ASSESSMENT OF CHEMICAL EXPOSURE AND SELF-REPORTED HEALTH AMONG TREE PLANTERS IN BRITISH COLUMBIA

by

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Abstract

In British Columbia harvested forests are manually replanted by seasonal workers. Fertilizers contained in perforated paper sachets are often planted with seedlings. There have been anecdotal reports of skin and respiratory illness associated with fertilizer exposure and due to potential metal content in fertilizer source material they may contain metals as contaminants. Workers may also be exposed to pesticide residues on seedlings. This study aimed to characterize fertilizer, metal and pesticide exposure among a sample of B.C. tree planters, and to examine worker respiratory and dermal health.

Between May 2006 and April 2007 223 tree planters were interviewed about their respiratory and dermal health, and the exposures of 54 tree planters at five geographically-disperse worksites were monitored. Four worksites were using fertilizer and one was not. The health questionnaire was a modification of the American Thoracic Society standardized questionnaire with questions on dermal health taken from a previous UBC study. Workers were grouped in exposure categories and symptoms analysed using logistic regression. Metals were measured by ICP/MS on post shift hand wipes, full shift air sample filters, in whole blood, bulk soil, seedling root balls, and fertilizer samples. Pesticides were measured on post shift hand wipes and on bulk seedling samples. Using nursery pesticide application records, analyses focused on known pesticides applied to the seedlings at the study sites. Carbamate pesticides were analyzed by HPLC/MS and other pesticides by GC/MS.

No evidence was found that tree planters who work with fertilizer are at an elevated risk of exposure to arsenic, lead, cadmium, chromium and nickel relative to other tree planters. Pesticide residues were found on seedlings taken from coastal work sites in April 2007. At coastal worksites the fungicides chlorothalonil and iprodione were found on the skin of workers at low levels (range 0.37 – 106.3 ng.cm^2 and 0.48 – 15.9 ng/cm^2 respectively). Work with fertilizer was linked with an increased risk of cough, phlegm, nasal symptoms, nose bleed, and skin irritation. Hygiene conditions at tree planting work sites are very poor. Although measured exposures were

low, hygiene conditions should improve to reduce the risk of health symptoms among tree planters.

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Co-Authorship Statement

Dr. Davies and Mr. Stjernberg were co-principle investigators of this study. The data collection methods presented in this thesis work were developed by Dr. Hugh Davies, and the questionnaire was designed and pilot tested by Ms. Meghan Winters.

I was involved in all subsequent stages of the study: study coordination and logistics, all site visits, all data collection (air monitoring, biological sampling, dermal sampling, interviews), data management, development of a questionnaire coding guide, data analysis and knowledge transfer, including talks to stakeholder groups and two international scientific conferences, as well as preparing a summary report to the funding agencies (WorkSafeBC and the Western Silviculture Contractors Association). I developed the data analysis strategy in consultation with my thesis supervisor, Dr. Hugh Davies, and my thesis committee, Dr. Mieke Koehoorn and Dr. Paul Demers.

Authorship of manuscripts (presented as chapters 2-4) reflect overall contributions to the study as well as to the individual papers. In the case of Chapter 2 (H Davies, proposed first author) I prepared draft text, all tables, contributed to all subsequent drafts and approved the final text.

Chapter 1. Introduction

In British Columbia (B.C.) harvested forests are replanted manually by seasonal tree planters. These workers are hired by independent tree planting contractors who are employed by forestry companies. There are an estimated 250 – 300 tree planting contractors in B.C. that hire over 5000 tree planters each year. The tree-planting season begins at snowmelt (usually February in coastal regions and May in mainland interior regions) and continues through the summer until October. Worksites are generally remote and are geographically dispersed throughout the coastal, interior, and northern regions of B.C. Seedlings are supplied by nurseries that are also geographically dispersed throughout the province. There are at least forty tree seedling nurseries in B.C.

Chemical Exposures and Tree Planting

Fertilizers and Fertilizer Contaminants

Tree planters in B.C. are frequently required to bury packets of fertilizer alongside seedlings as they are planted. These are typically nitrogen, phosphorus and potassium (NPK) fertilizers contained in perforated paper sachets. Some fertilizers used also contain “micronutrients” which are typically metals such as iron, boron, copper, manganese, and zinc. [1-3] Common chemical constituents of NPK fertilizers include urea, phosphoric acid, potash, ammonium phosphate, potassium chloride and potassium sulfate. [1-3] The blend of fertilizer used is customized to the crop and conditions of each planting operation. The fertilizer is partially polymer coated to allow slow release over the first few months of growth.

In addition to nitrogen, phosphorus, potassium and “micronutrients” fertilizers may contain non-essential heavy metal contaminants including arsenic, lead, cadmium and chromium. [4, 5] Natural phosphate ore contains measurable amounts of cadmium, lead and nickel therefore the presence of these metals may be due to the source material of the fertilizer. [4] Metal contaminants may also be unintentionally added to fertilizer alongside desired “micronutrients” such as zinc, copper, boron, iron and manganese. [4, 6] These micronutrients are sometimes incorporated into the fertilizer by the addition of industrial wastes or by-products, such as electric arc furnace dust. These wastes can contain arsenic, chromium and mercury. [6] One study of fertilizer plant workers showed blood and urine cadmium levels 7.8 and 10 times higher respectively than those in a control population.[7] No previous studies have been performed on the exposure of tree planters to fertilizer or heavy metal constituents of fertilizer despite concern amongst tree planters about these exposures. [6, 8]

Health Effects of Fertilizer

Anecdotal evidence of reactions to fertilizers exists amongst tree planters. Symptoms that have been reported include skin rashes, respiratory irritation, headaches, dizziness, nosebleeds, eye irritation and congestion. [5, 8] At least one tree planter in British Columbia has had a workers' compensation claim approved for symptoms acquired as a result of fertilizer exposure. [8, 9]

Health symptoms associated with fertilizer exposure have been studied in fertilizer manufacturing plants and in agriculture. In both of these settings fertilizer exposure has been associated with contact dermatitis and respiratory health effects. [10-15] One study found that fertilizer plant workers in Bulgaria were exposed at or above the occupational exposure limits for ammonia and NO_2 and were prone to disturbed liver function and respiratory, gastrointestinal and cardiovascular diseases. [16] Other studies have found that fertilizer plant workers exposed to ammonia, urea and diammonium phosphate have decreased lung function. [13, 14] Farm workers in China who work with fertilizer are at an increased risk for chronic phlegm, nocturnal cough, asthma attack, wheeze and chest tightness relative to farmers who do not work with fertilizer. [15]

Health Effects of Metals

Arsenic, cadmium, chromium, mercury, nickel and lead can all cause severe chronic health effects. Arsenic, cadmium and chromium [VI] are listed by the International Agency for Research on Cancer (IARC) as carcinogenic to humans while lead is classified as possibly carcinogenic to humans (mercury and chromium [III] are currently listed as not classifiable as to carcinogenicity to humans). [17] In addition to carcinogenicity, chronic exposure to any of these metals can cause other long term health effects.

Chronic exposure to arsenic can result in liver injury which can progress to cirrhosis and ascites. Arsenic is also a neurotoxicant causing paresthesia, muscle tenderness, weakness and demylination of long axon nerve fiber with chronic exposure. [18]

Chronic cadmium exposure can result in chronic obstructive pulmonary disease, emphysema and chronic renal and tubular disease. Cadmium exposure can also affect calcium metabolism, which can result in skeletal changes and bone pain. Epidemiology studies have suggested that cadmium exposure may also be associated with hypertension.[18] The half-life of cadmium in the body may be as long as 30 years and long term exposure to cadmium can therefore lead to accumulating levels of cadmium in the body. [18] This can be particularly harmful for those who are occupationally exposed to cadmium and who are also cigarette smokers. One cigarette contains 1 to 2 μg of cadmium, 10% of which is inhaled when the cigarette is smoked. [18]

Chromium [III] and chromium [VI] are the biologically significant oxidation states of chromium. Both are possibly present as fertilizer contaminants. Of the two oxidation states, chromium [III] is more abundant and chromium [VI] is more toxic. Chromium [VI] is corrosive and can cause chronic ulcerations of skin surfaces. Allergic skin reactions to chromium [VI] can also occur with chronic exposure. [18]

Nickel can be absorbed dermally therefore the inhalation, ingestion and dermal routes of exposure should all be considered for this metal. Dermal exposure to nickel can cause allergic dermatitis. [18]

Mercury is a neurotoxicant and long term exposure to mercury can damage the nervous system resulting in tremors and changes in muscle coordination, nerve conduction, personality and memory. [19] Chronic mercury exposure has also been associated with kidney and stomach damage. [19, 20]

Lead can accumulate in the bone and therefore has a very long half-life in the body. Due to this long half-life the concentration of lead in the body can increase with chronic exposure, even at low levels. Long-term exposure to low levels of lead can lead to peripheral and central nervous system damage. [21] Damage to the central nervous system can cause symptoms such as forgetfulness, irritability, headache and fatigue and the peripheral nervous system damage can cause weakness of the arms, legs, wrists and ankles. [18, 21] extended exposure to low levels of lead can also cause kidney damage, reduced hemoglobin production [21] and epidemiology studies have suggested that lead is immunosuppressive. [18] Lead exposure during pregnancy can lead to neurological damage for the fetus. [21]

Pesticides

The seedlings that are planted by tree planters are often treated with pesticides at nurseries before shipment. Insecticides are applied during the growth period to control pests such as aphids, cutworms, gnats, june bugs and leatherjackets. [22] Following the growth period seedlings intended for spring and early summer planting are placed in cold storage over the winter. Fungicides are applied to control mould growth during cold storage. Seedlings intended for summer planting are usually not placed in cold storage or treated with fungicides. [22] Integrated pest management systems are used at seedling nurseries meaning that pesticide use is tailored to regional and tree species specific needs. The use of these integrated systems means that not all stock is pesticide treated.

Pesticides comprise a large group of toxic agents with a wide variety of potential health impacts. Preliminary discussion with silviculture industry members indicated that the fungicides captan, chlorothalonil, iprodione and benomyl and the insecticides malathion, diazionon, permethrin and cypermethrin are in common use in tree planting.

Health Effects of Captan

Captan is a thiodicarboximide fungicide that is commonly used to control fungal diseases in fruit. Occupational allergic contact dermatitis has been associated with captan exposure. [23] Although IARC classifies captan as a group 3 agent (not classifiable as to its carcinogenicity to humans) [24] captan exposure has also been associated with an increased risk of non-Hodgkin's lymphoma in agricultural pesticide applicators. [25]

Health Effects of Chlorothalonil

Chlorothalonil is an aromatic chloronitrile fungicide. [23] It has been associated with contact dermatitis in a number of occupational groups including chlorothalonil manufacturing plant employees, farmers, horticultural workers, and banana pickers. [26, 27] Animal studies have shown kidney damage associated with chronic exposure to chlorothalonil [28] and kidney tumours have been observed in rats exposed to chlorothalonil. [29] IARC classifies chlorothalonil as a group 2B carcinogen (possibly carcinogenic to humans). [24]

Health Effects of Malathion and Diazinon

Malathion and diazinon are organophosphate insecticides. These insecticides are readily absorbed through the skin. [30, 31] Organophosphate insecticides act by inhibiting acetyl cholinesterase (AChE) in insects. They also inhibit AChE in humans. AChE inhibition results in the accumulation of acetylcholine which causes over stimulation of nicotinic and muscarinic receptors in the parasympathetic nervous system and cholinergic receptors of the central nervous system.[32] As a result of this AChE inhibition, exposure to acutely toxic levels of organophosphate insecticide can result in numerous symptoms including difficulty breathing, chest tightness, vomiting, cramps, diarrhea, blurred vision, sweating, headaches, dizziness, confusion, depression, hypertension, tachycardia, loss of consciousness, and possibly death. [30, 31]

Occupational organophosphate exposure (including exposure to diazinon and malathion) has been associated with an increased risk of Parkinson disease.[33] A risk of gestational diabetes amongst pregnant women exposed to diazinon has been suggested by data from a large US agricultural health study.[34] Organophosphate insecticides have also been associated with an increased risk of non-Hodgkin's lymphoma. [25] Using data from the US agricultural health study Hoppin et al. found that diazinon and malathion are associated with an increased risk of wheeze symptoms in agricultural pesticide applicators. [35] The agricultural health study data also suggested an increased risk of lung cancer and leukemia with occupational diazinon exposure.

[36,37] IARC has not classified diazinon with respect to human carcinogenicity. They have classed malathion in group three; not classifiable as to its carcinogenicity to humans. [24]

Health Effects of Iprodione

Iprodione is a dicarboximide fungicide. No studies on the effects of iprodione on humans have been performed. Rats and dogs fed approximately 60 mg/kg/day of iprodione for eighteen months showed no adverse effects. However, another study of dogs fed 2.3 mg/kg/day for a year showed decreased prostate and uterus weights, hemoglobin damage, and liver and kidney weight increases. A study of mice fed 22 mg/kg/day of iprodione for eighteen months showed carcinogenic effects. [38]

Health Effects of Permethrin and Cypermethrin

Permethrin and Cypermethrin are pyrethrin insecticides. The main routes of tree planter exposure to pyrethrin would be either inhalation or ingestion. Dermal absorption of pyrethrins is low. [39] Permethrin is a type I pyrethrin and cypermethrin is a type II pyrethrin. Type I pyrethrins are generally more potent toxicants than type II pyrethrins. [40]

Type 1 pyrethroid poisoning is characterized by a fine whole body tremor, twitching of dorsal muscles, hyper-excitability and death. [40]

Type 2 pyrethroid poisoning is more complex than type 1 poisoning, acting on a wider range of tissues. It is characterized by paraesthesia, dizziness, nausea, listlessness, muscular fasciculations, epigastric pain, nausea and vomiting, hypersalivation, opisthotonos, seizures and coma. [40] Numbness, itching, tingling, burning and paraesthesia have been reported by workers exposed to permethrin. [41]

Health Effects of Benomyl

Benomyl can case skin sensitization and eye irritation in humans. [23] Animal studies have shown that benomyl toxicity in rats, dogs and mice is low. An increased incidence of tumours was seen when mice and dogs were fed >500 mg/kg/day of benomyl for two years. [42]

Previous studies of pesticide exposure amongst tree planters

Two previous British Columbia studies have investigated tree planter exposure to pesticides. Alleyne et al. measured the fungicides captan, benomyl and chlorothalonil on the skin and captan and chlorothalonil in the breathing zone of twelve tree planters belonging to two different crews. [22] Typical dermal exposure levels were 0.2 μg/day for captan (maximum 8.3 μg/day), 0.6 μg/day for chlorothalonil (maximum 12.5 μg/day) and 9.5 μg/day (maximum 22.4 μg/day) for benomyl. All air measurements were below 0.16 $\mu g/m^3$. The American Conference of Governmental Industrial Hygienists' (ACGIH) threshold limit value (TLV) for captan in air is 5 mg/m^3 and the ACGIH TLV for benomyl is 10 mg/m^3. [17]There is no ACGIH TLV for chlorothalonil. [17] Although both air and dermal exposure levels were low, this study demonstrated the potential for exposure to residues of pesticides that were applied to seedlings months prior to planting. [22]

Robinson et al. measured acetylcholinesterase activity (AChE) and plasma pseudocholinesterase activity (PChE) in pre- and post-work blood samples taken from seventeen tree planters from one crew on ten different weekly visits. AChE and PChe inhibition is an indicator of exposure to organophosphate and carbamate pesticides. Of those studied, 15.9% exhibited significant AChE inhibition post work. A significant group mean for the pre-post work difference in AChE or PChE was seen on two sampling days. Despite the small sample size and chemical non-specificity of this study it does indicate pesticide absorption and the potential for pesticide poisoning. [43]

Both previous studies each examined only a single tree planting crew and did not capture any variability in geography, climate, and season. Due to the limitations of the previous studies it is not possible to estimate the exposures of all British Columbia tree planters based on the results presented above. Although the trend in British Columbia silviculture has been toward decreased pesticide use, [44] the lack of reliable estimates of pesticide exposure among tree planters means that it is not possible to be certain that this decrease in pesticide use has adequately protected tree planters against pesticide exposure.

Pesticides represent a wide range of chemical groups with a similarly large range of chemical properties and potential health effects. The previous studies did not examine all of the pesticides that tree planters are potentially exposed to. For example, permethrin and cypermethrin are insecticides commonly used in seedling nurseries yet exposures to these pesticides among tree planters have never been studied.

Two Swedish studies investigated exposure to permethrin and cypermethrin exposure among Swedish tree planters. In 1995 Kolmodin-Hedman et al. detected permethrin on the hands of 17 out of 18 tree planters studied (mean exposure of 0.7 μg) [45] and in 2008 Elfman found that the concentration of 3-phenoxybenzoic acid (a metabolic of cypermethrin) in urine was higher during a week working with cypermethrin treated seedlings than it was during a week working with untreated seedlings for 15 out of 19 workers. [46] Neither of the studies were able to connect the exposures to acute symptoms (including skin and respiratory irritation and paresthesia). Both of these studies were limited by small sample sizes, and both studied only a single crew. Work practices, geo-climactic conditions and tree planter living conditions between Sweden and British Columbia vary widely [46] and it is unlikely that the results of the Swedish studies are representative of pesticide exposures and associated health effects among British Columbia tree planters.

Possible Determinants of Exposure

Tree planting is an extremely physically strenuous occupation. [47] On a typical day a tree planter can hike sixteen kilometers over difficult terrain, while having to bend and dig to plant 150 to 200 trees per hour. [48] This high work rate has been shown to be sufficient to cause an elevated heart rate during the work day, muscle strain, and decreased body mass. [47-49] The strenuous nature of tree planting work suggests that the inhalation rate is also increased during tree planting work, potentially increasing inhalation exposure to airborne fertilizers and pesticides.

Tree planting work is generally performed in remote locations where there are limited opportunities for hand washing and bathing. Laundry facilities are often only available on days off. The unsanitary conditions could result in fertilizers and pesticides that are present on the skin remaining present for extended periods of time.

As a result of performing manual labour in a physically harsh outdoor work environment tree planters frequently experience dermal cuts and abrasions. These cuts and abrasions could cause chemicals present on the skin to be more likely to cross the dermal barrier. While an estimated 70% of tree planters report wearing gloves while tree planting [50] there is uncertainty regarding whether these gloves are selected to protect against chemical exposures or to protect against cuts and abrasions. It is also unknown whether or not there are personal protective equipment (PPE) programs at worksites to guide PPE selection and maintenance.

Tree planters are paid on a piece rate basis and are therefore motivated to plant as many trees as possible. This piece-rate payment system discourages taking time for rest and hygiene during work hours

A phenomenon known as tree planter "burn-out" has been associated with the strenuous nature of the occupation. Burn-out has been described as an increase in fatigue, apathy, and non-specific illness. [48] The increased fatigue and apathy may also contribute to a disinclination to maintain good hygiene practices while tree planting.

Work conditions faced by tree planters and described above may exacerbate their dermal and inhalation exposures. As a result it is important to determine the levels of these exposures and the determinants of exposure among tree planters in British Columbia and to estimate the prevalence of adverse health outcomes that may be related to these exposures.

