emission factors. Methods are presented for estimating the fossil-CO₂, methane and nitrous oxide emissions, from lime kilns and calciners. Greenhouse gas emissions from mill landfills and wastewater treatment plants are estimated using methods derived from those suggested by IPCC, as are emissions from vehicles and other fossil-fuel fired equipment. In all cases, however, companies may use site-specific information where it yields more accurate estimates of GHG emissions than the tools outlined in this report. Using these tools, indirect emissions related to imports of electricity or steam and emissions attributable to exports of electricity or steam are included in the inventory results but tracked separately from direct emissions. The emissions from combined heat and power (CHP) plants are allocated using the WRI/WBCSD “efficiency method.” The calculation tools envision that companies will often construct inventory boundaries that include emissions from (a) all on-site “core” pulp and paper making operations, regardless of the ownership of the emission source, and (b) other company-owned sources included in widely accepted GHG inventory protocols (e.g., company-owned truck fleets). It is understood, however, that companies will select inventory boundaries suited to the objectives of the inventory. To aid in interpreting the results of the inventory, these tools recommend that the inventory results include a list of the operations contained within the boundaries of the inventory and a list of emission factors used to estimate emissions. The format suggested for presenting the results of the inventory allows a company to separate the emissions that are “owned” by the company (direct emissions) from those that are not (indirect emissions). The company is free to select the method for determining the ownership of emissions, but the method must be explained in the inventory results. The user is directed to the WRI/WBCSD GHG Protocol for guidance on how to determine ownership of emissions from partly-owned or partly-controlled sources.

Greenhouse Gas Calculation Tools for Wood Products Facilities (Canadian Version) *(Updated 3/2022)*

With financial support from AF&PA and FPAC, and considerable assistance from a working group of wood products experts from FPAC, AF&PA, and NCASI member companies, NCASI completed development of a calculation tool for GHG emissions from wood product manufacturing facilities in 2004. The calculation tool consists of two parts: 1) a report (PDF) that describes the approaches for estimating greenhouse gas emissions from wood products facilities, and 2) an Excel spreadsheet to aid in the calculations. As with the pulp and paper tool, the calculation tool for wood products manufacturing facilities incorporate default approaches and emission factors which are consistent with guidance from the IPCC. These defaults can be overridden by companies as appropriate. The tools reflect many of the features of well-known and widely accepted protocols such as the “GHG Protocol” issued by WRI/ WBCSD, the “Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance” issued by USEPA, and the “Challenge Registry Guide to Entity and Facility-Based Reporting” issued by VCR in Canada. This user-friendly version of the tool was designed specifically for Canadian facilities, with NCASI data entry forms. The spreadsheet is appropriate for developing estimates to satisfy Canadian reporting requirements and contains emission factors, fuel property characteristics, and physical unit conversion factors drawn from the most recent Canadian Standards Association (CSA) GHG Challenge Registry guidance (formerly the Canadian Voluntary Challenge and Registry, or VCR). The spreadsheet has a user-friendly interface and a Quick Start Guide. It was last updated in August 2014. This version is available to NCASI members only.

Wildlife & Biodiversity

Technical Bulletins

Technical Bulletin No. 1066: Current State of Knowledge and Research on Woodland Caribou in Canada

(Published 6/20)

Caribou (*Rangifer tarandus*) is a species of deer that lives in the tundra, taiga, and forest habitats at high latitudes in the northern hemisphere, including areas of Russia and Scandinavia, the United States, and Canada. Caribou is the species' common name in North America, while reindeer is used in Europe and Asia. Woodland caribou (*Rangifer tarandus caribou*), a subspecies of caribou, has been listed under the Canadian Species at Risk Act (SARA) as threatened. Six populations of woodland caribou are recognized in Canada, where three have a conservation status of endangered (Southern Mountain, Central Mountain, and Atlantic-Gaspésie), one threatened (boreal), and two special concern (Northern Mountain and Newfoundland). Many of the populations across the species range are experiencing range retraction and population declines, believed to be predominately driven by unsustainable predation that is facilitated through habitat alteration (i.e., habitat loss, degradation, and fragmentation). Additional threats contributing to the decline or that may serve to impede recovery of woodland caribou have been identified: range encroachment by other ungulates species (i.e., moose and deer); disease and parasites; forage and nutritional limitations; and climate change. These individually and cumulatively have been documented in contributing to the decline of the species. Current population estimates and trends for a significant portion of woodland caribou subpopulations remain unknown because of absence or infrequency of monitoring, making it especially challenging to attribute cause and effect of declines. Although the magnitude of scientific research undertaken to date to better understand this species is substantial, it remains incomplete in several key research areas. While significant efforts have been made to understand the species' basic ecology and predator-prey dynamics, topics associated with genetics, nutrition, parasites, and diseases remain understudied across the species range, inhibiting effective management and recovery efforts for the species. Here, NCASI synthesizes current scientific literature to describe the state-of-knowledge of woodland caribou and conduct a gap analysis for the most recent decade (2009 to 2019) of research to assist the future direction of research and to identify knowledge and information gaps on woodland caribou.