Study Rationale and Research Objectives

No previous studies have examined the exposure of tree planters to fertilizers and although previous studies have suggested that pesticide exposures are low, the limitations of these studies were such that the typical level of pesticide exposure experienced by tree planters continued to be unknown. Even if exposure levels are low, there may still be potential for health effects. Exposure may be exacerbated by poor hygiene conditions and the physically demanding nature of the work and consequently occupational exposure limits may not be appropriate comparison values for levels of exposure in tree planting. Furthermore, tree planters are potentially exposed to multiple toxic agents including several metals, fertilizer components and a variety of pesticides. When there is exposure to more than one toxic agent at once there is the potential for interaction between the chemicals to affect the health impacts of the exposures. For example, two toxic agents that act on the same organ or body system may act synergistically meaning that the effect of the two agents combined on the organ or body system is greater than the sum of the effect of the agents individually. [51] The anecdotal reports of health symptoms related to occupational exposures that are present amongst tree planters suggest that chemical exposures in tree planting may be causing health symptoms. One workers' compensation claim has been accepted for a tree planter whose sinusitis was attributed to his work with fertilizer, but occupational disease is generally under represented in workers' compensation [52] and there may be many other cases of disease related to fertilizer exposure.

Prior to the commencement of this work, the exposures of British Columbia tree planters to pesticides, fertilizers and fertilizer contaminants were not well understood and there was no existing data on health symptoms among tree planters. In order to understand the relationship between exposures and health in this occupational group exposure monitoring (including geographic, seasonal and company variability) and a survey of health symptoms were both needed. This research aimed to increase the body of knowledge about chemical exposures and their health effects among tree planters in British Columbia. The objectives of this research were:

1. To measure personal exposure levels of pesticide residues and heavy metal contaminants of fertilizer

2. To examine determinants of exposure to pesticide residues and heavy metal contaminants of fertilizer

3. To measure the prevalence of respiratory and dermal symptoms and disease among current tree planters using standardized administered health questionnaires; and to compare symptom and disease prevalence among tree planters with comparable non-exposed working populations.

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Chapter 2. Exposure to Fertilizer and Metal Contaminants in British Columbia Tree Planters[a]

Introduction

It is common practice in B.C. to fertilize seedlings at the time of planting to promote survival and growth. Fertilizers primarily comprise phosphorous, potassium and nitrogen, typically present as phosphoric acid (P_2O_5), potash (K_2O) and urea or ammonium nitrate, plus "elemental nutrients" (also "micronutrients") such as boron, copper, manganese, etc., in blends customized to the needs of the crop and planting conditions. Certain fertilizer components may be sulfur/polymer coated to delay release.

Figure 2.1: Treeplanter "bagging up"; Seedlings (approx 300-600) are placed in two outer pockets, while fertilizer "teabags" are placed in middle pocket of hip belt.

Additionally, fertilizers may contain non-essential heavy metals as contaminants, for example arsenic, chromium, lead, cadmium, and nickel, depending on source of raw materials and processing. Phosphate fertilizers are manufactured from ore that naturally contains heavy metals, especially cadmium. Micronutrient fertilizers often have a phosphate base blended with metal-rich substances (i.e., furnace dust from steel manufacturing plants, tire ash and mine tailings) to achieve desired micronutrient levels. [1]

The Canadian Food Inspection Agency regulation requires product labels to list nitrogen, phosphorus, potassium and micronutrient content, but not non-essential metals. [2] Registration of phosphate fertilizers is not required, and Canadian standards for acceptable metal content in fertilizers are based on continuous addition to soil over a 45-year growing period, addressing

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long term ecological damage to plants, animals and land but not occupational exposure of fertilizer applicators. [3]

Seedling fertilizers are typically packaged in perforated paper containers ("teabags") designed to provide adequate fertilizer for one seedling for several months. Teabags are shipped in plastic bags of approximately 100 units, and after opening are carried in the hip bags along with the seedlings by the tree planter (see Figure 2.1) until use. Tree planters typically carry 200 teabags each containing approximately 25 g of fertilizer. Although the teabag and time-release polymer coating reduces dust and contact there are anecdotal reports of exposure to dust when teabags are broken or when opening new boxes, and of leaching occurring when teabags get wet. [4,5]

Concerns regarding the health effects of occupational exposure to fertilizers have been raised by both tree planters and contractors. [4, 6, 7] Tree planters have complained of skin rashes, nausea, headaches, nosebleeds, congestion, eye irritations and respiratory ailments when using powdered fertilizers. [5, 7] Exposure to fertilizer is most commonly associated with contact dermatitis, [8] and occupational contact dermatitis has occurred in both industrial and agricultural settings. A case of severe contact dermatitis in fertilizer factory worker was attributed to sensitization from nickel and cadmium in the fertilizer dust; [9] a farmer's acute reaction was attributed to calcium ammonium nitrate in a urea fertilizer used in his field. [10] Allergic reactions may also cause respiratory issues, rhinitis, gastrointestinal illness and eye symptoms. [8] In 2003, a 14-year tree planting veteran suffered from skin rash, blisters, headaches, runny nose and eyes, facial swelling, dizziness, nausea and respiratory illness; symptoms he attributed to a new tea bag fertilizer. This individual eventually had a workers' compensation claim accepted on the basis that the worker's condition (sinusitis) was a result of tree planting employment. [11] Of the primary fertilizer constituents, one is regulated; phosphoric acid has an 8-hour TLV of 1 mg/m^3 based on its irritant properties. In wet conditions there may be more skin contact and inhalation of the ammonia gas that is released from the wet urea granules and from the ammonium phosphate compounds (ammonia ACGIH TLV 25 ppm, STEL 35 ppm). [12]

While the health effects associated with the fertilizer appear to be primarily acute in nature, some non-essential (contaminant) metals have potential for causing chronic health effects. Arsenic, cadmium, and nickel are all confirmed or suspected human carcinogens; lead causes cancer in animals but its human carcinogenicity has not been determined. They also have severe non-malignant effects. Arsenic exposure can cause liver injury and demylination of nerve fibres. [13] Chromium and nickel can cause skin irritation and nickel can also cause pneumonoconiosis. [13] Cadmium and lead both affect the kidney. Lead is a central nervous system toxin and cadmium is a respiratory toxin and has been associated with chronic obstructive pulmonary disease and emphysema.[13] Cadmium and lead are particularly hazardous as they have very long half-lives in the body (possibly as long as 30 years for cadmium). [13] Studies on fertilizer plant workers have shown the potential for heavy metal exposures. In a comparison of 5 exposed workers with a non-exposed control group in a New Zealand phosphate factory, exposed workers had blood cadmium levels 7.8 times higher than controls, and urine levels 10 times higher. [14]

The Fertilizer Institute commissioned a health risk evaluation for fertilizer applicators resulting from their exposure to non-essential (contaminant) metals in fertilizers. [15] Screening of over 3200 phosphate and micronutrient fertilizers determined that only 15 micronutrient fertilizers marginally exceeded safe limits. [16] Modelled exposures for low risk scenarios (home owners, farmers and nursery workers) and high-risk scenarios (golf course workers and lawn care professionals) provided estimates of “safe metal concentrations” for fertilizers. However their result relies on assumptions in the exposure pathway including how often and how long the applicator is exposed, and the activity rate, breathing rate, body weight, and skin exposed of the applicator. These variables are considerably different for tree planters compared to the professions modelled in the study. As such, the conclusion that there is no risk to applicators from non-essential elements in fertilizers cannot be extrapolated to the tree planting population.

The nature of tree planting work and the environment likely influences the degree of hazardous exposure where it exists. For example lack of washing facilities means limited opportunity for hand washing increasing the risk of chemical exposure pathways via dermal absorption and ingestion. Planters utilize clothing protection against rain and sun and wear appropriate footwear, but are less much likely to wear dust masks that might cause discomfort during strenuous work in hot environments. [6] Although an estimated seventy percent of tree planters wear gloves while treeplanting [17] the glove materials worn may not be appropriate for chemical protection (see Chapter 3). Tree planting is piecework with payment per seedling planted; this can be a barrier to proper health and safety practice if safe practice is perceived to reduce productivity and income.

A high work rate can result in increased inhalation rate, thus increasing airborne exposure, and the physically harsh environment often leads skin lesions that can potentially enhance dermal uptake of hazardous chemicals.

This study was conceived to address the concerns of contractors and their employees as to the potential risk posed by chemical exposure from fertilizer in the reforestation industry. The specific objectives of this exposure phase of the study were to determine:

- Are tree planters in B.C. exposed to <u>fertilizer dust</u>? If so, at what levels?
- Are tree planters in B.C. exposed to <u>metal contaminants of fertilizers</u>? If so, at what levels?

Methods

Study sample

A convenience sample of five British Columbia tree planting operations was selected after informal advertising through the investigators' network of contacts. Four sites were fertilizing; two in the B.C. interior and 2 in coastal B.C., thus representing the two primary biogeoclimatic zones in B.C. where tree planting occurs. Controls, where fertilizers were not being used, were taken from a fifth (B.C. interior) worksite. All workers actively engaged in tree planting at the study sites were eligible for the study. Additional biological control samples were obtained from 10 individuals (students and their relatives) who had no tree planting experience.

Recruitment

Each site received study advertisements in advance of the arrival of the research team. Each site visit was begun with a crew meeting to go over the study objectives, methods, and to answer questions. The study team aimed to recruit 10 volunteer subjects at each worksite, 5 each on two consecutive days. Subjects provided signed, informed consent prior to participation. The investigators supplemented subjects' pay for the days that they participated, so that there was no loss of income as a result of participating. The study protocol was approved by the University of British Columbia Clinical Research Ethical Review Board (Certificate number H06-70039).

Air Sampling

Subjects wore SKC Model 224-44XR air pumps (SKC, Eighty Four, PA) and a GSP inhalable sampler (Stroéhlein, Kaarst, Germany), fitted at the lapel. Flow rate was 3.5 LPM; samples where the pre- and post-flow varied by more than 15% were excluded. Filters (0.8 μm mixed cellulose ester) were triple weighed on a microbalance (Sartorius, Goettingen, Germany) in a climate-controlled room after 24 hours equilibration. Laboratory and field blanks (10% of samples) were utilized. After post-sample weighing, filters were analyzed for metals.

Biological Sampling

Trained medical staff obtained 10ml venous (cubital) blood samples from subjects into heparin-treated lead-free/trace-metal vacutainers (BectonDickinson, Oakville, ON). Care was taken to thoroughly clean the forearm area before phlebotomy. Blood samples were placed on ice, and kept at 4ºC until analysis.

Dermal sampling

At the end of shift, three skin-wipe samples were taken from (i) the back of the hand, (ii) inside the forearm and (iii) fingers. Samples were taken with a proprietary cloth wipe (Ghostwipe) premoistened with deionised water (Environmental Express, Mt Pleasant, SC). Samples from hand and forearm were made with 12 wipes of consistent force of an area proscribed by a 1.5" x 1.5" plastic template. Three wipes were made in an initial direction followed by three in the opposite, three more at 90 degrees and a final three opposite to wipes 7 to 9, using a "fresh" side of the folded wipe after each set of 3. Samples from fingers were made with two continuous passes (one in each direction and using consistent force) from the lower extremity of the radius bone to the upper extremity of the ulna (at the wrist). The three samples for each individual were combined in a single container for analysis. Surface area of the skin covered by finger wipes was estimated from hand traces taken for each subject. The skin wipe strategy was developed by pooling methods described in a review of skin wiping methods by Brouwer et al and methods from the OSHA Technical Manual. [18, 19]

Environmental samples

Bulk samples of fertilizer, surface soil, and of all seedling types were obtained. Soil and seedling-rootballs were analysed for metals. Bulk fertilizers were handled in two ways. First, they were acid digested from a dry state and analyzed for metals and second, they were agitated in water for 8 hours and the liquid (the "leachate") was analysed for metals and ammonia that had been extracted by the water.

Chemical Analysis

All chemical analysis was done at an external commercial laboratory. Samples were analyzed for arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb) and nickel (Ni). Air sample analysis was based on Workers' Compensation Board of British Columbia method 1051 using acid digestion of the filter. [20] Metals in blood and on skin swabs were digested using nitric acid/hydrogen peroxide, based on Environmental Protection Agency method 200.3. [21] Due to the nature of tree planting work most personal air and skin samples contained soil – soil is not known to interfere with the analytical methods used. [20, 21] Metals in soil analysis was based on Canadian Society of Soil Science Methods, using a deionized water leach with measurement by pH meter. Analysis was by ICP or ICP/MS. Ammonia in water ("leachate") was measured using flow injection analysis based on Method 4500 from Standard Methods for the Examination of Water and Wastewater. [22]

Other Data

Participants were interviewed on previous fertilizer exposure, risk perception, determinants of exposure, duration of employment, fertilizer application, techniques, personal protective equipment use, personal hygiene, and exposure "incidents". A copy of the questionnaire used in the interview is attached in Appendix A.

Results

Characteristics of the five participating sites and sampling conditions are provided in Table 2.1. Site "M" was considered the "control" site for fertilizer and metal sampling as fertilizers were not used at this site. Several factors were correlated with "Interior" site location: temperatures were warmer, sampling occurred in a different planting "year", in a later season, and there were a greater average number of seedlings planted.

Table 2.1: Site Characteristics for the five tree planting work sites participating in a study of fertilizer and metal contaminants, 2006 – 2007.

Location	Interior or coastal region	Mean temperature over two sampling days (˚C)	Rainfall	Mean # seedlings planted per employee per day (Standard Deviation)	Month/ year of sampling	Seedling species planted	% Seedlings fertilized
B	Interior	15.1	Both days	1000 (167)	05/2006	Cedar, Spruce	100
G	Interior	17.9	One day	934 (137)	06/2006	Cedar, Spruce, Pine, Douglas Fir, Hemlock	100
N	Coastal	6.9	One day	708 (312)	04/2007	Pine, Fir	100
R	Coastal	8.2	One day	790 (218)	04/2007	Cedar, Spruce, Fir, Hemlock	100
M (control)	Interior	12.8	Both days	1214 (669)	06/2006	Spruce, Pine	0

Fifty-four subjects participated of whom complete data was available for 50 (blood samples); 42 (air samples) and 51 (dermal samples). Mean age of those fertilizer exposed was 29.7 years versus 23.7 for non-fertilizer exposed. Approximately 30% were female in both groups, but mean years of experience was greater amongst the fertilizer exposed (7.4 years) than controls (2.6 years). The external controls were slightly older (mean 32 years), 50% female, and none had any experience in tree planting or other occupations that would expose them to fertilizers or heavy metals.

The four sites using fertilizers were using 4 different fertilizer brands from 2 different manufacturers. Principal constituents (N, P, K) ranged from 18-26%, 9-12% and 6-10% respectively. All of the fertilizer types also contained elemental nutrients (micronutrients), including sulfur (up to 6%), and combinations of magnesium, boron, zinc, copper, manganese, iron, all at levels of 1% or less.

Dust

We measured the "inhalable" fraction of airborne dust (Table 2.2). Geometric means and standard deviations are shown because airborne exposure levels followed a log-normal distribution. Mean levels of dust range from a low of 0.67 mg/m^3 (site R) to a high of 1.4 mg/m^3 (site G). The range of individual levels was from below the limit of detection ("LOD", 0.39 mg/m^3) to 5.3 mg/m^3. Both the geometric and arithmetic mean were highest at the control (non-fertilizing) site.

Table 2.2: Personal inhalable dust (mg/m^3) among a sample of tree planters at five worksites in British Columbia, 2006-7 (n = 42)

	Location					
Exposure Measure	**B**	**G**	**N**	**R**	**Fertilizing locations**	**Non-fertilizing Site "M"**
N	9	10	9	5	33	9
AM*	1.0	1.0	1.1	0.95	1.0	1.4
GM*	0.86	0.95	0.70	0.67	0.8	1.1
GSD*	1.8	1.6	2.4	2.5	2.0	2.1
Range	<0.39 – 3.1	0.53 – 2.0	<0.39 – 5.3	<0.39 – 2.6	< 0.39– 5.3	<0.39 – 3.0

*AM: arithmetic mean, GM: geometric mean, GSD: geometric standard deviation

Metals in air

Table 2.3 shows the concentration of selected trace metals found in airborne particle samples. Overall, we obtained a total of 42 air-metal samples. Only five samples were obtained at site R because five of the ten samples taken at this site were destroyed due to water damage and could not be used. Concentrations were very low; only 7 samples (17%) had detectable levels of the metals examined: lead (Pb) at one site, nickel (Ni) at two sites and chromium (Cr) at three sites. All exposures were below the 8-hour time weighted average B.C. regulatory limits for airborne exposures of 10 µg/m^3 for arsenic, cadmium and chromium, and 50 µg/m^3 for nickel and lead. [23]

Table 2.3: Metals in inhalable dust samples among tree planters at 5 British Columbia work sites, 2006-2007 (n = 42). Because very few samples were above the limit of detection, ranges are shown rather than means and standard deviations.

	Location	B	G	N	R	All Exposed	M (control)
	N (samples)	9	10	9	5	33	9
As ($\mu g/m^3$)	# Detectable	0	0	0	0	0	0
	Range of LOD*	4.1 - 6.5	0.06 - 0.07	0.07 - 0.08	0.05 - 0.06	0.05 - 6.5	5.0 - 6.2
	Range of Detectables	N/A	N/A	N/A	N/A	N/A	N/A
Cd ($\mu g/m^3$)	# Detectable	0	0	0	0	0	0
	Range of LOD	0.10 - 0.16	0.01 - 0.02	0.01 - 0.02	0.01 - 0.12	0.01 - 0.16	0.12 - 0.15
	Range of Detectables	N/A	N/A	N/A	N/A	N/A	N/A
Cr ($\mu g/m^3$)	# Detectable	0	1	2	1	4	0
	Range of LOD	0.41 - 0.65	0.06 - 0.08	0.07 - 0.08	0.05 - 0.06	0.05 - 0.65	0.50 - 0.62
	Range of Detectables	N/A	0.07	0.15	0.11	0.07 - 0.15	N/A
Ni ($\mu g/m^3$)	# Detectable	0	0	1	0	1	1
	Range of LOD	0.36 - 0.57	0.06 - 0.08	0.07 - 0.08	0.05 - 0.06	0.05 - 0.57	0.44 - 0.54
	Range of Detectables	N/A	N/A	0.07	N/A	0.07	2.8
Pb ($\mu g/m^3$)	# Detectable	0	0	0	1	1	0
	Range of LOD	1.0 - 1.6	0.06 - 0.08	0.68 - 0.84	0.05 - 0.06	0.05 - 1.6	1.3 - 1.5
	Range of Detectables	N/A	N/A	N/A	0.05	0.05	N/A

*LOD = limit of detection. Ranges are presented because the limit of detection varied with volume of air sampled.

Direct comparison between sites using fertilizer (B, G, N and R) and the site not using fertilizer (M) is complicated by the variability in “limits of detection”. Due to differences in the analytical lab procedures for metals at the external analytical laboratory over the course of the study detection limits were higher for sites B and M than for the other sites. However, it is clear that there are not large differences in the exposure levels found at any of the sites, and for at least one metal (nickel) airborne levels were higher at the site not using fertilizer than at other sites.

Metals in blood

Levels of metals in blood were generally very low (Table 2.4). The highest number of samples with detectable levels of metals was seen at the control site (M). Where levels of metals were above the limit of detection however, blood levels were similar across sites.

Table 2.4: Metals in venous blood of a sample of tree-planters at five worksites in British Columbia, 2006-07 (n = 50). Because so few measurements were above the limit of detection ranges of results are given rather than means and standard deviations.

		Location						
		B	G	N	R	All Exposed	M* (Control site)	External Comparison Group†
	N	10	9	10	11	40	10	10
As (µg/g)	# Detectable	0	0	0	0	0	0	0
	LOD‡	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Range of Detectables	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cd (µg/g)	# Detectable	0	0	0	1	1	3	0
	LOD	0.004	0.004	0.004	0.004	0.004	0.004	0.004
	Range of Detectables	N/A	N/A	N/A	0.006	0.006	0.004 - 0.007	N/A
Cr (µg/g)	# Detectable	0	0	0	0	0	2	9
	LOD	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Range of Detectables	N/A	N/A	N/A	N/A	N/A	0.02 - 0.03	0.02 – 0.03
Ni (µg/g)	# Detectable	0	0	1	0	1	1	0
	LOD	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Range of Detectables	N/A	N/A	0.03	N/A	.0.03	0.03	N/A
Pb (µg/g)	# Detectable	3	4	5	2	14	7	2
	LOD	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Range of Detectables	0.03 - 0.05	0.02 - 0.04	0.02 - 0.03	0.02 - 0.05	0.02-0.05	0.02 - 0.1	0.02

*Fertilizer was not used at control site

†Comparison group were recruited at the University of British Columbia and who did not have tree planting experience or previous occupational exposure to metals.