Technical Bulletin No. 1005: A Review of the History and Scientific Basis of Species at Risk Assessments in Canada (Published 1/13)

The maintenance of biodiversity and the management of its related elements are important aspects of environmental resource management at the international, national, and local scales. When species populations decline to the point that extinction is a potential consequence, stopping and reversing that trend is imperative. Determining which species are in need of conservation action, which species are in more desperate need, and determining the tools that should be applied, is a complicated affair. Theoretical and practical efforts in the fields of ecology, genetics, and conservation biology have contributed significantly to our ability to assess, prioritize and manage species at risk. Species at risk assessment, which took root in the late 1800s, is undertaken at the global scale by the International Union for the Conservation of Nature (IUCN) through its Red List of Threatened Species. IUCN is charged with determining the relative risk of extinction for all species on the planet. Within Canada, species are assessed as to their relative risk of extinction by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), which bases its species risk assessment process on the IUCN process, with some modifications. This report reviews the science of species assessment and application of that science to both the IUCN and COSEWIC processes and identifies a number of opportunities for strengthening the process in Canada. A more transparent and repeatable assessment process, and more effective incorporation of elements such as natural rarity, temporal and geographical scale, and marginal species dynamics, should serve to increase the reliability and accuracy of the assessment process, thereby increasing the efficiency and effectiveness of species at risk management in Canada.

Technical Bulletin No. 964: Wildlife Responses to Stand-Level Structural Retention Practices in the Boreal Forest (Published 8/09)

Old-growth attributes are important in the boreal forest and elsewhere for maintaining various forest values, including several wildlife species. In recognition of the fact that the relative amount of older forest stands may be lost over time due to wildfire, forest harvesting, insect infestation, windthrow, and other factors, growing attention is being paid to the potential for stand-level structural retention practices to mitigate impacts of forestry on wildlife. This literature review examines our current state of knowledge of the short- and long-term responses of vertebrate wildlife (birds, mammals, and amphibians) to various stand-level management practices that manipulate the quantity and quality of live trees, snags, understorey vegetation, and coarse woody debris (CWD) available to wildlife post-harvest. While superficially, there appeared to be a broad body of research on which to base such a review, on closer examination, relevant material was limited by a failure of many studies to explicitly account for stand-level structure, or to do so at an appropriate scale, and by the highly variable quality of the research, particularly with regard to mammal responses. Both green tree retention (GTR) and well-developed understory practices appear to enhance both the short- and long-term habitat value of stands for the broadest array of wildlife groups. CWD retention was found to have a significant influence on marten and their prey, possibly in concert with overstorey and understorey retention. No patterns in wildlife responses to snag retention were apparent. There was insufficient information to draw conclusions on optimal quantities or spatial configurations for any of the structural variables reviewed.

Technical Bulletin No. 959: Fragmentation in the Boreal Forest and Possible Effects on Terrestrial Life (Published 12/08)

In forest management, “fragmentation” is a term often used to describe altering habitat amount and/or habitat area on a given landscape, and its effects on a host of flora and fauna. Fragmentation is often mentioned as a negative ecological consequence of timber production in Canada’s boreal forest, contributing to effects on a range of wildlife populations. The purpose of this report is to synthesize the available literature on fragmentation in the boreal and its effects on terrestrial vertebrates. The authors surveyed a wide range of scientific works originating primarily from Canada’s boreal forest, with some studies from Scandinavia and temperate North America. The results suggest that clarity and consistency is needed when examining forest fragmentation, as the term has been used in a variety of ways across the scientific literature, and has included a range of possible effects, confounding the results. Further, the report notes that the measured effects on terrestrial wildlife are scale-, landscape- and often species-specific, contributing to inconsistencies in the measured effects on populations. The authors suggest a number of research needs, including investigations into the temporal nature of fragmentation, the need for productivity- and population-level assessments, the investigation of fragmentation effects on lesser known or rare species, and a need to translate the effects of changing landscape metrics to wildlife populations.

Technical Bulletin No. 939: State of Knowledge and Analysis of Current Research on Woodland Caribou in Canada (Published 2007)

Caribou (*Rangifer tarandus*) is a species of deer that lives in tundra, taiga, and forest habitats at high latitudes in the northern hemisphere, including in Russia and Scandinavia, Alaska, Idaho and Washington states, and Canada. The species’ common name is caribou in North America and reindeer in Europe and Asia. Five populations of woodland caribou (*Rangifer tarandus caribou*), a subspecies of caribou, are listed under the Canadian Species at Risk Act, with one endangered, two threatened, one special concern, and one not at risk. Some areas are experiencing range retraction and population declines. Causes of declines and range retractions remain poorly understood, and are hypothesized to involve forest management, industrial disturbance, predator-prey dynamics, encroachment by other ungulates, climate change, or combinations of several factors. Scientific research into the biology and ecology of this species is substantial, but incomplete. While a good understanding of the species’ basic ecology has been documented, many questions remain unanswered. The current status of a quarter of the herds in listed populations in Canada remains unknown. Moreover, information about summer and fall foraging and nutritional requirements (factors that are well known to have significant effects on all ungulates in which they have been examined) is virtually absent from woodland caribou literature. Literature reviews examined here suggest a range of areas in which more effort is needed to fill gaps and better equip recovery efforts. Using a survey of researchers in Canada, this report compares current knowledge gaps with current research projects. While several research areas (e.g., basic ecology, predation) appear to be well addressed by current projects, research on woodland caribou energetics and nutrition is under-represented among ongoing projects.

Technical Bulletin No. 934: A Review of Ungulate Nutrition and the Role of Top-Down and Bottom-Up Forces in Woodland Caribou Population Dynamics (Published 6/07)

Management strategies to conserve populations of woodland caribou (*Rangifer tarandus*) frequently emphasize the importance of predator-prey relationships and availability of lichen-rich late-seral forests, yet the importance of summer diet and forage availability to caribou survival is poorly understood. We synthesized published information on the diet and nutritional needs of Rangifer populations to evaluate the importance of vascular forage, as well as potential interactions among forage and climate, disturbance, and predation in affecting caribou survival and reproduction. We also reviewed studies on the population dynamics of woodland caribou in North America to assess the relative importance of top-down and bottom-up factors in the decline of woodland caribou populations. Populations of forest-dwelling woodland caribou that share range with predators and alternate ungulate prey typically occur at low densities and evidence of density-dependent food limitation is not apparent. Predation is generally considered an important proximal factor limiting woodland caribou populations; however, our review suggests that methodological limitations in existing studies prohibit proper evaluation of the mechanism of decline and fail to elucidate potential interactions between top-down and bottom-up effects on populations. Our review of caribou dietary needs highlights the importance of vascular summer forage in the growth and reproduction of caribou. Diet may be seasonally important in relation to snow accumulation, reproduction, and landscape-scale disturbances that change the availability of preferred food items. Based on current knowledge, forest management is expected to have a greater potential to affect the availability of winter forage than summer forage.

Technical Bulletin No. 909: Defining Old-Growth in Canada and Identifying Wildlife Habitat in Old-Growth Boreal Forest Stands (Published 12/05)

In Canada, as elsewhere, there is concern about the impact of forestry operations on species that may depend on old-growth forest. However, during debates on old forest, a distinction is not always made between wildlife that requires “mature and older” forest and those that need only true “old-growth.” This is challenging for the forest industry, in terms of providing appropriate amounts of “mature and older” forest on the landscape versus providing strictly “old-growth.” This technical bulletin provides a literature review of old-growth forest definitions used in all the forest regions of Canada as well as a review of the relationship between wildlife species and old-growth stands in the Boreal Forest Region. Over 300 papers and books were reviewed and approximately 170 are cited in this report. Fundamentally, there are two approaches to defining old-growth forest stands. The first approach uses age-specific definitions. In this approach, stands, trees, or ecological sites are designated old-growth when they reach a specific age. This type of definition is common across Canada and is useful in preparing forest management plans because it is clear and the information is available in forest inventories. However, the diversity and complexity of forests in Canada means that old-growth conditions may occur at different ages, even for the same tree species, depending on the local conditions. This has led some to define old-growth to be when physical characteristics or the ecological function of the stand reaches a certain point. These process-based definitions can be vague or can be more complex and require more sophisticated measurements than age-specific definitions.

Technical Bulletin No. 893: Ecological Interactions Among Caribou, Moose, and Wolves: Literature Review (Published 12/04)

Woodland caribou populations are declining in many areas of Canada and there is concern that the decline may be associated with timber harvesting. Caribou, moose, and wolves share a long evolutionary history and their relationships may become altered by large-scale landscape disturbance. This technical bulletin presents a review of scientific literature pertaining to the hypothesis that increases in moose and wolf populations after timber harvesting have adverse effects on caribou. Specifically, large-scale habitat changes that have allowed moose populations to increase and thereby sustain higher wolf numbers presumably have resulted in excessive predation on caribou, apparently resulting in caribou population declines. Differentiation of caribou by ecotype rather than phenotype has advantages for conservation purposes. The forest-dwelling ecotype of woodland caribou often move across extensive areas at low densities, and populations have been difficult to define and monitor. Woodland caribou and moose often partition habitats on the landscape, such that caribou tend to graze mostly lichens and occupy nutrient-poor forest types, while moose browse vascular plant species such as willows, which are associated with more productive environments. The relatively high reproductive potential of moose enables their populations to respond rapidly to a superabundance of forage produced after forest fires or logging. Carrying capacities for caribou increase more slowly and are likely to decline suddenly after such disturbances. Some caribou populations experience the effects of multiple predators such as grizzly bears, black bears, cougars, coyotes, wolverines, lynx, eagles, and humans. The predation rate is determined by the predator’s functional and numerical responses to changes in prey density.