‡ LOD: Limit of detection

Lead was the most commonly found contaminant being found in 40% of all blood samples. Levels ranged from below the limit of detection (0.02 µg/g) to 0.1 µg/g. The latter is equivalent to 10 µg/100mL, assuming a specific gravity of blood of approximately 1.05. One subject (female, aged 23) had a blood-lead level of 10 µg/100mL (the recommended maximum level for women of child bearing potential). [12] This subject was in her first year of tree planting and on her first contract. She was working at the control site (M) where no fertilizers were being used. Three subjects had blood-cadmium levels that exceeded the ACGIH recommended blood-cadmium level of 5 µg/L (one male, two female, ages 23-26). [12] Two of these individuals (5 µg/L and 7 µg/L) were working at the control site (M) where no fertilizers were being used; both were on their first contract and had never worked with fertilizer. The third (6 µg/L) was employed at site R; this person had planted for 9 years, and worked with fertilizer approximately 90 days over the prior 2 years. This individual is therefore at the upper end of years of experience in this study (at the 75th percentile).

Metals on the skin

Levels of metals found on skin swabs are shown in Table 2.5. Arsenic and cadmium were found at detectable levels in 5 of the 51 samples. Only ranges of results are given for As and Cd in the table. Chromium, nickel and lead were more commonly found. Geometric means and standard deviations are given because the underlying distribution of results was lognormal; results are given in nanograms per surface area (cm^2) of skin. Mean levels at the control site (M) were second to lowest for chromium, but second to highest for lead and nickel, while the ranges seen for all three measureable metals were similar across all 5 sites.

Table 2.5: Trace metals on skin from a sample of tree planters across 5 worksites in British Columbia, 2006-7 (n = 51). Because few measurements were above the limit of detection (LOD) for arsenic and cadmium ranges of results are given rather than means and standard deviations.

	Location	B	G	N	R	All Exposed	M (control)
	N	10	10	10	11	41	10
As (ng/cm^2)	# Detectable	0	1	0	0	1	0
	Range of LOD*	1.5 – 1.9	1.4 – 2.5	1.4 – 1.9	1.5 – 2.0	1.4 – 2.5	1.4 – 2.0
	Range of Detectables	N/A	2.5	N/A	N/A	2.5	N/A
Cd (ng/cm^2)	# Detectable	0	1	0	1	2	2
	Range of LOD	2.9 – 3.8	2.8 – 4.7	2.9 – 3.8	3.0 – 5.6	2.8 – 5.6	2.9 – 6.2
	Range of Detectables	N/A	4.7	N/A	5.6	4.7 – 5.6	4.7 – 6.2
Cr (ng/cm^2)	AM†	6.2	2.4	8.1	10.0	6.8	3.8
	GM†	4.9	2.0	7.7	9.9	5.3	3.4
	GSD†	2.2	2.0	1.4	1.2	2.3	1.6
	Range	1.0 – 15.7	0.5 – 4.0	3.8 – 12.4	8.0 – 14.6	0.5 – 15.7	2.0 – 7.3
Ni (ng/cm^2)	AM	4.6	1.8	2.0	2.4	2.7	2.8
	GM	4.2	1.5	1.9	2.2	2.3	2.6
	GSD	1.6	1.7	1.5	1.5	1.8	1.5
	Range	2.5 – 8.9	0.8 – 5.3	1.0 – 3.11	1.3 – 4.2	0.8 – 8.9	1.4 – 4.2
Pb (ng/cm^2)	AM	2.8	2.2	3.7	8.7	4.5	5.2
	GM	1.9	1.8	3.5	6.3	3.0	4.4
	GSD	2.6	1.9	1.4	2.2	2.4	1.9
	Range	0.3 – 11.5	0.9 – 7.3	1.8 – 5.6	3.1 – 31.6	0.3 – 31.6	1.3 – 11.0

*LOD: limit of detection. Ranges are presented because the limit of detection varied with surface area wiped.
†AM: arithmetic mean, GM: geometric mean, GSD: geometric standard deviation

Environmental samples

Results for bulk samples of fertilizer, soil and root ball material are shown in Table 2.6. Note different units for leachate that was in liquid form. Bulk fertilizer data was only available from sites G and R, but we assayed 4 other fertilizer types that were obtained from fertilizer suppliers and had not been used at any of the sites tested for comparison purposes.

Among the solid samples (soil, rootball and bulk fertilizer) ranges of concentrations for each contaminant were similar with the exception of cadmium which was found at detectable levels only in fertilizer samples.

Table 2.6: Metal concentration in environmental samples and fertilizer across 5 tree-planting worksites in British Columbia 2006-07. (bulk soil from tree planting site, composite rootball samples from seedlings, liquid leachate from bulk fertilizer samples, and bulk fertilizer samples)

	Location	Fertilizer brand	As	Cd	Cr	Ni	Pb
Soil (µg/g)	B		0.4	<0.2	41	21	6.5
	G		6.3	<0.2	15.5	22.5	19.1
	N		2.1	<0.2	24.5	18.5	12.8
	R		0.4	0.2	<2.0	<2	2.8
	M (control)		1.1	<0.2	7	4	5.4
Root balls (µg/g)	B		1.1	<0.2	2.3	<2	0.53
	G		0.73	<0.2	4	<2	1.5
	N		0.80	<0.2	2.7	<2	1.0
	R		0.54	<0.2	114.8	24.2	1.8
	M (control)		0.40	<0.2	2.3	<2	0.70
Leachate from bulk fertilizer (mg/L)	B	RTI / Planters Pak	0.027	0.0021	0.13	0.16	<0.001
	G	Spectrum/Defender	0.016	0.0006	0.17	0.11	<0.001
	N	Spectrum/ Forest Pro	0.018	0.0009	0.26	0.13	<0.001
	R	RTI/ Silva Pak	0.017	0.0021	0.24	0.099	<0.001
Bulk Fertilizer (ug/g)	G	Spectrum/Defender	<2.0	<0.4	87	6	5
	R [a]	RTI/ Silva Pak	<2	4.1	70	<2	12
	Not used at study sites	Spectrum /Extra [b]	3	25.5	80	4	55
		RTI/Continuem RT Pak [b]	<2	5.3	50	<2	12
		RTI/Schirp Pak [b]	<2	5.7	114	<2	16
		RTI/Forest Pak [b]	<2	1.1	73	<2	6

[a] Bulk fertilizer samples only available for Sites G and R
[b] For comparison, not used at any of the tested sites

Ammonia was detected in "leachate" from bulk fertilizer samples from all sites. The concentrations in the "leachate" samples ranged from 613 – 996 mg/L of nitrogen. The concentrations of ammonia directly above the water samples were estimated using Henry's Law and a Henry's law constant of $1.6x10^{-5}$ atm · m^3/mol. [24] The estimated range of concentrations was 700 – 1140 ppm.

Discussion

Exposure to Fertilizer

Measurement of exposure to fertilizer dust was made indirectly by measuring levels of inhalable particulate. Although this gravimetric method cannot discriminate between sources of particles, higher particulate levels at sites using fertilizer would indicate the potential for airborne fertilizer exposure. We did not see this; the mean inhalable particulate levels were actually highest at the "control" site, although the range of exposure was similar across all sites. Some individual levels were quite high (> 5 mg/m^3 inhalable). Because the composition of the particulate is likely a combination of soil dust and rock dust (from roads sometimes blasted out of the hillsides) as well as fertilizer, these high levels should be a concern for the occupational health of tree planters. Silica exposure for example has been associated with rock blasting in tunnelling, [25] but levels associated with outdoor ungraded roads have not been measured. Even treating the dust exposure as "particles not otherwise specified" would mean that some of these exposures were above the "action level" of 50% of 10 mg/m^3 TLV. [12] The exposure limit for "particles not otherwise specified" may not be an appropriate comparison value for this dust as it assumes that the particulate is water soluble and of low toxicity. These assumptions would not be valid for this particulate if it contains fertilizer and/or silica dust.

Exposure to ammonia was estimated by placing fertilizer in water and then measuring ammonia in the water and estimating the concentration of ammonia in the air directly above the water sample. The estimates of ammonia concentration in air (700 – 1140 ppm) were all over an order of magnitude higher than the ACGIH short term exposure limit for ammonia (35 ppm). These estimates are based on ammonia from only a single fertilizer packet whereas tree planters carry up to two hundred packets of fertilizer at a time. Although laboratory conditions under which these measurements were taken differ from those experienced by tree planters in the fields, this demonstrates the potential for tree planters to be exposed to high levels of ammonia gas and ammonia in water and warrants further investigation.

Historically, before the advent of the "teabag", inhalable exposures may have been much higher when fertilizers were handled as a loose powder. In either case (loose or teabag) dermal exposure still occurs through routine contact with the fertilizer onto the skin of the hands or torso via handling or through the leaching of dissolved fertilizer after it has become wet (rain, sweat, etc.).

Exposure to metal contaminants

There was no apparent evidence linking increased exposure to the metals investigated (arsenic, nickel, lead, chromium and cadmium) and work with fertilizers. We examined metals in air and on the skin which would have been indicators of acute exposures, as well as blood level of the same metals that would have indicated exposures of more chronic nature. Direct comparison between sites using fertilizer and the site not using fertilizer was limited by problems related to the analytical process (detection limits were higher for samples from site B and the control site than for samples at sites G, M and R). However, it was clear that there were not large differences in the levels of metals in air found at any of the sites, and for at least one metal (Ni) airborne levels were higher at the site not using fertilizer than at other sites. As well, all airborne exposures levels for potentially contaminating metals (As, Cd, Cr, Ni, Pb) were below their respective regulatory limits.

Data from skin swab tests was used to compare across sites to examine whether dermal exposure to metals was greater among sites using fertilizer than the control site (site M). There was no consistent association between the use of fertilizer and elevated levels of metal dermal exposure. Mean skin exposure levels for chromium, nickel and lead were compared to environmental levels obtained from soil samples, rootballs and bulk fertilizer leachate for each site. Spearman correlation coefficients were generally low and inconsistent (below 0.4), making it difficult to attribute the source of the metals found on skin samples.

Levels of metals in blood were generally very low. The highest number of blood samples with detectable levels of metals was at the control site, and where concentrations of metals were above the limit of detection, concentrations were similar across all sites. One female subject had a blood lead level at the recommended limit for females of child-bearing age (10 µg/100mL), but she had no planting experience using fertilizers. She had previously worked as a painter. Three subjects had blood chromium levels above the recommended exposure limit. One of these subjects was at the upper end of years of tree planting experience for this study and had worked with fertilizer for a total of 90 days in the previous two years, however, two of the subjects with blood cadmium above the recommended levels had never planted using fertilizer and all three were smokers. Smoking is known to increase blood cadmium level into the range seen in these individuals; the American Conference of Governmental Industrial Hygienists notes that smoking is a significant source of cadmium exposure and median levels in blood of smokers are between 1.4 and 4.5 μg/L.[26]

Attribution of exposure to metals

To examine the environmental source of metal exposure we measured metal concentrations in soil from worksites, from seedling rootballs and from fertilizers. Fertilizer samples were examined as acid-extracts from the bulk material as well as from aqueous extracts from the bulk – the latter to simulate the exposure of the tree-planter to chemical leaching due to rain-soaked equipment for example. Across all the solid samples (soils, rootballs and bulk fertilizer) concentration ranges were very similar for the metals examined, except for cadmium that was detected at levels of 20-100 times higher in the bulk fertilizer than soil and rootball. It is difficult to interpret the meaning of this; blood cadmium levels were elevated in 3 subjects but only one of these had ever used fertilizer and they were all smokers. It does warrant further testing of additional fertilizer samples.

Determinants of exposure

The majority of tree planters in this study used only gardening gloves (i.e. rubber palm, cotton back) which would not provide a full chemical barrier. Gloves were changed infrequently, every six days on average (See Chapter 3). Glove materials can absorb and retain liquids and dusts and may increase exposures over time as chemicals are trapped and held against the skin if they are not changed frequently. Adequate personal protective equipment programmes must include provisions for replacement and cleaning of protective clothing like gloves, as well as training for the correct selection, donning and removal of such equipment, and it was apparent that none of these factors were in place in the tree planting worksites visited.

Furthermore, hygiene facilities were severely limited. At none of the five sites visited was water available for hand washing during the day, even prior to meals. Workers usually did laundry only on rest days, and although no data was collected it is unlikely that fresh clothing was put on every day, and there was certainly no requirement or provision from the employer to do so.

Strengths and limitations

The study is the first to examine metal exposure among tree planters. We examined a selection of potential metal contaminants and looked at both skin contamination (representing acute exposures) and blood levels (that would indicate chronic exposure). Because of the long duration of the study, we encountered changes in analytical laboratory procedures that changed limits of detection over time. This complicated comparisons, but was taken into account in the discussion and interpretation.

Although not all permutations of region/climate/weather/tree species/fertilizer types that exist in British Columbia were captured in this study, subjects were from several different sites representing different geographic regions and seasons. Fertilizer application procedures throughout the province are very similar so there is unlikely to be any variation related to application procedures that were not captured by this study. It would be prudent to exercise caution when working with fertilizer as some fertilizer blends may have higher metal content and may generate more dust than the fertilizer blends used at the sites visited during this study.

Recommendations

Although high exposure to fertilizer and contaminant heavy metals among tree planters was not demonstrated, metals were found in fertilizer bulk samples, in site soil samples and in seedling rootballs. There are reasons why it is prudent to take extra caution to minimize potential exposures to fertilizer and metals. Tree planting work is extremely physiologically demanding.[27-30] The heavy physiological demands of tree planting work can cause increased metabolic rates which may increase uptake of contaminants into the body and the poor hygiene conditions at the worksites and in living quarters can cause contaminants on the skin to remain present for days or weeks at a time and can increase the risk of transfer of metals from the skin to food. These extreme work conditions experienced by tree planters could cause even low levels of exposure to result in health symptoms. An additional reason for prudence is the transient nature of the workforce which makes follow up and determination of chronic impact of exposure difficult. Futhermore, the limitations of this study prevent greater generalization of results so it is unknown whether all tree planters in British Columbia experience exposures at low levels or if exposures are higher for some tree planters.

To this end, we believe it would be prudent to:

( ) monitor dermal and airborne ammonia exposure

( ) improve employee and employer risk awareness regarding workplace chemicals;

( ) improve worker hygiene facilities so that employees can wash hands during day and

( ) develop a suitable dermal protection programme.

Conclusion

We found no evidence of high exposure to heavy metal contaminants of fertilizer. However, the potential for health symptoms caused by low levels of exposure is increased by the extreme work environment and poor hygiene practices. We recommended increased risk awareness, improved hygiene and development of a dermal protection program.

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Chapter 3: Exposure to Pesticide Residues Among British Columbia Tree Planters[b]

Introduction

Seedlings used in tree planting in British Columbia (B.C.) are supplied by seedling nurseries. There are at least forty seedling nurseries geographically dispersed throughout B.C. Pesticides are often applied to seedlings at nurseries to protect them during early development and storage. Typically pesticides are sprayed onto seedlings with water through sprinkler systems. The pesticide treatment is part of an integrated pest management program and is targeted to threats specific to the region, tree species and local environment. Some stock is not treated with pesticides.

Seedlings are grown in polystyrene trays. During the growth stage insecticides are applied as necessary. Following the growth period seedlings are removed from trays and bundled for storage; each bundle is wrapped in plastic and then boxed in a waxed-cardboard box. This is known as “lifting”. Seedlings intended for spring planting (February to June) are grown the summer before and lifted in October, November or December. These seedlings are stored at -2°C over the winter. If it is deemed necessary by the nurseries, fungicides are applied prior to storage. After the winter the seedlings are removed from cold storage and thawed for approximately ten days before being shipped to tree planting crews in refrigerated vehicles (≤ 5°C). Seedlings grown for summer and autumn planting are grown early the same year. They are not kept in cold storage and are typically not treated with fungicides. [1]

When tree planting operations receive seedlings, they transport them to worksites in insulated storage containers. Seedling boxes are then stored at the side of the road under reflective tarpaulins designed to reduce seedling exposure to heat and sunlight. Tree planters open seedling boxes and remove seedlings for planting.

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[b] A version of this Chapter will be submitted as Gorman, MJ; Stjernberg, E; and Davies HW. Exposure to Pesticide Residues Among British Columbia Tree Planters

Pesticide Residue Exposure

Although pesticides are applied months before planting, pesticide residues may still be present on seedlings at the time of planting. Two previous studies (both conducted over fifteen years ago) demonstrated tree planter exposure to pesticide residues. [1, 2] Alleyne et al. detected the fungicides captan and chlorothalonil in personal air samples, and captan, chlorothalonil and benomyl on the skin of tree planters. [1] Robinson et al. showed cholinesterase inhibition in tree planters over the course of a work shift suggesting exposure to organophosphate or carbamate compounds. [2]

Both of these studies were limited by chemical non-specificity, small sample sizes, and a lack of geographical variability so it is not possible to generalize the results of these studies to the entire British Columbia tree planting industry. Therefore, little is known about the levels of exposure to pesticides among tree planters.

A wide range of chemicals are used as pesticides and consequently a wide range of health effects are possible depending on the specific pesticide that one is exposed to. Tree planters are potentially exposed to multiple pesticides which vary depending on the nurseries where the seedlings were grown. As an example, captan and chlorothalonil are fungicides used at some seedling nurseries. Both cause allergic dermatitis [3-5] and chlorothalonil is classified as possibly carcinogenic to humans by the International Agency for Research on Cancer. [6] Animal studies have demonstrated the potential for chlorothalonil to cause kidney tumours. [7] Organophosphate insecticides are also used at some seedling nurseries. These insecticides act by inhibiting acetyl cholinesterase and they can affect humans as well as insects. As a result of this AChE inhibition, exposure to acutely toxic levels of organophosphate insecticide can cause a variety of symptoms including difficulty breathing, vomiting, diarrhea, headaches, dizziness, and hypertension. [8, 9] Organophosphate exposure has been associated with increased risk of Parkinson disease [10] and non-Hodgkin's lymphoma. [11]

Tree Planting Work Conditions

Work sites usually lack washing facilities and tree planters are therefore unlikely to wash their hands before eating, drinking or smoking during the workday. Payment is piece-rate reducing the likelihood of taking time for hygiene during work hours. During the planting season tree planters live either at motels or in camps that are within a two-hour drive of their worksites. At camps laundry and shower facilities are often not available and workers are only able to shower and wash their clothes during trips to the nearest town on days off. These unsanitary conditions can result in persistent dermal exposures and accumulation over a number of days. Shift structures vary among tree planting work crews and can range from three to as many as ten consecutive workdays before a rest day. If pesticides are present on the skin tree planters may be at risk of exposure via both the dermal and ingestion pathways, as pesticides on the skin might be transferred to food, drink containers or cigarettes.

Dermal exposures may be exacerbated by the physically harsh work environment. Tree planting is highly demanding outdoor manual labour and tree planters frequently experience dermal cuts and abrasions that might enhance dermal uptake of pesticides.

An estimated 70% of tree planters report wearing gloves while tree planting. [12] It is unclear whether these gloves are used to protect against chemical exposure or cuts and abrasions. Additionally it is unknown whether there are any personal protection equipment programs in place to ensure the selection of appropriate glove materials.

The objective of this study is to determine if B.C. tree planters are dermally exposed to pesticide residues, and to determine the levels of dermal exposure and factors contributing to this exposure.

Methods

Subject Recruitment

The research team visited tree planting crews between May and August of 2006 and in April 2007. At each site sampling was completed over the course of two days. Eleven tree planting operations in British Columbia and two in Alberta volunteered work crews for study participation. All workers in each crew were eligible (crews contained between 9 and 51 tree planters). Workers at all thirteen sites participated in an exposure and health symptom interview, and exposures were monitored to workers at five of the thirteen sites.

Workers were informed about the study via a flyer that arrived at least forty-eight hours before the on-site visit by the research team, and during a meeting upon arrival of the research team. Volunteers were requested at the meeting. Subjects were compensated for lost production during their participation in the study, but no other incentive was paid. All subjects gave signed informed consent.

Skin Wipes

Post-shift skin wipes were taken from fifty-four workers from five of the thirteen sites. All five of these sites were in B.C. At each of these sites skin wipes were taken from seven to ten workers at the end of one workday.

Tree planters typically always use the same hand to hold the shovel and the same hand to plant the seedling; skin wipes were taken from the "seedling hand". Three samples were taken from (i) the back of the hand, (ii) inside the forearm and (iii) perimeter of hand and fingers. Skin was wiped with three 1.5" X 1.5" cotton batten swabs pre-moistened with 70% ethanol. Samples from hand and forearm were made with 12 wipes of consistent force of an area proscribed by a 1.5" x 1.5" plastic template. Three wipes were made in an initial direction followed by three in the opposite, three more at 90 degrees and a final three opposite to wipes 7 to 9, after every three wipes the swab was turned to expose an unused area. Samples from the perimeter of the hand were made with two continuous passes, one in each direction. The wipe covered the area from the lower extremity of the radius bone to the upper extremity of the ulna (at the wrist). The skin wipe strategy was developed by pooling methods described in a review of skin wiping methods by Brouwer et al and methods from the OSHA Technical Manual. [13, 14]

Skin wipes were taken by three trained occupational hygienists. To prevent contamination of samples the hygienists wore nitrile gloves during wipe procedures. New gloves were used for each subject. At each site one control sample was taken. The control samples were taken to the worksite but were not used to wipe skin.

Each wipe sample was stored in a separate glass vial, kept on ice or refrigerated at 4ºC in dark containers and transported to the analytical laboratory within one week of sampling. The three wipe samples for each subject were combined and analysed as a single sample.

A trace of the perimeter of each subject's "seedling hand" was taken to determine the surface area of the perimeter (finger) wipe.

Following collection of skin wipe samples subjects were asked about production, personal protective equipment use and personal hygiene pertinent to that shift.

Seedling samples

Seedling samples were taken from the same five sites where workers provided skin wipe samples. At least one sample was taken of each tree species that was planted during the sampling day. Where seedlings were supplied by more than one nursery, at least one sample from each nursery was taken. Seedlings were placed in plastic bags, stored on ice in dark containers or refrigerated at 4ºC and transported to the analytical laboratory within one week of sampling. Nursery pesticide application records were obtained for each seedling collected.

Interview

Interviews were administered at all 13 worksite to as many tree planters as possible. Information was collected on work history, personal protective equipment use and personal hygiene. At the same time information on skin and respiratory health was collected and is reported in Chapter 4.

Chemical Analysis

Pesticide analysis was targeted to pesticides identified on the nursery pesticide application records for the seedlings collected as well as pesticides known to be in common use in British Columbia. All seedlings (stems and foliage) and skin swabs collected in May to June 2006 were analysed for chlorothalonil, iprodione, malathion, permethrin, cypermethrin, and captan. Samples collected in April 2007 were also analyzed for benzimidazole and diazinon. Nursery application records were used to guide selection of pesticides for analysis. Analyses were based on US EPA methods 507, 525, 608 and 8270. [15-18] Samples were solvent extracted and quantified using GC/MS. Due to the nature of tree planting work most personal air and skin samples contained soil – soil is not known to interfere with the analytical methods used. [15-18] Dermal pesticide levels were standardized by dividing mass on skin by surface area wiped (the sum of the two template areas and the hand perimeter surface area).

Statistical Analysis

Descriptive statistics and histograms were obtained for continuous demographic variables such as age, duration of employment and number of trees planted for the 54 subjects who provided skin wipes. To investigate factors that might influence pesticide residue levels on seedlings linear regression analysis was performed with seedling pesticide residue concentration as the outcome variable and number of days between application and lifting, number of days between lifting and planting, and concentration of pesticide applied per unit area of nursery as determinants of exposure. Pesticides are typically applied by spraying so pesticide application is recorded by nurseries per unit area (e.g. active pesticide ingredient per hectare). The data distribution was highly skewed (geometric standard deviation = 17.4) and following the recommendations of

Hornung and Reed concentrations that were below the limit of chemical detection were recoded as 1/2 the detection limit. [19] Statistical analysis was completed in Intercooled Stata Version 9.2 for Windows © (Stata Corp LP, Texas).

Ethical Approval

This study was approved by the University of British Columbia Clinical Research Ethical Review Board (Certificate number H06-70039).

Results

Subject demographics and study site characteristics

54 subjects participated in the study of chemical exposures among tree planters. (See Chapter 2) Forty-seven of those subjects provided skin wipes that were tested for pesticides. Of the 54 subjects who participated in exposure monitoring, 31% were female. The mean age was 28.4 years (range: 20 – 58; standard deviation: 0.9) and the mean number of years of experience was 7.4 (range: 1 – 29; standard deviation: 5.6).

Table 3.2: Site Characteristics for the five tree planting work sites participating in a study of pesticide residue exposure, 2006-07.

Location	Interior or coastal region	Mean temperature over two sampling days (˚C)	Rainfall	Mean # seedlings planted per employee per day (SD)	Month, year of sampling	Seedling species planted
B	Interior	15.1	Both days	1000 (167)	05/2006	Cedar, Spruce
G	Interior	17.9	One day	934 (137)	06/2006	Cedar, Spruce, Pine, Douglas Fir, Hemlock
N	Coastal	6.9	One day	708 (312)	04/2007	Pine, Fir
R	Coastal	8.2	One day	790 (218)	04/2007	Cedar, Spruce, Fir, Hemlock
M (control)	Interior	12.8	Both days	1214 (669)	06/2006	Spruce, Pine

*SD: Standard Deviation

Pesticides on seedling samples

Pesticide-treated seedlings were planted at all five sites, but at interior sites, not all species had been treated. Pesticide residues were found on eight of the nineteen seedlings that were tested (Table 3.2). Fungicides detected were captan, chlorothalonil and iprodione. Insecticides detected were permethrin and diazinon. The concentrations of pesticide residues detected ranged from 0.06 – 1090 µg/g (µg of pesticide per gram seedling mass). The highest concentration (1090 µg/g) was chlorothalonil on a Douglas Fir seedling taken from site N. Pesticides were detected on all of the seedlings taken from coastal sites in April 2007 (sites N and R), while no pesticides were detected on seedlings taken from interior sites in May and June of 2006 (Sites B, G and M).

Among the seedlings that were pesticide treated, the amounts applied were generally equivalent, however permethrin on 2006 seedlings was applied at less than half the active ingredient per hectare compared to 2007 seedlings.

Two inconsistencies between nursery records and chemical analyses were found. Captan was detected on a Sitka Spruce seedling taken from site R although captan application was not recorded in the nursery records. Chlorothalonil and iprodione were detected on a Coastal Douglas Fir seedling taken from site N while records do not show pesticide application on this batch of seedlings.

Table 3.2: Summary of pesticide residue data for seedling samples from five tree planting worksites in British Columbia, 2006-07 (n = 19).

Site ID	Species	Pesticide	Days from application to planting	Days from application to lifting	Days from lifting to planting	Date Planted	Pesticide concentration (ug/g)[a]
B	Hybrid Spruce	Iprodione	224	35	189	23-May-06	<1
	Hybrid Spruce	Pesticide Free	-	-	216	24-May-06	All <LOD[b]
	Western Red Cedar	Iprodione Benzimidazole	220 220	61 61	159	23-May-06	<1 Not Tested
G	Western Red Cedar	Pesticide Free	-	-	199	5-Jun-06	All <LOD
	Interior Douglas Fir	Permethrin Cypermethrin Chlorothalonil Fenhexamid	318 262 215 226	114 58 11 22	204	6-Jun-06	<0.05 <0.1 <1 Not tested
	Douglas Fir	Pesticide Free	-	-	207	5-Jun-06	All <LOD
	Lodgepole Pine	Cypermethrin	233	31	202	5-Jun-06	<0.1
	Hybrid Spruce	Cypermethrin Permethrin	363 349	221 207	142	6-Jun-06	<1 <0.05
M	Lodgepole Pine	Pesticide Free			196	13-Jun-06	All <LOD
	Lodgepole Pine	Iprodione	285	77	208	14-Jun-06	<1
	Hybrid Spruce	Pesticide Free			200	13-Jun-06	<LOD
N	Douglas Fir	Chlorothalonil Iprodione	No record[c] No record	No record No record	101	2-Apr-07	604 0.39
	Douglas Fir	Chlorothalonil Iprodione	119 138	14 33	105	2-Apr-07	1090 83.3
	Western White Pine	Benzimidazole Diazinon Permethrin Captan	297 358 315 394	186 247 204 283	111	2-Apr-07	<0.1 1.59 0.11 <0.05
R	Western Red Cedar	Chlorothalonil Iprodione Permethrin	146 146 324	68 68 246	78	12-Apr-07	10.1 0.9 0.08
	Western Red Cedar	Chlorothalonil Iprodione Permethrin	146 146 324	80 80 258	66	12-Apr-07	29.6 3.14 <0.05
	Douglas Fir	Chlorothalonil Iprodione Permethrin	146 146 324	76 76 254	70	12-Apr-07	28.4 1.15 0.06
	Western Hemlock	Chlorothalonil Iprodione Permethrin	142 142 324	20 20 202	122	12-Apr-07	48.7 6.49 0.19
	Sitka Spruce	Chlorothalonil Iprodione Permethrin Captan	147 147 325 No record	34 34 212 No record	113	13-Apr-07	6.4 1.28 0.2 34.5

[a] ug/g = PPM or parts per million
[b] All < LOD = All pesticides tested below limit of detection
[c] No record means that application is not recorded in nursery application records.

Determinants of pesticide residue levels

The natural log of pesticide residue concentration was used in modelling because the underlying data distribution was log normal. It was assumed that the seedling that was labelled pesticide free yet carried chlorothalonil and iprodione residue had erroneous application records (records showed no pesticide application). For the sake of modelling it was assumed that this seedling received the application of chlorothalonil and iprodione typical of the nursery where it was grown. Captan was only detected on one seedling for which there was no record of any captan application so captan was excluded from modelling.

Results of the linear regression modelling (Table 3.3) demonstrate that pesticide residue increases with the amount of active ingredient applied per hectare. Pesticide residue decreased with the increasing days between application and lifting (time between application and placement in cold storage) and increasing days between lifting and planting (time between removal from cold storage and planting).

Table 3.3. Linear regression analysis of log transformed pesticide residue (ln µg/g) on seedlings collected from five tree planting worksites in British Columbia, 2006-07.

Variable	Coefficient	95 % Confidence Interval	P-value
Intercept	3.97	1.78 , 6.16	0.001
Active Ingredient per Hectare (g)	0.00049	0.00023 , 0.00075	0.001
Number of Days Between Application and Lifting	-0.019	-0.027 , -0.012	<0.0001
Number of Days Between Lifting and Planting	-0.027	-0.038 , -0.016	<0.0001

Degrees of Freedom = 31
Adjusted R^2 = 0.7693

Pesticides on the skin

Pesticide residues were detectable on the skin of tree planters at sites N and R. At site R, chlorothalonil and iprodione were both found on the majority of skin samples, while at site N chlorothalonil was found on 9 out 10 samples and iprodione on a single sample. Where detected, chlorothalonil levels ranged from 0.37 to 106.3 ng/cm^2 of skin and iprodione levels ranged from 0.7 to 15.9 ng/cm^2 (Table 3.4).

Table 3.4: Dermal pesticide residue exposures. Skin wipe samples from hand and forearm of a sample of British Columbia treeplanters, 2006-7 (n = 47)

Site	N	Pesticide	Chlorothalonil (ng/cm^2)[a]	Iprodione (ng/cm^2)	Captan (ng/cm^2)	Malathion (ng/cm^2)	Permethrin (ng/cm^2)	Cypermethrin (ng/cm^2)	Diazinon (ng/cm^2)	Benzimidazole (ng/cm^2)
B	7	% Detectable	0	0	0	0	0	0	Not Tested	Not Tested
		Range of LOD[b]	4.9 - 6.3	4.9 - 6.3	4.9 - 6.3	0.49 - 0.63	0.25 - 0.31	0.49 - 0.62	Not Tested	Not Tested
		Range of Detectables	N/A	N/A	N/A	N/A	N/A	N/A	Not Tested	Not Tested
G	10	% Detectable	0	0	0	0	0	0	Not Tested	Not Tested
		Range of LOD	4.7 - 6.7	4.7 - 6.7	4.7 - 6.7	0.47 - 0.67	0.23 - 0.34	0.47 - 0.67	Not Tested	Not Tested
		Range of Detectables	N/A	N/A	N/A	N/A	N/A	N/A	Not Tested	Not Tested
M	10	% Detectable	0	0	0	0	0	0	Not Tested	Not Tested
		Range of LOD	4.7 - 6.6	4.7 - 6.6	4.7 - 6.6	0.47 - 0.66	0.24 - 0.33	0.47 - 0.66	Not Tested	Not Tested
		Range of Detectables	N/A	N/A	N/A	N/A	N/A	N/A	Not Tested	Not Tested
N	10	% Detectable	90	10	0	0	0	0	0	0
		Range of LOD	4.8 - 6.3	0.48 - 0.63	4.8 - 6.3	0.48 - 0.63	0.24 - 0.32	0.24 - 0.32	0.14 - 0.19	4.8 - 6.3
		Range of Detectables	9.5 -106.3	3.97	N/A	N/A	N/A	N/A	N/A	N/A
R	10	% Detectable	60	70	0	0	0	0	0	0
		Range of LOD	5.0 - 6.6	0.50 - 0.66	0.25 - 0.33	0.50 - 0.66	0.25 - 0.33	0.25 - 0.33	0.15 - 0.20	0.50 - 0.66
		Range of Detectables	0.37 - 7.8	0.70 - 15.9	N/A	N/A	N/A	N/A	N/A	N/A

[a] ng/cm^2 = nanograms of pesticide per square centimeter of skin wiped
[b] LOD = limit of detection. Ranges are presented because the limit of detection varied with surface area wiped.

Personal Protective Equipment Use and Hand Washing

Among subjects tested for pesticides, all subjects wore gloves. Some wore two gloves in combination. Sixteen of the 54 subjects wore nitrile, neoprene, rubber or latex gloves. Three subjects wore dishwashing gloves. The remaining 37 subjects wore either a cotton glove or a gardening style glove (rubberized palm of hand, cotton back of hand). See Table 3.5.

Table 3.5. Self reported glove use on wiped hand ("seedling hand") on sampling day from a sample of British Columbia tree planters who participated in a study of pesticide residue exposure 2006-07.

Glove type	Material	Frequency of Use
Garden Style Glove [a]	Garden glove only	27
	Garden glove over cotton glove	2
	Two garden gloves	1
	Garden glove over duct tape	1
	Total	**31 of 54 subjects (57.4%)**
Thick [b] solvent glove (Nitrile, Neoprene or Rubber)	Thick solvent glove only	3
	Thick solvent glove over cotton glove	7
	Total	**10 of 54 subjects (18.5%)**
Thin[b] nitrile or latex glove	Thin nitrile or latex glove under cotton glove	1
	Thin nitrile or latex glove under garden glove	5
	Total	**6 of 54 subjects (11.1%)**
Cotton glove	Cotton glove only	1
	Total	**1 of 54 subjects (1.9%)**
Dishwashing glove	Dishwashing glove only	3
	Total	**3 of 54 subjects (5.6%)**

[a] Garden glove has a rubberized front of hand and cotton back of hand
[b] For this investigation thick gloves are defined as ≥0.3mm. Thin gloves are <0.3mm.

Among the full sample of tree planters across the thirteen worksites in B.C. and Alberta, 144 (64.6%) reported always wearing gardening style gloves on their seedling hand and 23 subjects (10%) wore them sometimes. Ten subjects (4.5%) reported always wearing "thin" latex or nitrile gloves (18 or 8.1%, sometimes), and 13 subjects (5.8%) always wore dishwashing gloves (18 or 8.1%, sometimes). Dishwashing gloves may include solvent gloves that resemble dishwashing gloves and are made of such materials as nitrile, neoprene and rubber.

Among the pesticide residue exposure sample, only three of the 51 subjects (5.6%) reported hand washing during the workday. Of the 223 subjects interviewed 214 (96%) reported rarely or never washing their hands before eating, and 99% of smokers rarely or never washed their hands before smoking. A total of 141 of the 214 (65.8%) subjects who rarely or never wash their hands before eating report taking other precautions such as avoiding touching food (eg. holding food by wrapper or napkin), eating with the non "seedling hand", and/or removing gloves before eating.

On average the 223 subjects washed their clothes every 5 days (standard deviation = 2.35). Fifty-seven percent of interviewed subjects mixed their tree planting clothes with non tree planting clothes when doing laundry. They washed or changed their gloves on average every 6 days (standard deviation = 2.35).

Discussion

Despite application four to 12 months prior to collection for this study, pesticide residues were found on 8 of the 19 seedlings collected. These contaminated seedlings were all collected from the two coastal sites sampled in April 2007 (sites N and R). Pesticides were not detected on seedlings at the sites visited in the interior of B.C. in May and June of 2006. It may be that the greater length of time between application and seedling collection allowed more decay of pesticide residues. This hypothesis is supported by the linear regression analysis (Table 3.3) which showed that both the length of time between pesticide application and seedling lifting and the length of time between lifting and planting were significantly associated with a decrease in the amount of pesticide detected on seedlings.

Of the pesticides detected on seedlings, the fungicides chlorothalonil and iprodione were found on the most seedlings and at the highest concentrations. Fungicides were applied later than insecticides, prior to lifting and cold storage. This later application time is the likely reason for the high concentrations of fungicides relative to insecticides.

It is tempting to conclude from this work that pesticide residues are only present early in the tree planting season in the coastal region of B.C. However, this work only represents ten of the forty nurseries in British Columbia and a relatively small time window. Further work is necessary to fully understand the factors that contribute to the persistence of pesticide residue on seedlings at the time of planting. For this study the investigators were unable to obtain information on the number of pesticide applications as many nurseries only record the date of last application. Nurseries are located throughout British Columbia; the varying geographical and climactic conditions mean that threats from pests and need for pesticide use can differ between nurseries. Additionally, different nurseries may employ different pest management strategies. Future work on seedling pesticide residues should collect greater numbers of seedlings from the different geographical regions including multiple seedlings from each nursery. Greater sample size would allow examination of variables that were unable to be explored in the present study, such as tree species, nursery and pesticide type. Future work could determine the conditions that are necessary to ensure that pesticides on seedlings have completely decayed by the time that tree planters plant the seedlings and eliminate exposure to pesticides among tree planters.