Technical Bulletin No. 892: Bird - Forestry Relationships in Canada: Literature Review and Synthesis of Management Recommendations *(Published 12/04)*

This document presents a review of the influences of forest management on birds in Canada. The review draws primarily (but not exclusively) on Canadian literature for two reasons; first, and most importantly, is that the communities of birds and responses of birds to forest management are logically more likely to be similar within a geographic region or forest type. The second reason is to highlight the contributions of Canadian research to the present state of knowledge, and as a corollary, to identify topics and issues about which Canadian research is needed. The primary focus of this review is songbirds, although information on raptors has been included as well. The objectives of this review are to: describe studies of bird-forestry relationships from Canada's Bird Conservation Regions (BCRs); describe existing knowledge of the effects of forest management on birds and bird habitat; synthesize management recommendations, and identify future research needs. Well over 100 research-oriented publications were reviewed. Findings from those studies were combined with information from over 200 other documents to provide assessments of bird response to forest management practices at different spatial scales. At the stand scale, the effects of practices (primarily associated with harvesting) lead to the broad conclusion that short-term effects on pre-harvest communities are in general proportional to the extent of harvest operations. Of course, there are many caveats to this broad assertion. For example, retention of residual structure may play an important role in ameliorating post-harvest effects on some species; the removal of overstory vegetation provides important habitat for bird species associated with early successional habitats, and many effects are likely analogous to those which occur following natural disturbances.

Special Reports

Special Report No. 18-01: Species at Risk Assessment in Canada: A Cross-Jurisdictional Review *(Published 2/18)*

In 1992, Canada signed and ratified the International Convention on Biological Diversity, the key purpose of which is the protection and conservation of the world's flora and fauna. Conserving species at risk is a vital part of the maintenance of biodiversity. As a party to the Convention, Canada has committed to the identification and protection of species at risk, and each jurisdiction within Canada has committed to work together with the federal government to do the same within their respective regions. That said, given that natural resources and land-use decisions fall under the jurisdiction of provincial and territorial governments, the way in which species at risk are assessed, categorized, and managed may vary. The purpose of this report is to review the species at risk assessment and management mechanisms used across Canada by the federal, provincial, and territorial governments, and to examine the role science plays in helping to ensure assessments and listings are objective, transparent, and science-based. While most jurisdictions within Canada have some mechanisms for recognizing and managing species at risk, only some have dedicated legislation for that purpose, and one jurisdiction has no specific species at risk programs at all. While species at risk management varies significantly across the country, it is a complex undertaking with multiple elements to be considered. Biological and ecological science plays a key role in helping in the assessment, recovery, and ultimately the long-term conservation of species at risk.

Special Report No. 14-03: Compilation of Canadian Provincial and Federal Regulations Relevant to Forest Management Activities *(Published 5/14)*

Forest companies face a complex and variable regulatory platform with respect to forest management practices. In Canada, forest management is predominantly governed by provincial governments, but overarching federal legislation also plays a role in influencing forest management. This report offers a comprehensive overview of the Canadian federal and provincial regulatory environment as it pertains to forest management. The report examines legislation, regulation, and guidelines pertaining to forestry across all provinces and summarizes the regulatory environment and key components for each jurisdiction. The focus of the review is on forest management practices and includes information on Crown forest tenure, private forest management, forest practices and silviculture prescriptions, forest management planning, water resource management, land management, resource protection, chemical management, transportation, and timber export. Brief discussion of sustainable forest management certification programs used in Canada is also included. The report is accompanied by an Excel workbook that examines selected themes on forest management to offer more detail and facilitate comparisons across jurisdictions.

Special Report No. 11-02: An Inventory of Caribou Research Programs in Canada (Published 7/11)

Caribou (*Rangifer tarandus*) is a species of deer that lives in tundra, taiga, and forest habitats at high latitudes in the northern hemisphere, including Russia and Scandinavia; Alaska, Idaho, and Washington states; and Canada. The woodland caribou (*Rangifer tarandus caribou*) has been listed under Schedule 1 of the Species at Risk Act (SARA) and is a high profile subspecies as it relates to forested environments across Canada. Further, the decline of this emblematic species has been linked to forest management practices throughout its range, and as a result, conservation of the species is a high priority for many forest products companies. As research on this subspecies is important to aid in its conservation and management, researchers from across Canada were surveyed to document the current research effort within the species range. These findings are a follow-up to a similar NCASI project in 2007, and show a notable increase in caribou-related research since that time. While some research topics have shown decreases in effort, most have seen increased effort. Overall, the number of research programs across the country has increased since 2007, with several jurisdictions showing significant increases in research projects. It is hoped that this inventory will be useful for coordinating research efforts on woodland caribou, and in helping delineate future research efforts with an eye to long-term caribou conservation. This report is accompanied by an Excel spreadsheet.