Pesticide Residues on Skin

The fungicides chlorothalonil and iprodione were the only pesticides detected on skin, and only at the sites where pesticides were also found on seedlings. On seedlings, these two fungicides were detected the most frequently and generally in the highest concentrations of all pesticides examined which is likely the reason they were the only pesticides observed to transfer to skin. Correlations between seedling and skin levels were otherwise inconsistent. This may be because pesticide residues levels vary between individual seedlings within the same batch, and in most cases for the present study only a single seedling was sampled per species per site.

Health Risk Assessment

The concentrations of chlorothalonil and iprodione detected on skin that are presented in Table 3.4 are corrected for surface area wiped. The uncorrected range of chlorothalonil detected on seedling hands was 0.06 – 22 μg. The uncorrected range of iprodione detected was 0.14 – 2.5 μg.

In 1988 Alleyne et al. measured chlorothalonil on the "seedling" hands of tree planters at the end of a shift and found less than 0.6 μg on most tree planters, the highest level they found was 12.5μg. [1] Although Alleyne et al. did not correct their measurements for surface area wiped, they report that they wiped the entire hand. During the current study only a portion of the hand was wiped. The fact that the masses detected by Alleyne et al. are similar to those seen in the current study despite the larger surface area wiped by Alleyne et al. suggests that dermal exposure to chlorothalonil has not decreased since 1988.

To assess health risks from these exposures, detected levels were compared to toxicological endpoints used by the United States Environmental Protection Agency for human health risk assessment (Table 3.6).[20-22] The dermal endpoint for chlorothalonil was the no observable adverse effect level (NOAEL) taken from a dermal toxicity study of rats with no uncertainty factor applied. For this study an uncertainty factor of 100 was applied to the dermal endpoint.[17]

Table 3.6. Toxicological Endpoints for Chlothalonil and Iprodione used by the United States Environmental Protection Agency.

	Chlorothalonil (mg/kg/day)	Iprodione (mg/kg/day)
Dermal Exposure	6*	Not known
Oral Exposure	0.003	0.06
Cancer	7.33×10^{-3}	0.043

* An uncertainty factor of 100 was applied to this endpoint

Our highest measured concentration of chlorothalonil on skin was 106.3 ng/cm^2. A typical surface area for a hand is 520 cm^2 for males.[23] Assuming a constant distribution of chlorothalonil on the hand this would correspond to a total mass of about 55 micrograms. For a 70 kg person this would be a dermal exposure of 7.9×10^{-4} mg/kg/day from the seedling hand. Although this estimate makes a number of assumptions and does not include possible exposure on other areas of the body, it is lower than the toxicological endpoint (6 mg/kg/day) by several orders of magnitude.

Most tree planters do not wash their hands during the workday and as a result it is likely that chlorothalonil and iprodione on the skin are transferred to food, drinks or cigarettes and ingested. It is unknown how much chlorothalonil or iprodione is being ingested however. For chlorothalonil, assuming that the amount ingested is equivalent to the amount on the seedling hand this dose would again be about 7.9×10^{-4} mg/kg/day. This is lower than both the oral reference dose and the dose used for carcinogenic effects. Because there is uncertainty about the actual amount ingested caution should be exercised around this estimate, the true dose may be higher than the amount estimated above.

No information on dermal exposure to iprodione exists making it difficult to evaluate the health risk associated with the exposures found in the present study. The highest concentration detected on the hand of a tree planter was 15.9 ng/cm^2. Assuming a hand surface area of 520 cm^2, a 70 kg person and 100% absorption this corresponds to a dose of 1.2×10^{-4} mg/kg/day, much lower than the endpoints used for both the oral reference dose and for carcinogenic effects. Even if the true absorption is one hundred times the estimated amount on the hand (827 µg) and a further 827 µg is ingested this only gives a total dose of 0.024 mg/kg/day for a 70 kg person, still lower than the EPA endpoints.

In this study only a portion of one hand was wiped so the full amount of pesticide present on the skin may not have been captured. Also, hands were wiped at the end of the day so the amount that was absorbed over the course of the day is unknown, as is the amount that was previously on skin but has rubbed or evaporated off or has been ingested. However, for both chlorothalonil and iprodione the amount detected was lower than the toxicological endpoint and it is likely that the true exposure levels are also below these endpoints.

The health effects of chlorothalonil include contact dermatitis, kidney damage, and potentially cancer of the kidneys.[4, 5, 7, 20] No studies on the effects of iprodione on humans have been performed. A study of dogs that were fed iprodione for a year showed decreased prostate and uterus weights, hemoglobin damage, and liver and kidney increases. Another study of mice fed iprodione eighteen months suggested that iprodione is carcinogenic in mice.[24] No information is available on the effect of dermal exposure to iprodione or the dermal absorption rate for iprodione.

Based on these dose estimates the risk of health effects from chlorothalonil exposure appear to be low. However, because of the nature of tree planting work exposures may be exacerbated, for example by the high work rates and prevalence of dermal cuts and abrasions. There is continued uncertainty about the average dose because the present study sampled only a small section of the body. However the study has shown that tree planters do experience dermal exposure to pesticides and that efforts should be made to reduce or eliminate exposure to chlorothalonil. The level of exposure to iprodione is very low and is not likely to be of concern as a health risk to tree planters. However, due to the limited information about the health effects and dermal absorption rate of iprodione, exposure to even these low levels of iprodione should be avoided.

This study improved on previous assessments of pesticide residue exposure among British Columbia tree planters by targeting analysis to pesticides, however, inconsistencies were found between nursery application records and pesticides detected on seedlings. This study dealt with potential record inaccuracies by analyzing all samples for pesticides known to be in common use at British Columbia nurseries, it is possible that some pesticides that were applied were not captured. Due to these nursery record inconsistencies, tree planters should exercise caution even when working with seedlings labeled pesticide free.

Hygiene and Personal Protective Equipment Use

Personal hygiene practices among this group of workers is very poor. Pesticides were likely being transferred to food, drink containers and cigarettes and then ingested. Workers did report taking precautions such as avoiding touching food by holding it by a wrapper, or eating with the other hand however these practices may be insufficient to eliminate the risk of ingesting pesticides from accidental contamination. Soap and water has been shown to remove 50% of chlorothalonil on skin. Hand washing would be a simple and effective way of reducing the risk of dermal and oral exposures [25] but washing facilities were not reported at any of the sites visited.

Tree planters wash their clothes only on days off. Fifty-seven percent reported mixing tree planting clothes with non-tree planting clothes increasing the risk of contamination of non-tree planting clothes with pesticides. [26] Tree planters should be educated on the possibly of exposure to pesticide residues and on simple practices such as separating work and non-work clothes, washing clothes in hot water, changing clothes immediately upon return home, and wearing clean clothes each day. [26]

Personal protective equipment usage in this group of workers appeared to be aimed more toward protection from abrasion than to protection from chemical exposures. No personal protective equipment programs existed at the sites visited to assist tree planters in choosing appropriate glove materials. If an inappropriate glove material is used exposures may accumulate or spread throughout the glove material and be held against the skin, [27] potentially increasing exposures above the levels that would be seen if no glove was used.

Dermal exposure to pesticides appeared to be low. If hand washing stations are implemented at tree planting work sites, and personal hygiene practices improved then implementation of a full personal protective equipment program may not be necessary.

Conclusions

Pesticide residues were found on seedlings taken from coastal work sites in April 2007 but not at interior worksites in May and June of 2006. At the coastal worksites the fungicides chlorothalonil and iprodione were found on the skin of workers. Levels detected on skin were low, but due to uncertainty about the total ingested and absorbed dose and the harsh work environment caution should be taken when working with pesticide treated seedlings. Currently hygiene conditions at tree planting work sites are very poor. If these conditions improve and tree planters have access to hand washing stations dermal and oral exposures to pesticides could be reduced. Further work should be done to determine the conditions necessary to ensure that pesticide residues on seedlings are completely decayed when tree planters plant the seedlings.

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Chapter 4. Fertilizer use and self reported health among tree planters in British Columbia and Alberta[c]

Introduction

Tree planters in British Columbia are frequently required to bury fertilizers alongside the seedlings they plant to promote survival of the seedlings during the first several months of growth. These fertilizers are packaged in perforated paper sachets known as "tea bags". The fertilizer is partially polymer coated to ensure slow release over the course of several months. Fertilizer "tea bags" are carried by tree planters in hip bags. One fertilizer sachet is inserted by hand in the soil beside each seedling that requires fertilization.

The seedling fertilizers used in B.C. contain nitrogen, phosphorus and potassium (NPK). These elements are commonly present as combinations of phosphoric acid, potassium oxide (potash), urea, ammonium phosphate, ammonium nitrate, potassium chloride and/or potassium sulfate. Some fertilizers also contain "micronutrients" such as iron, boron, copper, manganese and zinc. The specific blend of fertilizer constituents is selected for each planting operation to match the needs of the crop and the conditions. Fertilizers can also contain non-essential metals such as arsenic, cadmium and chromium as contaminants. Preliminary work suggests that personal exposure to these metals is present but at low levels (See Chapter 2). The heavy physiological demands of tree planting work and the poor hygiene conditions at both worksites and living quarters may exacerbate the health effects of low exposures. (See Chapter 2) Other exposures that tree planters may be subject to include rock dust from logging roads, and pesticide residues on seedlings (See Chapters 2 and 3).

Health concerns

Concerns regarding the health effects of occupational exposure to fertilizers have been raised by both tree planters and their employers. Anecdotal reports exist of symptoms including skin

[c] A version of this chapter will be submitted for publication. Gorman, M.; Winters, M.; Stjernberg, E.; Demers, P.; Koehoorn, M.; Davies, H. Fertilizer use and self reported health among tree planters in British Columbia.

rashes, respiratory irritation, headaches, dizziness, nosebleeds, eye irritation and congestion. [1-3] At least one tree planter in British Columbia has had a workers' compensation claim approved for sinusitis that was attributed to his work as a tree planter. [3]

Occupational contact dermatitis associated with fertilizer exposure has been observed in fertilizer manufacturing factories and in agricultural settings. [4-6] Fertilizer exposure has also been associated with respiratory health effects. Decreased lung function has been seen among fertilizer factory workers, an effect attributed to exposure to nitrogenous components of fertilizer (ammonia, urea and diammonium phosphate).[7, 8] A study of risk factors for respiratory symptoms in rural China found that work with fertilizer was a risk factor for chronic phlegm, nocturnal cough, asthma attack, wheeze and chest tightness.[9]

A 1998 Bulgarian study of a nitrogen fertilizer plant showed that workers were exposed at or above the TLV for ammonia and NO_2. These workers were shown to have disturbed liver function and a tendency towards diseases of the respiratory, gastrointestinal and cardiovascular system. [10]

The "tea bag" fertilizers are polymer coated and are thought to pose a smaller health risk than powdered fertilizer as the fertilizer is less available for dermal contact and is less likely to enter the air as dust. However, in rainy conditions the "tea bag" may become wet causing the coating to degrade. Ammonia has been detected in water that has been in contact with a "tea bag" fertilizer for eight hours. (See Chapter 2) Tree planters are often in dermal contact with wet tea bags on both the hands and the hips, particularly given the wet climate of coastal British Columbia. Tree planters are therefore potentially dermally exposed to ammonia and phosphoric acid. Inhalation exposure could also occur as gas is released from the wet fertilizer granules.

No previous work has studied the health effects associated with fertilizer exposure among tree planters. The aim of this study was to investigate the relationship between work with fertilizer and dermal and respiratory health symptoms among tree planters.

Methods

Subject Recruitment

Following informal advertising to tree planting operations, eleven work crews in B.C. and two in Alberta volunteered to participate in the study. The research team visited these crews between May and August of 2006 and in April 2007.

Crews consisted of between 9 to 51 tree planters plus 1 to 5 supervisors. Supervisors all had experience working as tree planters therefore both supervisors and tree planters were eligible to participate in the study. Efforts were made to recruit every worker within a crew. Two hundred and twenty-three subjects were recruited. Sixty-nine of the subjects had not worked with fertilizer in the previous two years; these subjects were used as a comparison group. Fifty-six of the subjects also participated in an exposure monitoring study that measured their exposure to dust, metals and pesticides. This part of the study is described in Chapters 2 and 3.

An advertisement describing the study and requesting volunteers was sent to each crew at least forty-eight hours before the arrival of the research team. Upon arrival, the research team held a meeting with the crew to describe the study. Tree planting work is piece rate and subjects who agreed to participate in the survey were compensated for foregone production. Volunteers all provided written informed consent. The study was approved by the University of British Columbia Clinical Research Ethical Review Board (Certificate number H06-70039).

Interview

A health and exposure history interview was administered to participants. The interview is available in Appendix A. Participants were interviewed by the research team either at the work site during work hours, or at their accommodations in the evening. All interviewers were trained in administration of this questionnaire to reduce interviewer bias.

The interview contained respiratory health symptom questions taken from the American Thoracic Society (ATS) standardized questionnaire with additional questions on duration of symptoms and situations that exacerbate symptoms. [11, 12] Dermal health questions were adapted from methods developed by Verughese et al., and tree planting work history questions were developed for this study.[12] The work history questions addressed hygiene practices and personal protective equipment use (results described in Chapter 3), fertilizer and pesticide exposures on the current work contract, non – tree planting work experience, duration of tree planting employment, and details on fertilizer use, tree species planted, and location of all tree planting work contracts undertaken in the previous two years. Marijuana smoking was known to be prevalent among tree planters and questions about marijuana smoking were also included. [13] Subjects were asked about age, sex, level of educational achievement and province of residence. The interview was pilot-tested on tree planters not located at the 13 sites before use in the field.

Analysis

All interview responses were coded and double entered to statistical software. Analysis was completed in Intercooled Stata Version 9.2 for Windows © (Stata Corp LP, Texas)

The questions in the interview were designed to provide a measure of current symptoms. There were also questions designed to determine how long the symptoms have been present. Symptoms were defined as "work – related" if the subject reported that i) the symptom was usually present, ii) the symptom improved on days off or during the non-planting season, iii) the symptom was aggravated by work related activities (i.e. general work environment, work with fertilizers, work with pesticides, dust) and iv) the symptom was absent prior to the commencement of work as a tree planter. [12] Cumulative exposure to fertilizer over the previous two years was estimated by summing the total number of days worked on contracts where fertilizer was used.

Work-related symptoms with prevalence >10% and symptoms of *a-priori* interest were investigated with multivariate logistic regression analysis to determine the effect of cumulative fertilizer exposure over the previous two years (odds ratios and 95% confidence intervals were determined for each symptom examined). All analyses were adjusted for age and sex. Nose bleed and respiratory symptoms were adjusted for cigarette smoking status and cumulative amount smoked. Non-smokers were subjects who had never smoked cigarettes regularly, ex-smokers who had previously smoked regularly but had quit at least one month prior to completion of the interview. Respiratory symptoms (but not nose-bleed) were adjusted for history of childhood asthma (defined as asthma onset before age 16). Dermal symptoms were adjusted for work with spruce over the previous two years due to the abrasive properties of spruce needles which causes "spruce rash", a common complaint among tree planters. Spruce exposure was estimated by summing the total number of days worked on contracts where spruce was planted. The reference group for the exposure variable (estimated number of days of fertilizer use in the previous two years) was no days of fertilizer use in the previous two years. The remaining exposed workers were divided into quartiles and the variable was treated as categorical.

Correlations among variables were examined. Years of tree planting experience and age were highly correlated so only age was included in the analysis. Of the two variables age was selected for inclusion in the models because it represents the effects of aging on health, while the inclusion of years of tree planting experience would represent the effects of cumulative exposure, a variable which is partially described by self reported fertilizer exposure. Bivariate analyses were then conducted examining the relationship between the fertilizer exposure variable and the covariates with each health symptom. Marijuana smoking was not included because it was not found to be a predictor of any of the symptoms of interest.

The cumulative exposure duration could not be estimated for two subjects who did not recall the duration of contracts on which they had worked with fertilizer and they were excluded from the analysis. Subjects for whom symptom data was missing were also excluded from analysis on a per symptom basis. Subjects were also excluded if information on other predictor variables was missing.

Results

In total 13 work crews were visited and 223 tree planters were interviewed. Sixty-nine interviewed workers (30.9%) had not worked with fertilizer in the previous two years. This group was considered currently unexposed and used as a control group. Fifty-four (78%) members of the unexposed group worked in crews in Alberta. These workers had worked exclusively in Ontario and Alberta where fertilizers were less likely to be used.

Interview response rate

Tree planting work is transient and crew sizes fluctuate daily, as such the study team was unable to determine the precise number of workers in each crew. Based on approximations of crew sizes it is estimated that between 85 and 90% of tree planters in the crews visited volunteered to participate and were interviewed. The major reason for omission was that the investigators were unable to locate the workers during the workday (tree planters work in remote locations and often workers in the same crew work several kilometers away from one another). Some tree planters were missed because they were unwilling to take time away from planting to participate in an interview. The research team visited tree planting camps and hotels in the evening to capture people who were missed during the workday. Six tree planters (2%) who were approached at their camp declined to participate as they did not want to be disturbed in their time off and three tree planters (1%) declined to participate at any time with no reason given.

Subject demographics

Demographic information on both the exposed and unexposed groups is presented in Table 4.1. The group was 67% male; the proportion of males to females was the same in both the exposed and unexposed groups. The unexposed group was younger than the exposed group with an average age of 23.2 in the unexposed group and 29.9 in the exposed. On average the unexposed group also had fewer years of tree planting experience. The majority of tree planters regardless of exposure status were either current or past marijuana smokers.

Table 4.1. Description of a sample of tree planters across 13 worksites in British Columbia and Alberta, 2006-07 who participated in a health symptom and fertilizer exposure interview

	Fertilizer Exposed in the previous two years	Fertilizer Unexposed in the previous two years	Total
n	154	69	223
Age in years [mean (sd), range]	29 (7.7), 18 - 58	23.2 (3.1), 18 - 41	26.4 (7.0), 18 - 58
Female, n (%)	51 (33%)	23 (33%)	74 (33%)
History of childhood asthma, n (%) [a]	16 (11%)	11 (16%)	27 (12%)
Years of experience [mean (sd), range]	6.6 (6.2), 1 - 35	3.3 (2.0), 1 - 12	5.6 (5.4), 1 - 35
Cigarette smoking status[b]			
Non-smokers, n (%)	64 (42%)	36 (52%)	100 (45%)
Current-smoker, n (%)	63 (41%)	23 (33%)	86 (39%)
Ex-smokers, n (%)	26 (17%)	10 (14%)	36 (16%)
Cigarette smoking amount (packs/day x yrs smoked)			
Current smokers [mean (sd), range]	5.8 (6.8), 0.1 – 26.3	2.5 (2.0), 0.1 – 7.0	4.9 (6.1), 0.1 – 26.3
Ex-smokers [mean (sd), range]	4.7 (5.3) 0.1 – 24.3	2.2 (2.0) 0.1 - 5	4.1 (4.7) 0.1 – 24.3
Marijuana smoking status[b]			
Non-smokers, n (%)	37 (24%)	23 (33%)	60 (27%)
Current-smoker, n (%)	72 (47%)	34 (49%)	106 (48%)
Ex-smokers, n (%)	44 (29%)	12 (17%)	56 (25%)
Marijuana smoking amount (joints/month)			
Current smokers [mean (sd), range]	36.7 (60.7), 1 - 450	26.2 (23.4), 1 - 100	33.3 (51.8), 1 - 450
Ex-smokers [mean (sd), range]	29.5 (36.1), 1 - 150	22.2 (18.1). 1 - 60	27.9 (33.0). 1 - 150

[a] Data not available for two subjects
[b] Data not available for one subject

Symptom Prevalence

Four work-related symptoms had prevalence greater than 10%. Nasal symptoms (including sneezing and stuffy nose) had a prevalence of 36%, and work-related phlegm, cough and skin symptoms had prevalence of 16%, 14% and 11% respectively. Work related cough, phlegm, wheeze, nosebleed, eye irritation and skin symptoms were more prevalent in the fertilizer exposed group than the unexposed group. (Table 4.2) Only work-related nasal symptoms were less prevalent in the exposed group.