Special Report No. 10-02: Compendium of Long-Term Wildlife Monitoring Programs in Canada (Published 10/10)

This compendium details the various wildlife monitoring programs in existence or, if appropriate, previously in existence, across Canada that deal with vertebrate species in the wild. The compendium is a tool to help forest researchers and managers better harness the value in these datasets, and to identify sources of information, gaps, redundancies, and opportunities for industry collaboration. For every program in the compendium, the reader will find a detailed description, contact information, and, when possible, a map of the area covered by the program in question. Three criteria were evaluated for each program: program duration, spatial extent, and number of species surveyed. Program duration was defined as an absolute criterion, meaning that all programs in the compendium must have a minimum of three years of data, or at least long-term monitoring expectations. Spatial extent and the number of species surveyed were described as accessory criteria. Ideally, monitoring programs found in the compendium are primarily large-scale surveys that follow more than one species. However, large-scale and long-term programs monitoring a single species were included (e.g., Canadian Peregrine Falcon Survey and Canadian Lakes Loon Survey), as well as small-scale long-term monitoring programs following multiple species (e.g., Beaver River Drainage Basin Historical Fishing Survey). Programs were rejected if they were both small-scale and single-species monitoring programs. Projects hosting databases from potentially compendium- pertinent programs (monitoring programs or other) were also added to the compendium (e.g., Nature-Counts, Northwest Territories Wildlife Management Information System, etc.).

Tools & Handbooks

Handbook of Forestry Practices for Migratory Birds (Updated 4/16)

In Canada, the Migratory Birds Convention Act (MBCA) is intended to help conserve and maintain populations of migratory birds in Canada, and to fulfill Canada's obligations under the Migratory Birds Convention Treaty of 1916, as interpreted by the courts. While its regulations and statutes contain many prohibitions designed to mitigate actions that are directly implicated in harming birds and their nests, the Act does not appear to discriminate between the wilful destruction of nests and losses that occur incidental to other activities, be they industrial or societal. Environment Canada terms such losses as "Incidental Take," and there is currently no permit system in place in Canada to allow for activities that may result in such losses. As a result, Environment Canada is participating with stakeholders to develop a risk-based "Beneficial Management Practices" (BMPs) approach to managing incidental take of migratory birds in the context of forest management activities. While development and use of BMPs will not eliminate the legal risk of actions that result in destruction of birds or their nests or eggs, they will be useful in providing a tool that optimizes migratory bird-related management practices across the sector and in demonstrating due diligence on behalf of proponents who use them. The Handbook of Forestry Practices for Migratory Birds was developed to help the forest products industry meet requirements of the MBCA or new regulatory frameworks. These practices were pulled from a number of sources, including the scientific literature, members of the forest products community, and guidance from Environment Canada. The Handbook details 18 different practices providing information for each one on (a) the basis for the practice in conservation science, (b) how to apply the practice, (c) measures of effectiveness of the practice, and (d) the compatibility of each practice with others. The Handbook also includes information on Canada's Bird Conservation Regions (BCRs) and, based on a survey of the Canadian forest product industry, information on the frequency and use of these practices in Canada. The publication was released by the Forest Products Association of Canada, and technical content was developed by NCASI.

NCASI-FPAC Species at Risk Database *(Updated 2/16)*

The Canadian Species at Risk Database was developed by NCASI, sponsored by its member companies and by the Forest Products Association of Canada (FPAC). The database compiles information available from Canadian federal and provincial governments, as well as COSEWIC, on species at risk in Canada. In addition to helping track the progress of individual species as they proceed through the Species at Risk process, the database is designed to help prioritize research efforts by the forestry sector, targeting species with less information available that may have significant impacts on forest management regulations and/or wood supply. It is also intended to serve as a strategic tool for the sector, in prioritizing activities related to the evolution of regulations and policy under the Act. The Excel file is comprised of several spreadsheets containing significant amounts of material gathered from various Canadian federal and provincial sources. It will be updated periodically as new information becomes available. A companion document has been developed to provide quick reference to range maps of species at risk in Canada, along with links to various status reports.



WATERSHEDS & WETLANDS

Technical Bulletins

[Technical Bulletin No. 975: Water Profile of the Canadian Forest Products Industry](#) *(Published 3/10)*

Runoff from managed forest watersheds yields approximately one-fifth of Canada's freshwater resource. The effects of harvesting activities on water quality and forest hydrology are effectively controlled by the application of provincial regulations and forestry best management practices. Managed forestlands in Canada receive 1.35 trillion m³/yr of precipitation and produce roughly 0.67 trillion m³/yr of streamflow and groundwater. The forest products industry's manufacturing operations draw about 0.3% of these surface and subsurface sources. Approximately 88% of the water used by manufacturing processes is returned directly to surface waters following treatment; nearly 11% is evaporated during manufacturing and wastewater treatment, and about 1% is imparted to products or solid residuals. Federal pulp and paper mill effluent standards, in conjunction with process improvements and advanced biological treatment systems, have resulted in declining trends in discharge loads of biochemical oxygen demand (BOD), total suspended solids (TSS), adsorbable organic halides (AOX), and dioxins and furans. Laboratory testing and artificial stream assessment of aquatic organisms exposed to these effluents at different concentrations have shown variable effects on organism survival, growth or reproductive capacity. In contrast, extensive in-stream studies carried out to date suggest that treated pulp and paper mill effluents have little effect on aquatic community structure.

[Technical Bulletin No. 969: Effects of Forest Management on Water Resources in Canada: A Research Review](#) *(Published 12/09)*

Although forestry practices commonly occur at the stand level, watersheds are used as the study unit for hydrological and water quality issues. Watersheds are natural or artificial drainages on which all precipitation and emanating spring discharges collect and flow to a common outlet. To establish a cause-and-effect relationship of ecosystem response to disturbance, it is essential to determine watershed level impact by removing biases that could occur at smaller scales. However, since the hydrologic cycle is driven by numerous processes that occur at smaller scales (e.g., evapotranspiration and snow melt), stand-level research is also vital in understanding responses at the watershed scale. More than 25 research watersheds in Canada have been used to examine the hydrologic and water quality impacts of forestry practices. Research has shown that the effects of forest management on hydrology and water quality are highly variable in both magnitude and duration. Factors such as topography, sub-surface geology, forest type, watershed composition and extent of harvest all play a part and are difficult to separate. Although a common goal in hydrological research is to transfer information gained at one scale of study to larger or smaller scales, or to transfer knowledge from one region to another, the field of forest watershed research is rife with scaling issues and uncertainty in transferability. The watershed research community is moving toward embracing these challenges. For example, several watershed research projects in Canada are incorporating information about stand-level processes in simulation models.

[Technical Bulletin No. 938: Synthesis of Technical Information on Forest Wetlands in Canada](#) *(Published 2007)*

The present total estimated wetland coverage in Canada is 1,240,368 km² (Tarnocai 2001). The Canadian Wetland Classification System recognizes five major classes or types of wetlands: bogs, fens, marshes, swamps, and shallow open water. Wetlands can be broadly grouped into organic wetlands (also called peatlands) and mineral wetlands. Organic wetlands include fens and bogs, while mineral wetlands include swamps, marshes, and shallow open water. Both peatlands and mineral wetland classes have gradients in richness and wetness that produce a number of sub-classes (e.g., thicket swamp, conifer swamp etc.) within the five major classes. These classes and their ecological properties are discussed in detail. In addition, we supply a listing and brief review of classification systems used for wetlands across the country. Wetlands provide a range of ecological goods and services that contribute to the Canadian economy and our well-being. These services include timber production, non-timber forest products such as peat moss, habitat for wildlife, water filtration, and carbon sequestration. Wetlands are also a critical component of the lifestyle and values of Canada's Aboriginal peoples. While federal, provincial and industry developed inventories exist throughout the country, it should be noted that the quality and extent of wetland inventories depend on mapping limitations (e.g., mapping scale, remote sensing limits), data availability, and inventory purposes; thus, records of wetlands can be incomplete. We provide a list of inventories and standards that exist for forest wetlands. An extensive body of Federal and Provincial legislation, policies and guidelines can affect wetland ecosystems. We review these in detail for Canada and each of the provinces individually.

Technical Bulletin No. 922: Structural and Functional Roles of Riparian Management Areas in Maintaining Stream Values in the Acadian Forest *(Published 8/06)*

Dynamic geomorphic and hydrological processes maintain the ecosystem functions of both the aquatic and terrestrial components of the riparian areas of forested streams. These ecosystem functions include the moderation of stream temperature and light, the filtration of sediments and nutrients entering streams, and the inputting of fine and large organic debris into streams. Riparian areas also provide habitats that sustain a range of biodiversity in both the stream and adjacent terrestrial areas, and provide corridors of habitats that may facilitate movement and dispersal of plants and animals. Much of our knowledge of the ecological functions of riparian zones comes from observations of the effects of forest harvesting on riparian ecosystems. In light of these observations, Riparian Management Areas; (strips of forest retained on either side of streams) have been used to mitigate these effects. This literature review focuses on how riparian communities respond to forest harvesting with retention of RMAs in particular reference to Acadian forest streams. The Acadian forest spans the Maritime provinces of Canada and in the United States most of Maine, New Hampshire, and Vermont; part of Massachusetts and Connecticut; and a small portion of New York. The Acadian forest is considered a transitional forest, retaining elements of both the boreal forest to the north and the deciduous forest to the south. Although research addressing the effects of forest management on the ecological functions of the riparian systems of the Acadian forest is limited, it is fairly diverse, perhaps with a slight bias toward examining the water quality aspects of these systems.