For each health symptom, subjects for whom a response was missing for any variable included in the work-related symptom definition were excluded from the prevalence estimates. In many cases this occurred because subjects did not recall when they began to experience the symptom.

Table 4.2. Overall and work-related symptom prevalence's among a sample of tree planters in British Columbia and Alberta who participated in a health symptom and fertilizer exposure interview 2006-07 (n = 223)

Symptom	N[a] (Total)	All n (%)	Fertilizer Exposed (N = 154) n (%)	Fertilizer Unexposed (N = 69) n (%)
Overall				
Any Cough	223	79 (35%)	61 (40%)	18 (26%)
Any Phlegm	223	88 (39%)	58 (38%)	30 (43%)
Occasional Wheeze	221	68 (31%)	46 (30%)	22 (32%)
Any Chest Tightness	222	27 (12%)	15 (10%)	12 (18%)
Any Nasal Symptoms	223	154 (69%)	114 (74%)	42 (61%)
Any Nose-bleed	223	60 (27%)	45 (29%)	15 (22%)
Any Eye Irritation	223	27 (12%)	19 (12%)	8 (12%)
Any Skin Symptoms	222	43 (19%)	36 (24%)	7 (10%)
Work-related				
Work-related Cough	216	31 (14%)	23 (16%)	8 (12%)
Work-related Phlegm	215	34 (16%)	25 (17%)	9 (14%)
Work-related Wheeze	216	19 (9%)	15 (10%)	4 (6%)
Work-related Chest Tightness	220	3 (1%)	2 (1%)	1 (1%)
Work-related Nasal Symptoms	216	78 (36%)	56 (30%)	22 (32%)
Work-related Nose-bleed	223	21 (9%)	17 (11%)	4 (6%)
Work-related Eye Irritation	222	14 (6%)	11 (7%)	3 (4%)
Work-related Skin Symptoms	220	25 (11%)	21 (14%)	4 (6%)

[a] Sample sizes less than 223 are reported for some symptoms because of missing information.

Exposure Response Analysis

Work-related cough, phlegm, nasal symptoms, and skin irritation were selected for logistic regression analysis because of overall prevalence greater than 10%. Nosebleed was modeled because of interest due to anecdotal reports from tree planters although prevalence was lower than 10%.

The results of the exposure response analysis are presented in Table 4.3. In the highest exposure category (82 days or more of fertilizer use in the past 2 years) an increased odds ratio was seen for all symptoms. The odds ratio was only significant for work-related phlegm (4.33 [95% confidence interval, 1.16, 16.21]). Trends of increasing odds ratios with increasing exposure were seen for work-related cough and phlegm. Dips in odds ratios were seen for work-related nose bleed and skin irritation in the third and fourth exposure quartiles respectively. Trend analysis showed an overall trend of slightly increasing risk with each increasing day of exposure for work-related nose bleed (OR = 1.004 [95% confidence interval, 0.991 – 1.017]) and work-related skin irritation (OR = 1.004 [95% CI = 0.991 – 1.016]).

Increasing levels of pack years for current smokers was associated with increasing odds ratios for all respiratory symptoms (cough, phlegm, and nasal symptoms) and females were at greater risk for all symptoms. Age and "work with spruce" appeared to be unrelated to symptoms.

Table 4.3. Adjusted odds ratios [95% confidence intervals] for symptoms by days of fertilizer use in the previous two years among a group of tree planters in British Columbia and Alberta who participated in a health symptom and fertilizer exposure interview 2006-07 (n = 221)

Fertilizer Use (Days)[a]	Work Related Cough[b]	Work Related Phlegm[b]	Work Related Nasal Symptoms[b]	Work Related Nose Bleed[c]	Work Related Skin Irritation[d]
0 (n = 69)	1	1	1	1	1
1 – 20 (n = 41)	0.71 [0.19, 2.59]	0.52 [0.13,2.11]	0.98 [0.39, 2.43]	1.84 [0.42, 7.95]	2.00 [0.45, 8.96]
21 – 37 (n = 36)	0.87 [0.23, 3.29]	0.94 [0.27, 3.26]	1.58 [0.63, 3.95]	2.60 [0.63, 10.68]	2.94 [0.65, 13.36]
38 – 81 (n = 39)	1.45 [0.41, 5.20]	2.15 [0.60. 7.66]	0.99 [0.36, 2.69]	0.91 [0.14, 5.97]	4.64 [1.08, 19.90]
82+ (n = 36)	1.34 [0.33, 5.42]	4.33 [1.16, 16.21]	2.10 [0.71, 6.21]	2.87 [0.56, 14.83]	1.87 [0.33, 10.50]

[a] Estimated days of fertilizer use in the previous two years.
[b] Logistic regression controlling for age, smoking status, sex and history of childhood asthma
[c] Logistic regression controlling for age, smoking status and sex
[d] Logistic regression controlling for age, sex and work with spruce (in previous 2 years)

Discussion

Tree planting is a very active occupation with a relatively young and physically fit workforce. [14] Prevalence of respiratory symptoms was higher than would be expected for such a young and fit group. The results of this study were compared to the results from two other groups of British

Columbia workers; entertainment industry workers who were exposed to theatrical smokes and fogs, and British Columbia Ferry Corporation workers who were concerned about past asbestos exposure. These two groups of workers were interviewed using the same respiratory health questions used in the present study. [12]

When compared to the group of ferry workers, tree planters have a higher overall prevalence of cough, phlegm and nasal symptoms (Table 4.4). Ferry workers with significant asbestos exposure were excluded from this comparison group. Tree planters also had higher prevalence of cough and phlegm than the entertainment industry workers. Both the ferry workers and the entertainment industry workers were exposed to respiratory irritants; theatrical smokes and fogs in the case of the entertainment industry workers and vehicle exhaust, kitchen smoke, and cleaning products for the ferry workers. The comparison groups were also both older than the tree planters [Entertainment workers mean age = 33.5 (standard deviation = 10.2), Ferry workers mean age = 39.8 (standard deviation = 8.7)]. There are similar proportions of females among all three groups. Although the proportion of current smokers was highest among tree planters, tree planters had the lowest proportion of former smokers and amount smoked (measured in pack years). [12] The fact that of these three groups of British Columbian workers with possible respiratory irritant exposures tree planters, the youngest group, has the highest prevalence of cough and phlegm is surprising and demonstrates that further investigation of chemical exposures among tree planters is warranted.

Table 4.4. Prevalence of respiratory symptoms among a group of tree planters in British Columbia and Alberta who participated in a health symptom and fertilizer exposure interview 2006-07, and two other British Columbian occupational groups

	Entertainment Industry Workers **n (%)**	**British Columbia Ferry Workers** **n (%)**	**All Tree Planters** **n (%)**	**Fertilizer Exposed Tree Planters** **n (%)**	**Fertilizer Unexposed Tree Planters** **n (%)**
n	101	70	223	154	69
Any Cough	19 (18.8%)	7 (10.0%)	79 (35%)	61 (40%)	18 (26%)
Any Phlegm	27 (26.7%)	14 (20.0%)	88 (39%)	58 (38%)	30 (43%)
Occasional wheeze	31 (30.7%)	17 (24.3%)	68 (31%)	46 (30%)	22 (32%)
Chest tightness	23 (22.8%)	12 (17.1%)	27 (12%)	15 (10%)	12 (18%)
Nasal symptoms	69 (68.3%)	33 (47.1%)	154 (69%)	114 (74%)	42 (61%)
Eye irritation	13 (12.9%)	12 (17.6%)	27 (12%)	19 (12%)	8 (12%)

The exposure response analyses shown in this study suggest that the high prevalence of respiratory symptoms is related to work with fertilizer. There are other exposures that tree planters may be subject to which could also contribute to respiratory symptoms. These include exposure to pesticide residues (See Chapter 3), and dust exposure (see Chapter 4).Tree planters are less likely to recall pesticide and dust exposure levels than fertilizer exposure so the current study was unable to obtain self-reported historic data on these exposures and they were not included in this analysis. Marijuana smoking was not studied in the entertainment worker and ferry worker groups but during the present study marijuana smoking was not seen to be related to an increased risk of the chronic respiratory symptoms studied so a difference in marijuana smoking habits between the three groups is unlikely to explain the high prevalence of chronic respiratory symptoms among tree planters.

The health effects that were seen to be related to fertilizer use may be caused by irritant constituents of fertilizer including phosphoric acid and the nitrogenous components of fertilizer which likely release ammonia.[7-10] These irritants were not measured in this study so it is difficult to describe the relationship between them and the health effects that were seen. Tree planter dust exposure has been investigated however the researchers were unable to estimate what fraction of the total dust exposure is fertilizer dust in order to relate fertilizer dust exposure to health symptoms (See Chapter 2).

Although individual estimates are not statistically significant, the results of the exposure response analysis suggest that work with fertilizer is associated with increased odds of chronic cough, phlegm, nose bleed and dermal irritation (Table 4.3). A dose response relationship is seen for work-related phlegm, and the highest exposure group (82 days or more of fertilizer use in the previous two years) had statistically significantly elevated odds of chronic work-related phlegm relative to the reference group.

The dose-response relationships for work-related cough, nosebleed and skin irritation are less clear however the trend in the results suggests a relationship between an increase in symptoms associated with an increase in exposure to fertilizer even if one of the categories of exposure within a symptom model did not adhere to a clear dose-response relationship. For work-related cough and skin irritation a pattern of increasing odds ratios with increasing levels of fertilizer use is seen until the highest exposure level where the odds ratios for both symptoms are seen to decrease. The decrease for work related cough is small (OR = 1.45 for 38-81 days of fertilizer use and OR = 1.34 for 82 days or more of fertilizer use) which suggests that the effect of exposure may plateau. The decrease in odds ratio is greater for work related skin irritation (OR = 4.67 for 38 – 81 days of fertilizer use and OR = 1.87 for 82 days or more). This decrease in odds ratio may be the result of a healthy worker survivor effect whereby exposed workers who experience symptoms leave the industry. The healthy worker survivor effect may also explain the plateau that is seen for work-related cough. Bias due to the healthy worker survivor effect is common among cross-sectional studies which describe only a snap shot in time.[15] It may also be that workers become acclimatized to fertilizer exposure and skin irritation diminishes with increasing duration of exposure.

The exposure response analysis suggests a relationship between work-related nose bleed and fertilizer exposure. Increasing odds of work-related nose bleed was seen in categories with higher number of days of fertilizer use with the exception of the third highest exposure level, 38 – 81 days of fertilizer use in the previous two years. This is an exception to the trend which otherwise suggests a trend in the exposure response relationship. Only 21 cases of work-related nosebleed were seen in this study, the lowest number of cases of any of the work-related symptoms examined using linear regression analysis. It is possible that with such a low number of cases that the estimates of odds ratios are unstable and the departure from the trend observed in one exposure level is a result of this instability. [16] It is also possible that the other exposures require continued exposure to elicit a response while nosebleeds may elicit a response on first exposure. If this is the case then the likelihood of getting a nose bleed may not increase with increasing duration of exposure. It could also be that the way this symptom was defined by the interview makes it less heavily influenced by increasing days of exposure than the other symptoms. For all other symptoms, subjects were asked if they often had the symptom. For nose bleed, subjects were asked if they ever have nose bleeds. Subjects who have worked with fertilizer on only a few days may not report that they often have a cough even if they coughed every day that they worked with fertilizer. By contrast, a subject who has worked with fertilizer on only one day and experienced a nose bleed that day is likely to have their symptom captured by this study.

A number of study limitations may contribute to the lack of statistical significance of the odds ratio estimates. For example, the exposure measure (days of fertilizer use) only included the previous two years. Study participants were only asked about their last two years of work to minimize the duration of time required to complete the interview and because of the difficulty of recalling specific details pertaining to contracts that were worked three or more years ago. Although no information about earlier exposures was collected, it is likely that at least some workers were exposed during this time and those exposures may contribute to their current symptoms, particularly if sensitization has occurred. There may be workers who were placed in a low exposure category during this investigation who have worked more extensively with fertilizer in the past. The average number of years of experience in the reference group is 3.3 years (standard deviation = 2.0) and many of the subjects in this group have done most or all of their tree planting work in Ontario where fertilizer is not used, so it is unlikely that there are many members of the reference group with extensive fertilizer exposure over two years prior to their participation in this study.

Another source of misclassification was the method of calculating the number of days of exposure. For each contract that subjects worked on they were asked how long the contract was (in days) and whether they used fertilizer on that contract. Then, the total number of days worked on contracts where fertilizer was used was summed for each subject to determine the number of days worked with fertilizer. However, fertilizer may not have been used on every day of these contracts so the number of days of exposure may be overestimated for some subjects.

The exposure was self reported which may have contributed to further exposure misclassification if subjects did not accurately recall their exposure. Self reported exposures can be influenced by a differential recall bias whereby subjects who experience symptoms are more likely to recall exposures than those without symptoms. [17] Tree planters work directly with fertilizer (it adds a step to their work process and affects their rate of pay) so they know when they are exposed to it and recall bias is thought to be a minimal for the two year recall period. It is likely however that some error and misclassification was introduced when subjects were asked about the number of days worked on each contract.

Usually non-differential misclassification biases results toward the null. [17] Exposure misclassification may have contributed to the non-significance of the results and the wide confidence intervals but despite this possible bias toward the null and despite sources of potential differential misclassification which could lower odds ratio estimates, a trend for increases in odds ratios were seen with increasing exposure.

The majority of the reference population had only worked as tree planters outside of British Columbia (in Ontario and Alberta) where fertilizers were not used. Exposures associated with tree planting in these provinces differ from those in British Columbia tree planters. For example, pesticide residues which may have been present on seedlings may have had higher or lower concentrations. Also, rock dust created from rock blasting to create roads (see Chapter 2) in these regions may have harmful constituents that are not present in British Columbia (or vice versa). Chemical exposures associated with tree planting have not been studied in Ontario and Alberta and we are unable to predict the direction of the potential bias.

There may be intentional over-reporting of symptoms by workers who dislike work with fertilizer. It has been speculated that tree planters dislike work with fertilizer because their earnings may decrease. Tree planters are paid per tree planted and when fertilizer is planted beside a seedling a separate hole must be created for the fertilizer. Tree planters are paid for each "teabag" planted however the wage for planting a "teabag" is less than that for planting a seedling typically by nearly an order of magnitude. If intentional misreporting of symptoms is a source of bias then an increased odds of symptoms would be expected in all categories of fertilizer exposure would be seen. This effect may be present in the results for work-related nosebleed and skin symptoms where elevated odds of symptom is seen in even the lowest exposure group and the trend of increasing odds of symptom with increasing exposure may be due to heightened frustration with fertilizer work as the frequency of the work increases. However, this expected effect is not seen for all symptoms so although intentional misreporting of symptoms may contribute to the elevated odds ratio of symptoms seen with fertilizer work, it does not fully explain the increasing odds ratios with increasing exposures that were seen for the symptoms in this study.

Conclusion

This is the first study of health effects as they relate to chemical exposures among Canadian tree planters. Although findings were not statistically significant, the results suggest a relationship between chronic respiratory symptoms (cough, phlegm and nasal symptoms), nose bleed, and skin irritation and work with fertilizers among tree planters in British Columbia. The long term health effects of this exposure remain unknown. Exposure control measures should be implemented including improved personal hygiene and personal protective equipment programs. Exposure control measures should be guided by monitoring of exposures to fertilizer dust and ammonia.

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Chapter 5. Discussion

The overall objective of this thesis work was to assess fertilizer and pesticide exposures among British Columbia tree planters and to examine the health effects associated with these exposures. To assess exposure levels we measured personal exposure levels to dust, metal contaminants of fertilizer, and pesticide residues and tested bulk samples of fertilizer (for metals and ammonia) and seedlings (for pesticide residues) (Chapters 2 and 3). Measured exposure levels were compared to control groups, toxicological endpoints, and threshold limit values (set by the American Conference of Governmental Industrial Hygienists). Working conditions in the tree planting industry (such as poor hygiene conditions, unconventional shift structures, and high physical activity) may exacerbate exposures and even low levels of exposure may be harmful therefore comparison to exposure limit values may not be appropriate in determining risk of health symptoms in this group. To address this concern and to characterize respiratory and dermal health in this occupational group, tree planters were interviewed about their health symptoms and exposure history (Chapter 4). The specific objectives of this thesis work were to measure personal exposure levels of pesticide residues and metal contaminants of fertilizer (Chapters 3 and 2), to examine determinants of exposure to pesticide residues and metal contaminants of fertilizer (Chapters 2 and 3), to measure the prevalence of respiratory and dermal symptoms and disease among tree planters (Chapter 4) and to compare prevalence of symptoms and disease to non-exposed populations (Chapter 4). The methods and results of the studies designed to address these objectives were presented and discussed in chapters 2 – 4. This chapter will summarize the main messages from those chapters, discuss the strengths and limitations of the thesis work, present policy recommendations based on the findings of the work, and suggest future directions of study that are needed to address questions that remain unanswered.

Summary of Main Messages

Exposure to Metal Contaminants of Fertilizer

The metals arsenic, cadmium, chromium, nickel and lead were found as contaminants in fertilizers commonly used in silviculture. However, the evidence suggested that the presence of these metals was not creating an exposure hazard for B.C. tree planters. Airborne concentrations in personal exposure samples were all below WorkSafeBC exposure limits and blood levels of tree planters who have worked with fertilizer are within the range of an unexposed group of UBC students and their relatives. Chromium, nickel and lead were found in detectable quantities on the hands of tree planters however these metals were also found in soil and in seedling rootballs. Tree planters who worked with fertilizer did not have higher levels of dermal exposure to chromium, nickel and lead than tree planters who do not work with fertilizer.

Exposure to Dust

Tree planting work is dusty and the range of inhalable particulate exposure during a day of tree planting work ranged from a time weighted average of <0.39 to 5.3 mg/m^3 with an average exposure of 1.1 mg/m^3. Although all measurements are below the WorkSafeBC exposure limit for particulate not otherwise classified (10 mg/m^3) this many not be the appropriate comparison value for exposure to this particulate as the composition of the particulate is not fully understood.[1] The limit for particulate not otherwise classified is intended only for particles that are insoluble in water and have low toxicity. [2] We cannot be certain that either of these criteria are met by the particulate measured in the tree planters' personal samples.

Pesticide Residue Exposure

Pesticides are applied to seedlings at nurseries up to a year before tree planters handle the seedlings. Because of the length of time between application and planting it is often assumed in the industry that the concentration of pesticides on seedlings will have decayed completely by the time of planting. We found detectable levels of pesticides on 8 of the 19 seedlings collected from tree planting work sites. Fifty-four tree planters provided skin wipes which were analysed for pesticides. The fungicides chlorothalonil and iprodione were detected on the hands of 15 and 17 tree planters respectively. Although the exposure levels were low the results indicate potential for pesticide exposure. Given the uncertainty over potential for health effects due to the limitations of the current study and due to the extreme nature of tree planting work, this exposure warrants caution when working with seedlings.

Hygiene and Personal Protective Equipment Use

Personal hygiene practices among this group of workers were very poor. Tree planters rarely wash during the work day. Dermal exposures are therefore likely being transferred to food, drink containers and cigarettes and subsequently ingested. Tree planters wash their clothes only on days off and, in some cases, are only able to bathe or shower on days off. This means that dermal exposures (including pesticides and fertilizer constituents) may stay on their skin for three to ten days potentially increasing the absorption.

Most tree planters wore gloves and the most commonly used glove type was the cotton and rubber gardening style glove. These gloves offer little to no protection against chemical exposures and may increase the risk of dermal absorption if chemicals accumulate on the glove material. During this investigation no evidence was found of personal protective equipment programs in the tree planting industry that would help tree planters to match glove materials to the specific chemicals they may be exposed to.

Tree Planting Working Conditions

Tree planting work is physically demanding which can increase metabolic rates,[13,15,16] potentially increasing the uptake of chemical exposures including metals, fertilizer constituents and pesticides. Tree planters also work unusual shift structures ranging from three days of work followed by a day of rest to as many as ten days of work before a rest day and the work day can range from 8 to 12 hours (including travel time). Exposure limits assume a 40 hour work week of eight hour shifts as different shift structures will result in different capabilities for the body to metabolise and excrete toxic agents.[2] Tree planters also frequently experience dermal cuts and abrasions due to the nature of their work which can increase the dermal absorption rate for dermal exposures. Although exposures to both metals and pesticides were found to be low the impact of these exposures on the health of tree planters may be exacerbated by the tree planting working conditions.

Health Effects of Fertilizer Exposure

A questionnaire that collected information on self reported fertilizer use and health symptoms was administered to 223 tree planters in British Columbia and Alberta. The subjects were placed in exposure categories ranging from no fertilizer use in the past two years to over 82 days of fertilizer use in the past two years. The results of the study suggested a relationship between work with fertilizer and work related cough, phlegm, nose bleed and skin irritation. The dose-response relationship and strength of effect were particularly evident for work-related phlegm and skin irritation.

The health effects that were seen to be related to fertilizer use may be caused by irritant constituents of fertilizer including phosphoric acid and the nitrogenous components of fertilizer which likely release ammonia.[3-7] Fertilizer "teabags" were soaked in water for eight hours and the water was then tested for ammonia (see Chapter 2). Ammonia was detected in the water and the estimated concentration of ammonia gas above the water samples was over an order of magnitude higher than the exposure limit for ammonia. Ammonia in water and ammonia gas may be responsible for some of the symptoms seen however, personal ammonia samples were not taken so it is difficult to describe the relationship between ammonia exposure and health symptoms among tree planters. Personal inhalable dust was measured, however we were unable to estimate the portion that was fertilizer dust. Nickel and chromium, dermal irritants, were found to be present in bulk fertilizer samples. Although the measured exposures to these metals were low their combined effect and/or the effect of cumulative exposure may lead to skin irritation. It is also possible that due to tree planting working conditions which may exacerbate exposures (eg. Poor hygiene, dermal cuts and abrasions, increased respiratory rate) even low levels of exposure to metals can cause irritation in tree planters.

Strengths and Limitations

Limitations of study

There were a number of limitations associated with this study that contribute to uncertainty over the estimates made and the interpretation of the results.

This was a cross sectional sample selected by convenience. A cross sectional sample only provides information about a snapshot in time and a convenience sample is not randomised and therefore the results may be biased. For example, the tree planting companies that we were able to contact and who volunteered to participate in the study may be more health and safety conscious than other companies potentially leading to exposure levels and health symptom prevalence lower than what is typical of tree planting in B.C. Different hygiene and work practices at other tree planting companies may lead to higher exposure levels. Tree planting is seasonal transient work and it is very difficult to determine how many tree planters there are in British Columbia and where they are located. There are 250 to 300 contractors spread throughout the province. Many operate from remote locations and are difficult to get in contact with. Most crews don't know with any certainty exactly where and when they will be working with much advanced notice. These factors, combined with the large land mass of British Columbia (925,186 square kilometers) [9] made it logistically difficult to examine a randomized sample that is fully representative of the range of conditions experienced by tree planters in British Columbia. In particular, we did not visit any tree planter worksites in the north of British Columbia and none of our exposure monitoring took place during the late summer/early autumn part of the season. However, despite the logistical difficulties in obtaining complete representation of this difficult to reach occupational group we were able to collect information from over 200 workers from thirteen crews spread across different geographical regions. This is a large sample with a high response rate (85-90%) representing a variety of conditions and although the sample was cross sectional and selected by convenience the estimates of exposures and health symptom risk are likely to be representative of the conditions faced by tree planters in British Columbia.

Unlike seedlings grown for spring and early summer planting, seedlings grown for late summer/early autumn planting are not placed in cold storage over the winter and they are unlikely to be treated with fungicides. This may decrease the risk of exposure to pesticide residues, however because we did not sample any of these seedlings we cannot be sure. It could also be that the time between pesticide application and planting is shorter for these seedlings allowing less time for pesticide decay leading to a greater risk of exposure.

One of the original research objectives of this study was to examine determinants of exposure to pesticide residues and metal contaminants of fertilizer. Over 50% of our air and blood metals and dermal pesticide samples were below detection limits so we were unable to model determinants of exposure with this data. In addition to the large proportion of samples below detection limits, changes in analytical methods at the chemical analysis laboratory resulted in the detection limits for the same analyte varying by 1 – 2 orders of magnitude for air metal samples, making comparisons between sites and between individuals even more difficult. However, the fact that so many samples were below detection limits is generally encouraging as it suggests that exposure levels are low.

Two other objectives of the study were to measure the prevalence of respiratory and dermal symptoms and disease among tree planters and to compare prevalence of symptoms and disease to comparable non-exposed populations. The original intention had been to assess the effects of both pesticide and fertilizer exposure on respiratory and dermal symptoms and disease, however once the data had been collected it became clear that it would only be possible to consider fertilizer exposure. In the health symptom study exposure to fertilizer and pesticides were self-reported. For each of the contracts worked in the previous two years subjects were asked if they had i) planted pesticide treated seedlings and ii) used fertilizers. We found that subjects remembered whether or not they had used fertilizers but, in general, they were less likely to recall whether or not the seedlings had been pesticide treated. This is likely because tree planters are actively involved in fertilizing seedlings whereas pesticides are applied at nurseries and tree planters would have had to have sought the information on pesticide application records from seedling packaging.

A further limitation is that, due to financial constraints, we were unable to assess the exposure of tree planters to mercury. Along with arsenic, cadmium, chromium, nickel and lead, mercury is a potential fertilizer contaminant. It cannot be assumed that because exposures to the other metals are at low levels exposure to mercury is low as well.

As outlined in Chapter 4, there were several possible sources of misclassification which may have biased the estimates of odds ratios of health effects associated with increased fertilizer use. These include the possibility that the number of days of fertilizer use are overestimated for some subjects (which could lower the odds ratio estimate), potential over-reporting of symptoms by tree planters who disliked work with fertilizer (which could have led to artificially high odds ratio estimates), and incorrect recollection of self-reported duration of work contracts (likely a non-differential bias which could bias the estimate towards the null). Another possible source of bias in the health symptom study was that 78% of the reference group had experienced all or most of their tree planting work in Ontario and Alberta and not in British Columbia. Pesticide and dust exposures associated with tree planting in Ontario and Alberta may differ from those in British Columbia potentially influencing the risk of work-related symptoms. Insufficient information currently exists about the differences in pesticide, dust and other non-fertilizer exposure between British Columbia and other Canadian provinces to predict the direction of this bias.

The questionnaire used in the current study may not have been ideal for studying health symptoms related to seasonal employment. Subjects were asked questions such as “do you usually have a cough” or “do you usually bring up phlegm from your chest”. To limit interviewer bias entering the results interviewers were trained not to define “usually”. During administration of the questionnaires interviewers noticed that some subjects reasoned that they experienced the symptom only during the tree planting season therefore they did not experience the symptom “usually” and they responded “no” to the question. The work-related symptoms of these subjects were not captured by the current study. The result is that our odds ratio estimates may be underestimates.

We were unable to adjust for the healthy worker survivor effect. The healthy worker survivor effect is frequently a source of bias in cross sectional studies.[10, 11] This bias can result when workers who experience health effects as a result of their exposures at work leave the occupation and subsequently fail to be captured in studies. The result is that the workers who do remain in the occupation are less susceptible to the health effects of the exposure and the estimates of the risk of effect associated with the exposure are lower than the true risk. Because tree planting work is transient and seasonal it is likely that some tree planters who experience health effects related to fertilizer use do leave the industry. If this is the case then it's also likely that the experiences of many of these workers have not been captured by the current study.

Due to the combined effect of all potential sources of misclassification and bias it is likely that the odds ratio estimates presented in this study are underestimates and the true risk of experiencing symptoms when exposed to fertilizer is higher.

Strengths of the Study

Since fertilizer use began in the tree planting industry fifteen to twenty years ago there have been concerns amongst tree planters about health effects related to fertilizer use and anecdotal reports of symptoms experienced when working with fertilizer. [12] This was the first study to examine the effects of fertilizer exposure on tree planters and it is the first step in gathering information that will help to inform policy on the human health effects of the use of fertilizers in this industry. It is also the first study on pesticide exposure in this industry in over fifteen years, and the first that examines more than one crew working in different regions of the province. [13, 14] Although we were unable to capture the full range of conditions potentially encountered by tree planters in British Columbia, this study represents an improvement over previous studies of chemical exposures in this occupational group by including a wider range of seasonal, geographical, and company variability from an occupational group that is typically transient, geographically dispersed, and difficult to reach.

Another strength of this study was the inclusion of tree planter control groups. The living conditions, hygiene conditions and physiological strain involved in working as a tree planter are extreme compared to many other occupations [13, 15, 16] and it may not be appropriate to compare the health of tree planters as a group to the health of other occupational groups. We were able to compare the health of tree planters who work with fertilizers to a group of 69 tree planters who had not worked with fertilizers in the previous two years. We were also able to compare the metal and dust exposure of tree planters working with fertilizer to a crew who were not working with fertilizer. The use of tree planters as control subjects rather than individuals from other occupations decreases the potential for bias that could arise due to differences between tree planting and other occupations.

Recommendations

The findings of this work have shown that there are potentially harmful chemical exposures associated with tree planting work and that tree planters experience respiratory symptoms and skin irritations associated with working with fertilizers. They experience these symptoms at a greater prevalence than other occupational groups exposed to irritants. We have also shown that personal hygiene practices in the tree planting industry are very poor. Dermal and ingestion exposures to pesticides and fertilizer components could be reduced by improving hygiene practices.

One improvement that should be made is the inclusion of hand washing stations at tree planting work sites. Hand washing during the workday could decrease the dermal load of pesticides [17] and fertilizer components and decrease the risk of food contamination. However, no hand washing facilities were available to tree planters at the worksites we visited. During knowledge translation activities associated with this research we have suggested including hand washing stations at work sites. This recommendation has been met with some resistance, as the perception among some employers is that it would be very difficult to supply and maintain hand-washing stations in remote tree planting worksites where workers are spread across hectares of land. However, employers already transport boxes of seedlings, workers, and drinking water and, in some cases, fertilizer to these remote worksites. Seedlings, fertilizer and drinking water are typically kept at roadside “caches” and workers return to their nearest cache to collect supplies when necessary. If it is already possible to transport these supplies to the remote worksites then it should also be possible to provide soap and water for hand washing at each cache.

Tree planters should also be educated about the possibility for exposure to pesticides and fertilizers in their workplace and hygiene practices that can reduce these exposures. Tree planters should be educated about the importance of hand washing before eating, wearing clean clothes each work day to prevent build up of contaminants on clothing, washing work clothes separately from non-work clothes, and appropriate use of personal protective equipment (PPE). Although many workers wore gloves during work, at the worksites visited there were no PPE programs in place to help tree planters select appropriate PPE and to guide workers in the correct use of PPE. This should include information on matching glove materials to specific exposures and PPE maintenance. The risk of exposure to pesticide residues on seedlings is likely greater for nursery workers than it is for tree planters. Tree planting contractors could work with nurseries to develop PPE programs for protection against pesticides.

Our findings demonstrated a link between skin rashes and fertilizer exposure so it would also be prudent for tree planters to carry fertilizer in chemically impervious bags (for example, made from butyl rubber, nitrile or neoprene) to reduce the possibility of fertilizer carried in hip bags getting wet and the resulting fertilizer and water solution from contacting the skin.

Tree planters often drive for up to an hour on dusty logging roads and the drive to and from work is a potential source of dust exposure. The inhalable particulate measurements taken during the current study did not include the drive to and from work. Some of the concentrations of inhalable particulate measured for tree planting work were above the action limit for particulate not otherwise classified ($>5 mg/m^3$). Because these measurements do not include driving time they may be underestimates of true daily dust exposures. Windows should be kept closed during the drive to and from work to limit dust exposure.

We also found a relationship between work with fertilizer and work related cough, phlegm, nose bleed and skin irritation. There is currently insufficient evidence to warrant cessation of the use of fertilizers in silviculture work in British Columbia. However, given that fertilizers are not used on every crop of seedling in British Columbia, the health effects of fertilizer work should be considered by forestry companies when deciding whether or not to fertilize individual crops of seedlings.

Although not specifically measured by this study, ammonia and phosphoric acid are possible contributors to the health symptoms found to be associated with fertilizer work. When working with fertilizer butyl, neoprene or nitrile rubber gloves would protect against dermal irritation associated with ammonia and phosphoric acid if used as part of a PPE program.[18, 19]

Future Directions of Study

The research conducted in this thesis work was preliminary and much more work is necessary to understand the exposures associated with tree planting work and to inform policy.

In order to better understand the exposures to metals, dust and pesticides among tree planters further sampling is necessary. Notable omissions from the current study include the northern region of the province, the late summer/autumn portion of the tree planting season, and exposures to mercury, ammonia and other irritant components of fertilizer. Follow up sampling could address these omissions. Sites in the southern interior and coastal regions should also be sampled and the spring/early summer period should be included to allow comparison of the results from the current study to exposures in other years and seasons. Further sampling would allow better generalization about exposures experienced by tree planters in British Columbia.

The composition of the inhalable particulate measured during this study is unknown, but is likely a combination of soil and rock dust, which may contain silica. [20] Silica dust exposure among tree planters should be investigated.

A notable finding of this study was that pesticide residues were found on seedlings and on the skin of tree planters during spring coastal planting in 2007 but not during late spring/early summer planting in 2006. Insufficient seedling samples were taken to fully explain the reason for these findings. Future work could collect seedlings from a wider range of nurseries representing coastal, southern interior and northern regions, during different years, and throughout the tree planting season (early spring, late spring, early summer, late summer, and autumn). The findings of this research could help nurseries to ensure that seedlings are pesticide free by the time tree planters plant them. This work would have to be done in cooperation with nurseries in order to allow collection of information which was unavailable during the present study. During the present study most nurseries were approached for information about seedlings two to three years after the seedlings were grown and in some cases the records were difficult to locate. In other cases nurseries did not keep records on information of interest to the study (such as number of applications of individual pesticides). Partnerships between researchers and nurseries could ensure that sufficient information is collected to understand the factors that contribute to pesticide residues remaining present on seedlings at the time of planting.

A limitation of the current study was that the wording of health questionnaire was not ideal for capturing health effects related to seasonal employment. The work-related symptoms of some subjects may not have been captured. Follow up work should be done with wording that would include the experience of these subjects. For example, subjects could be asked, "during the tree planting season do you usually have a cough". Follow up questions could determine whether this symptom is also present in the non-tree planting season.

Discussions with tree planters during field work and knowledge translation activities indicated that tree planters are concerned about the long term health effects of tree planting work, particularly physiological strain on the body and cancer related to pesticide exposure. The current study did not examine the long-term health effects of tree planting work. Future work should examine the health of ex-tree planters to determine whether there are any long term health implications of tree planting work, including the long term implications of pesticide and fertilizer exposure among tree planters.

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Appendices

Appendix A: Health Symptom Questionnaire

Time started: _____________Time finished:___________Time used (min):__________

Tree Planter Fertilizer Exposure Study
Contact Sheet

University of British Columbia

PERSONAL CHARACTERISTICS

The following information will allow to contact you with the results of this study. It is confidential and will not be released to another party without your permission.

Full Name: Last [____]

First [____]

Address: Apt: [_ _ _ _]

Street: [____]

[____]

City/town: [____]

Province: [_ _ _] Postal Code [_ _ _-_ _ _]

Telephone: [_ _ _-_ _ _-_ _ _ _]

Email address: [____]

Study ID _______________

Tree Planter Fertilizer Exposure Questionnaire

University of British Columbia

Administrative use only:	Row[03]
Today's Date [_ _/_ _/2 0 0 6] (day month year)	[ ] 03-08
Block: [___________________________] Contractor: [______________________]	[ ] 09-30
Location:[____]	

Part One PERSONAL CHARACTERISTICS

The following information will allow us to describe the tree planter demographic and is not linked to your personal identifying information.

Age: _____ [ ][ ] 31-32

Province of Residence: _____________ [ ] 33

Sex: 0. Male____ 1. Female _____ [ ] 34

Level of Education: [ ] 35

1. some high school___
2. high school diploma____
3. some college or university___
4. some vocational training___
5. college diploma___
6. vocational diploma___
7. university bachelor degree___
0. university graduate degree___

Extra code (SC) [ ] 36

Study ID _______________

Part Two HEALTH HISTORY

These are questions mainly about your health. Please answer yes or no.
If in doubt about the answer, please answer no.