Tools & Handbooks

Canadian Watershed Handbook of Control and Mitigation Measures for Silvicultural Operations *(Published 4/09)*

The protection of water resources and values is one of the most important aspects of forest management. In addition to providing habitat for aquatic organisms, streams and watercourses play important roles in ecosystem processes such as nutrient cycling and water filtration. Experience and research have shown that care must be taken to protect these values during forest operations. The Canadian Watershed Handbook of Control and Mitigation Measures for Silvicultural Operations documents a wide range of watershed protection and mitigation methods, and details costs of implementation, effectiveness, limiting factors to effectiveness, and complementary practices that can be used to improve effectiveness. The handbook also lists extensive references, allowing the user to follow up specific mitigation methods in greater detail as required. This handbook benefited from an earlier Handbook of Control and Mitigation Measures for Silvicultural Operations that was developed by Andy Gallagher, George Ice, and Walt Megahan for the United States, under the direction of the NCASI Forest Watershed Task Group. This updated and greatly expanded handbook is based largely on management practices in Canada, but its application should also be useful in U.S. operations.

CONSERVATION PLANNING & SUSTAINABLE FORESTRY

Technical Bulletins

Technical Bulletin No. 1089: Herbicide Use and Alternative Vegetation Management Strategies in Canada (Published 06/24)

Herbicides have long been recognized for their effectiveness in managing competing vegetation, a critical component contributing to the success of reforestation practices. Glyphosate, in particular, has been the cornerstone of vegetation management strategies in Canadian forestry due to its broad-spectrum efficacy, cost-efficiency, and ease of application. However, growing concerns over environmental impacts and public health have led to increased scrutiny and regulation of herbicide use, prompting exploration and adoption of alternative vegetation management techniques. This Technical Bulletin reviews and evaluates an array of non-herbicide alternative vegetation management strategies that have been explored and implemented across the Canadian forestry sector. These include physical methods such as tree shelters, manual and mechanical brushing, mulching, and mechanical site preparation; thermal methods such as prescribed burning; and cultural techniques, including the strategic use of seedling culture, cover crops, grazing, and biological controls. Each strategy was examined through the lens of six critical factors: effectiveness in reducing vegetative competition, scalability across different forestry contexts, practicality of implementation, social acceptability, cost implications, and potential environmental impacts. The analysis revealed that while herbicides offer the most straightforward approach regarding scalability, effectiveness, and cost, alternatives such as mechanical site preparation and the strategic use of enhanced seedling planting stocks have shown promise under specific environmental conditions. These methods, refined over decades of research, present a feasible, albeit more costly, alternative capable of achieving comparable results in certain contexts. Nonetheless, the scalability and universal applicability of these alternatives remain limited, often making them suitable only for specific scenarios. Overall, no single alternative vegetation strategy can universally replace herbicides, but an integrated, site-specific approach, and when possible, combining multiple vegetation management strategies, is essential to meet the diverse needs and objectives of sustainable forest management. This comprehensive review aims to inform decision making among forest managers, policymakers, and stakeholders/land rights holders, and underscores the inherent complexity of vegetation management across Canadian forests.

Technical Bulletin No. 1075: Potential Contributions of Forest Management Areas as Other Effective Area-Based Conservation Measures (OECMs) (Published 11/21)

Over the past few decades, several international treaties have been developed to implement coordinated efforts to minimize the loss of biodiversity worldwide, including the Convention on Biological Diversity (CBD), an international treaty with 193 member countries. In 2010, the CBD's Strategic Plan for Biodiversity 2011-2020 included 20 Aichi Biodiversity Targets, which address each of the five strategic goals defined in the plan. A new conservation designation, Other Effective Area-Based Conservation Measures (OECMs), was introduced within the CBD's Aichi Target 11 and aims to protect at least 17% of the world's terrestrial and inland water and 10% of the coastal and marine areas by 2020. As a signatory under the CBD, Canada is obligated to develop a national strategy to conserve biological diversity, which it did in 2015 with the release of its 2020 Biodiversity Goals and Targets for Canada. This strategy includes four goals and nineteen targets, including Target 1, whereby Canada has committed to conserve the same proportions of terrestrial and inland water and coastal and marine areas identified in Aichi Target 11. At the end of 2020, Canada achieved its coastal and marine conservation target (13.8%), mainly through marine OECMs, but failed to meet its conservation target for terrestrial land and inland waters (12.1%). Because Canada is rich in natural capital, it is uniquely positioned to achieve its terrestrial conservation goals for several reasons: (1) it is the second largest country in the world; (2) it includes an engaged forest sector that manages large proportions of land that are set aside from active forest management and thus could contribute to additional OECMs in the future; and, (3) it is currently a world leader in OECM application. Canada's forest sector has long been interested in effective conservation of biodiversity over the long term within the lands it manages, and there may be related opportunities to contribute to OECMs. Further, a significant portion of the Canadian landmass is under long-term forest management agreements, through which areas are also managed for non-timber goals and values such as biodiversity and habitat conservation. Canada remains committed to conserving even more of its lands for biodiversity in the future, but significant hurdles must be overcome before fully embracing OECMs as a conservation option towards meeting its national and international commitments. These include a lack of clear mechanisms, limited information and knowledge exchange, a disconnect between government and non-government organizations and industry, and limited resources (staff and financial) to evaluate areas for suitability as OECMs. In this report, NCASI outlines Canada's commitments to the CBD and its national strategy for conserving biodiversity, provides an overview of OECMs, and outlines their possible application within Canada's managed forests.

Technical Bulletin No. 983: The Role of Forest Management in Maintaining Conservation Values *(Published 4/11)*

Biodiversity is a key concept in conservation biology and a prime target for conservation efforts across the globe. In North America forest management planning and operations have been under intense scrutiny to ensure the maintenance and sometimes enhancement of biodiversity in every area of operation. Forest management policy and guidelines and public and private forest certification schemes have been developed to take biodiversity into consideration and contribute to extensive efforts to plan for the adequate protection of biodiversity. However, biodiversity is difficult to conceptualize, and therefore more difficult to quantify. As a result, numerous criteria and indicators have been developed and selected that if measured and maintained on a landscape, would be expected to conserve biodiversity. Based on a report by the Yale School of Forestry and Environmental Studies, the following 12 criteria were examined: 1) representation, 2) species richness, 3) species endemism, 4) rarity, 5) significant or outstanding ecological or evolutionary processes, 6) presence of special species or taxa, 7) threatened species, 8) species decline, 9) habitat loss, 10) fragmentation, 11) large intact areas, 12) high and low future threat. The purpose of this report is to link a selection of these criteria to their scientific underpinnings, by examining the published scientific literature that underscores them. The basis for each criterion (ecological/environmental or social) is described, and where notable, uncertainties are noted. Findings suggest that there are at least three categories into which the criteria can be examined (species, landscape, and future threat), relatively few can be quantified in a meaningful way, and most of them are significantly inter-related and confounded.

Technical Bulletin No. 924: Similarities and Differences between Harvesting- and Wildfire-Induced Disturbances in Fire-Mediated Canadian Landscapes *(Published 10/06)*

For decades, many have hypothesized that the effects of harvesting and wildfire differed significantly and that this would have significant effects on ecosystem processes and biodiversity. However, it is only recently that an appreciable amount of scientific data has emerged on this topic. In this report, we present our review of the similarities and differences between the ecological effects of fire- and harvesting-induced disturbances that have been noted in the scientific literature. Comparisons of the effects of these disturbances on numerous forest attributes (coarse woody debris, soil nutrients, productivity, plant diversity, wildlife response) are presented at two distinct spatial scales: stand and landscape. At the stand scale, our review noted significant differences between harvesting and wildfire early after disturbance. Structurally, young post-fire stands are characterized by more snags, less downed woody debris, and significantly thinner forest floors than logged sites. Additionally, while both disturbances generate a pulse of extractable nutrients, the intensity of the pulse is greater after wildfire than clearcut harvesting and an increase in soil pH is observed after fire as opposed to little change or a slight decrease after harvesting. Early after disturbance, biodiversity elements significantly differ between burned and logged sites. Dissimilar understory vascular and non-vascular communities generally colonize burned and logged sites, although differences are usually a question of abundance rather than species absence/presence. As compared to fire, faunal assemblages, be it mammals, invertebrates or birds, all seem to respond differently to harvesting.

Special Reports

Special Report No. 06-05: Synthesis of Large-Scale Bird Conservation Plans in Canada: A Resource for Forest Managers *(Published 11/06)*

There are four major bird management plans in effect in Canada: the North American Landbird Management Plan, the North American Waterfowl Management Plan, the Canadian Shorebird Conservation Plan, and Wings Over Water (the Canadian waterbird conservation plan). These plans cover almost all native bird species that occur regularly in Canada. All of these plans operate under the North American Bird Conservation Initiative (NABCI). The intent of this report is to increase awareness of the four major Federal bird plans among the forest industry, to provide forest managers a common reference point relative to the Federal government's perspective on managing various types of birds in Canada, and to synthesize information on birds that is most relevant to forest management planning. About 634 species of birds occur in Canada. We reviewed all of those bird species and identified species which may be affected by forestry operations. Effects of forestry on birds may be positive, negative, or mixed depending on the species, specific management practices, spatial scale, and time scale. We also reviewed the Bird Conservation Region (BCR) concept, a tool developed for the North American Bird Conservation Initiative. BCRs are ecologically defined units that share similar avifaunas and provide a consistent spatial framework for bird conservation across North American landscapes. The BCR concept is very relevant to the forest industry because most of the forest bird conservation planning processes currently underway in Canada are related to BCRs and the priority forest bird species within each.



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