1.COUGH

Row[04]

A. Do you **usually** have a cough? (count cough with first smoke or first going out of doors. Exclude clearing throat.) 1.Yes__0.No__ [ ] 03

IF **YES** TO **'A'**, ask:

B. Do you **usually** cough as much as 4 to 6 times a day, 4 to more days a week? 1.Yes__0.No__ [ ] 04

IF **NO** TO **'A'**, ask:

C. Do you **usually** cough at all on getting up or first thing in the morning? 1.Yes__0.No__ [ ] 05

D. Do you **usually** cough at all during the rest of the day or night? 1.Yes__0.No__ [ ] 06

IF **YES** TO **ANY OF ABOVE**, ask:

E. Do you **usually** cough like this most days for 3 consecutive months or more during the year? 1.Yes__0.No__ [ ] 07

F. For how many years have you had this cough? ______________ number of years [ ][ ] 08-09

G. Does the cough improve:
- On days off? 1.Yes__ 0.No__ [ ] 10
- In the non-planting season? 1.Yes__ 0.No__ [ ] 11

H. Is there any thing or situation which makes your cough worse? 1.Yes__ 0.No__ [ ] 12
list all: ____________________________ [ ][ ] 13-14

____

____

____

2. PHLEGM

A. Do you **usually** bring up phlegm from your **chest**? (count phlegm with first smoke or first going out of doors. Count swallowed phlegm. Exclude phlegm from the nose.)	1.Yes__ 0.No__	[ ] 15

IF **YES** TO **'A'**, ask:

B. Do you **usually** bring up phlegm like this As much s twice a day, 4 or more days out of the week?	1.Yes__ 0.No__	[ ] 16

IF **NO** TO **'A'**, ask:

C. Do you **usually** bring up phlegm at all on getting up or first thing in the morning?	1.Yes__0.No__	[ ] 17
D. Do you **usually** bring up phlegm at all during the rest of the day or at night?	1.Yes__0.No__	[ ] 18

IF **YES** to **any of the above**, ask:

E. Do you **usually** bring up phlegm like this most days for 3 consecutive months or more during the year?	1.Yes__0.No__	[ ] 19
F. For how many years have you had trouble with phlegm?	________ number of years	[ ][ ] 20-21
G. Does the phlegm improve:		
On days off?	1.Yes__ 0.No__	[ ] 22
In the non-planting season?	1.Yes__ 0.No__	[ ] 23
H. Is there any thing or situation which makes you bring up phlegm?	1.Yes__ 0.No__	[ ] 24
list all: ______________________		[ ][ ] 25-26
______________________		
______________________		
______________________		

3. WHEEZING

Does your **chest** ever sound wheezy or whistling: row [05]

A. When you have a cold? 1.Yes__0.No__ [ ] 03

B. Occasionally apart from colds? 1.Yes__0.No__ [ ] 04

C. Most days and nights? 1.Yes__0.No__ [ ] 05

IF YES TO 'B' or 'C', ask:

D. For how many years has this been present? ____________ number of years [ ][ ]06-07

E. When does the wheeze occur MOST frequently? [ ]08
1. at work____ 2. on return home after work___
3. during sleep____ 0. no difference____

F. Do these symptoms improve:
On days off? 1.Yes__ 0.No__ [ ]09
In the non-planting season? 1.Yes__ 0.No__ [ ]10

G. Is there any thing or situation which makes you wheeze? 1.Yes__ 0.No__ [ ]11

If yes, specify____________________________________ [ ][ ]12-13

H. Is the wheeze associated with chest tightness or difficulty breathing? 1.Yes__ 0.No__ [ ]14

4. CHEST TIGHTNESS

A. Do you ever have episodes or **attacks** of chest tightness? 1.Yes__ 0.No__ [ ]15

IF **YES** TO '**A**', ask:
B. Is the chest tightness associated with difficulty in breathing? 1.Yes__ 0.No__ [ ]16

IF **YES** TO '**B**', ask:

C. How old were you when you had your first attack? _______________ [ ][ ]17-18

D. Have you ever required medicine or treatment for these? 1.Yes__ 0.No__ [ ]19

E. During the past year how many attacks did you have? [ ]20
0. None ____
1. A few(1-3) ____
2. Several(4-12)____
3. Most days (13+) ____
4. Almost everyday ____

F. Does it improve:
on days off? 1.Yes__ 0.No__ [ ]21
in the non-planting season? 1.Yes__ 0.No__ [ ]22

G. Is there any thing or situation which makes your chest tight? 1.Yes__ 0.No__ [ ]23
If yes, specify_____________________________________ [ ][ ]24-25
____
____
____

5. BREATHLESSNESS

A. Are you **troubled** by shortness of breath when **hurrying on the level** or walking up a **slight hill**? 1.Yes__ 0.No__ [ ]26

IF **YES** TO '**A**', ask:

B. Do you have to walk slower than people of your own age, **on the level**, because of breathlessness? 1.Yes__ 0.No__ [ ]27

C. Do you have to stop for breath when walking at **your own pace** on the level? 1.Yes__ 0.No__ [ ]28

D. Do you ever have to stop for breath after walking about 100 yards (**or a few minutes**) on the level? 1.Yes__ 0.No__ [ ]29

E. For how many years have you had shortness of breath? ____________________ number of years [ ][ ] 30-31

F. Does it improve:

- on days off? 1.Yes__ 0.No__ [ ]32
- in the non-planting season? 1.Yes__ 0.No__ [ ]33

G. Is there any thing or situation which makes your breathlessness worse? 1.Yes__ 0.No__ [ ]34

If yes, specify____________________________________ [ ][ ]35-36

____

____

____

6. CHEST COLDS AND CHEST ILLNESSES

A. If you get a cold does it usually go to your chest? (i.e. more than half the time)	1.Yes__ 0.No__	[ ] 37
B. During the past 3 years, have you had any chest illness that has kept you off work, indoors at home, or in bed?	1.Yes__ 0.No__	[ ] 38

IF **YES** TO '**B'**, ask:

C. Did you produce phlegm with any of these illnesses?	1.Yes__ 0.No__	[ ]39
D. In the past 3 years, how many such illnesses **(with phlegm)** did you have which lasted a week or more?	_______________ number of episodes	[ ][ ] 40-41

7. NASAL SYMPTOMS

row[06]

A. Do you ever have sneezing, or an itchy, runny nose **when you do not have a cold**? 1.Yes__ 0.No__ [ ]03

IF **YES** TO **'A'**, ask:

B. For how many years has this been present? ______________ (number of years) [ ][ ] 04-05

C. Does this improve:

on days off?	1.Yes__ 0.No__	[ ]06
in the non-planting season?	1.Yes__ 0.No__	[ ]07

D. Do you **usually** have a stuffy or blocked nose? 1.Yes__ 0.No__ [ ]08

IF **YES** TO **'D'**, ask:

E. For how many years has this been present ______________ (number of years) [ ][ ]09-10

F. Does this improve:

on days off?	1.Yes__ 0.No__	[ ] 11
in the non-planting season?	1.Yes__ 0.No__	[ ] 12

IF **YES** TO **'A' OR 'D' OR BOTH**, ask:

G. Is there any thing or situation that makes the nasal symptoms worse? 1.Yes__ 0.No__ [ ] 13

if yes, specify: ________________________________ [ ][ ]14-15

____

____

____

H. Do you ever have nose bleeds? 1.Yes__ 0.No__ [ ] 16

IF **YES** TO '**H**', ask:

I. For how many years has this been present? ______________ (number of years) [ ][ ]17-18

J. Does this improve:

on days off?	1.Yes__ 0.No__	[ ]19
in the non-planting season?	1.Yes__ 0.No__	[ ]20

K. Have you ever had to seek medical treatment for these nosebleeds? 1.Yes__ 0.No__ [ ]21

8. EYE SYMPTOMS

A. Do you **usually** have burning, itching, watering eyes? 1.Yes__ 0.No__ [ ]22

IF **YES** to '**A**', ask:

B. For how many years has this been present? ____________ number of years [ ][ ] 23-24

C. Does this occur on most days? 1.Yes__ 0.No__ [ ]25

D. Does this improve:

on days off? 1.Yes__ 0.No__ [ ]26

in the non-planting season? 1.Yes__ 0.No__ [ ]27

E. Is there any thing or any situation which makes your eye symptoms worse? 1.Yes__ 0.No__ [ ]28

If yes, specify:___________________________________ [ ][ ]29-30

____

____

____

9. SKIN SYMPTOMS

row [07]

A. Do you often have skin rashes? 1.Yes__ 0.No__ [ ]03

IF **YES** to '**A**', ask:

B. For how many years has this been present? ______________ (number of years) [ ][ ] 04-05

C. Do they occur:
1. intermittently __ 3. year round __ [ ]06
2. seasonal __ 0. less often __

D. Is this rash:

itchy?	1.Yes__ 0.No__	[ ]07
scaley?	1.Yes__ 0.No__	[ ]08
red?	1.Yes__ 0.No__	[ ]09
weeping?	1.Yes__ 0.No__	[ ]10
blisters?	1.Yes__ 0.No__	[ ]11

E. Is the rash located

generalized?	1.Yes__ 0.No__	[ ]12
on the hands?	1.Yes__ 0.No__	[ ]13
on the foot?	1.Yes__ 0.No__	[ ]14
on the face?	1.Yes__ 0.No__	[ ]15
on the legs?	1.Yes__ 0.No__	[ ]16
on the trunk?	1.Yes__ 0.No__	[ ]17

F. Does the rash improve:

on days off?	1.Yes__ 0.No__	[ ]18
in the non-planting season?	1.Yes__ 0.No__	[ ]19

G. Is the rash worse in the:
1. winter___ 2. summer___ [ ]20
0. no difference___

H. Has the rash caused you to miss work? 1.Yes__ 0.No__ [ ]21

I. Have you consulted a doctor about the rash? 1.Yes__ 0.No__ [ ]22

IF **YES** to '**I**', ask:

J. Was the doctor a
0.Family doctor ___ 1. Dermatologist ____ [ ]23
2. First Aid attendant____

K. What was the diagnosis? _________________

[ ]24

10. ECZEMA

A. Have you ever had eczema? 1.Yes__ 0.No__ [ ]25
(scaly, itchy rash in flexures of the body)

IF **YES** TO '**A**', ask:
B. Do you still have it? 1.Yes__ 0.No__ [ ]26
C. Was it confirmed by a doctor? 1.Yes__ 0.No__ [ ]27
D. At what age did it start? _______________ years [ ][ ]28-29

E. If you no longer have it, at what age did it stop? _______________ years [ ][ ]30-31

11. SKIN REACTIONS

A. Have you ever had a rash as a result of contact with any of the following:

metals? 1.Yes__ 0.No__ [ ]32

leather? 1.Yes__ 0.No__ [ ]33

rubber? 1.Yes__ 0.No__ [ ]34

adhesive? 1.Yes__ 0.No__ [ ]35

cosmetics? 1.Yes__ 0.No__ [ ]36

medicines? 1.Yes__ 0.No__ [ ]37

gloves? 1.Yes__ 0.No__ [ ]38

if **yes**, specify type of glove: __________________________ [ ][ ]39-40

soil? 1.Yes__ 0.No__ [ ] 41

seedlings? 1.Yes__ 0.No__ [ ] 42

if **yes**, specify species of seedling: ____________________ [ ][ ]43-44

other plants? 1.Yes__ 0.No__ [ ] 45

if **yes**, specify type of plant: ___________________________ [ ][ ]46-47

12. PAST ILLNESSES

row[08]

A. Did you have any lung trouble before the age of 16? 1.Yes__ 0.No__ [ ]03

B. Have you ever had any of the following:

	IF YES: Was it confirmed by a doctor?	Age Started	
1. Attacks of bronchitis 1.Yes__ 0.No__	1.Yes__ 0.No__	_____	[_ _ _ _] 04-07
2. Pneumonia 1.Yes__ 0.No__	1.Yes__ 0.No__	_____	[_ _ _ _] 08-11
3. Hay fever 1.Yes__ 0.No__	1.Yes__ 0.No__	_____	[_ _ _ _] 12-15
4. Chronic Bronchitis 1.Yes__ 0.No__	1.Yes__ 0.No__	_____	[_ _ _ _] 16-19
5. Emphysema 1.Yes__ 0.No__	1.Yes__ 0.No__	_____	[_ _ _ _] 20-23
6. **Pulmonary** tuberculosis 1.Yes__ 0.No__	1.Yes__ 0.No__	_____	[_ _ _ _] 24-27

C. Have you ever had asthma? 1.Yes__ 0.No__ [ ]28

IF **YES** TO '**C**', ask:

1. Do you still have it? 1.Yes__ 0.No__ [ ]29
2. Was it confirmed by a doctor? 1.Yes__ 0.No__ [ ]30
3. At what age did it start? _______________ (year) [ ][ ]31-32
4. If you no longer have it, at what age did it stop? _______________ (year) [ ][ ]33-34
5. Do you require medication for it? _______________ [ ]35
   - If **yes**:
     What medication are you taking?_____________

   How often? _____________

D. Have you ever had:

1. Any other chest illnesses? 1.Yes__ 0.No__ [ ]36

   If **yes**, specify________________________________ Age____

2. Have you ever had any chest injuries? 1.Yes__ 0.No__ [ ]37

If **yes**, specify________________________________ Age____

3. Have you ever had any chest operations? 1.Yes__ 0.No__ [ ]38

If **yes**, specify________________________________ Age____

E. Has a doctor ever told you that you had heart trouble? 1.Yes__ 0.No__ [ ]39

If **yes:** have you had treatment for heart trouble in the past 10 years? 1.Yes__ 0.No__ [ ]40

F. Has a doctor ever told you that you had high blood pressure? 1.Yes__ 0.No__ [ ]41

If **yes:** have you had treatment for high blood pressure in the past 10 years? 1.Yes__ 0.No__ [ ]42

G. Do you have any other health problems? 1.Yes__ 0.No__ [ ]43

If **yes**, specify:______________________

____

H. Are you taking any medications at present? 1.Yes__ 0.No__ [ ]44

If **yes**, specify:______________________

____

The following questions are about some habits which are important to us in evaluating your health. Please answer to the best of your memory.

13. SMOKING

row[09]

This first set of questions pertains to smoking tobacco products. A later set of questions will include address any use of marijuana.

SMOKING BY PEOPLE LIVING AROUND YOU:

When you lived at home:

A. Did your father smoke?	1.Yes__ 0.No__	[ ]03
B. Did your mother smoke?	1.Yes__ 0.No__	[ ]04

In your current household:

C. Do any members smoke (other than you)?	1.Yes__ 0.No__	[ ]05

YOUR SMOKING

CIGARETTE SMOKING

D. Have you ever smoked cigarettes? (No means less than 20 packs of cigarettes or less than one cigarette a day for one year)	1.Yes__ 0.No__	[ ]06
IF YES TO 'D', ask:		
1. Do you now smoke cigarettes? (as of 1 month ago?	1.Yes__ 0.No__	[ ]07
2. How old were you when you first started **regular** cigarette smoking?	________ years	[ ][ ]08-09
3. If you have stopped smoking cigarettes completely, how old were you when you stopped?	________ years	[ ][ ]10-11
4. How many cigarettes do you smoke per day now?	________ cigarettes per day	[ ][ ]12-13
5. On average, for the entire time that you smoked, how many cigarettes did you smoke per day?	________ cigarettes per day	[ ][ ]14-15

Study ID _______________

PIPE SMOKING

E. Have you ever smoked a pipe regularly? (Yes means more than 12oz. of tobacco in a lifetime) — 1.Yes__ 0.No__ — [ ]16

IF YES TO 'E', ask:

1. How old were you when you first started to smoke a pipe **regularly**? — ________ years — [ ][ ]17-18
2. If you have stopped smoking a pipe completely, how old were you when you stopped? — ________ years — [ ][ ]19-20
3. How much pipe tobacco do you smoke per week, now (one pouch=2oz)? — ________ ounces per week — [ ][ ]21-22
4. On average, for the entire time that you smoked a pipe, how much pipe tobacco did you smoke per week? — ________ ounces per week — [ ][ ]23-24

CIGAR SMOKING

F. Have you ever smoked cigars regularly? (Yes means more than 1 cigar/week for 1year) — 1.Yes__ 0.No__ — [ ]25

IF **YES** TO '**F'**, ask:

1. How old were you when you first started smoking cigars regularly? — ________ years — [ ][ ]26-27
2. If you have stopped smoking cigars completely, how old were you when you stopped? — ________ years — [ ][ ]28-29
3. How many cigars do you smoke per week now? — ________ cigars per week — [ ][ ]30-31
4. On average, for the entire time that you smoked cigars, how many cigars did you smoke per week? — ________ cigars per week — [ ][ ]32-33

MARIJUANA SMOKING

The following questions are about marijuana use. Please remember this survey is confidential.

G. Have you ever smoked marijuana **regularly**? 1.Yes__ 0.No__ [ ]34
(No means less than 20 joints or less than one joint per year)

IF YES TO 'G', ask:

1. Do you smoke marijuana regularly now? (as of 1 month ago?)	1.Yes__ 0.No__	[ ]35
2. How old were you when you first started smoking marijuana regularly?	________ years	[ ][ ]36-37
3. If you have stopped smoking marijuana completely, how old were you when you stopped?	________ years	[ ][ ]38-39
4. How many joints do you smoke per **week** now?	________ joints per week	[ ][ ]40-41
5. On average, for the entire time that you smoked, how many joints did you smoke per **month**?	________ joints per month	[ ][ ] 42-43

Study ID _______________

Part Three EMPLOYMENT SETTING

These are questions mainly about your experience in the tree planting industry.

14. CURRENT OCCUPATIONAL SETTING

row[10]

Administrative use only:

Camp contractor: ____________________ [ ]03-25

Region:

1.Coastal BC___ 2.Southern Interior BC___

3.Northern Interior BC___ 4.Other:____________________ [ ]26

A. What day did you start working at this block? _ _/ _ _/ _ _ _ _ [ ][ ]27-34
d d / m m/ y y y y

B. What is your current job title? 0. Planter __ 1. Crew Boss ___ [ ]35
2. Supervisor __ 3. Other:__

C. At **this** block what is the total number of days you have worked? ______ days [ ][ ]36-37

D. On average, how many hours do you **plant** per day? ______ hours per day [ ][ ]38-39

E. What is the shift structure at this site? ______ [ ] 40
(ie, 5 days on/1 day rest, etc.)

F. How many days has it been since your last day off? ______ days [ ] 41

G. On average, how many seedlings do you plant per day? ______ seedlings per day [ ] 42-44

H. What is the average price per tree at this block? _______ cents [ ][ ]45-46

I. In total, how many years have you been in your current position? _______ years [ ][ ]47-48

J. In total, how many years have you been planting trees? _______ years [ ][ ]49-50

15. HYGIENE AND PERSONAL PROTECTIVE WEAR

The following questions refer to protection that you may use while planting on the block.

A. How often do you use any of the following on your "**shovel hand**"?
(Check all that apply, read entire list before answering)

row[11]

	Type	1. Always	2. Sometimes	3. Rarely/ Never	
1.	Gardening gloves				[ ]03
2.	Dishwashing gloves				[ ]04
3.	Leather gloves				[ ]05
4.	Surgical gloves				[ ]06
5.	Golf gloves (full finger)				[ ]07
6.	Half gloves, no fingers				[ ]08
7.	Duct tape				[ ]09
8.	Barrier creams				[ ]10
9.	Other:				[ ]11
10.	Other:				[ ]12

Combinations: ____

B. How often do you use any of the following on your "**seedling hand**"?
(Check all that apply, read entire list before answering)

	Type	1. Always	2. Sometimes	3. Rarely/ Never	
1.	Gardening gloves				[ ]13
2.	Dishwashing gloves				[ ]14
3.	Leather gloves				[ ]15
4.	Surgical gloves				[ ]16
5.	Golf gloves (full finger)				[ ]17
6.	Half gloves, no fingers				[ ]18
7.	Duct tape				[ ]19
8.	Barrier creams				[ ]20
9.	Other:				[ ]21
10.	Other:				[ ]22

Combinations: ____

The next questions are regarding hygiene. We ask these to all participants.

C. If you are a smoker, how often do you wash your hands before smoking when bagging up?
Choose from the following options:
1. Always ____ 2. Sometimes ____ 0. Rarely/ Never ____ 3. N/A:_____ [ ]23

D. How often do you wash your hands before eating on the block or when bagging up?
1. Always ____ 2. Sometimes ____ 0. Rarely/ Never ____ [ ]24

E. Do you take other precautions when eating or smoking on the block or when bagging up?
1.Yes__ 0.No__ [ ]25

If **yes**, specify:________________________________ [ ][ ]26-27

____

____

F. On average, how often do you wash your work clothing?
On days off:____ or every______(days) [ ][ ]28-29

G. When you wash your clothes do you mix planting clothes with non-planting clothes? 1.Yes__0.No__ [ ]30

H. On average, how often do you wash/change gloves?
On days off:____ or every______(days) [ ][ ]31-32

16. EXPOSURE

These next questions are around the use of chemicals at work. The first set of questions is on fertilizers (granules that are added to the trees at time of planting, and may be either loose or packed into 'teabags'). The second set will be on pesticides (chemicals that are applied to seedling at the nursery).

These questions are about your current contract.

A. **At this block,** have you applied fertilizers while tree planting? 1.Yes__0.No__ [ ]33

IF YES TO 'A', ask:

1. What form did the fertilizer come in? Was it:
   0. Loose ____ 1. Stake ______ 2 . Tea bag ____ [ ]34

   If "tea bag": *Brand name*___________ [ ][ ]35-36

   # tea bags per tree _____ [ ]37

2. How often did you apply fertilizers at this site? Was it:
   1. All the time ____ 2. ½ time ____ 3. ¼ time ____ 4. Other:___ [ ]38

3. What species were fertilized on this block? All:______ or: _______________

4. What was the species mix on this block?
   Pine______% Spruce ______% Fir __________%

   Cedar_____% Larch _______% Hemlock _____% Other ______%

B. At this site, are you involved in other activities using fertilizers (distributing, loading)?
1.Yes. List: ______________________ 0.No__ [ ][ ]39-40

C. **At this site,** to the best of your knowledge, have you planted seedlings treated with pesticides?
1.Yes__0.No__ [ ]41

IF YES TO 'C', ask:

1. What type of pesticide was it?
   1. Name: ___________ 2. Don't know ____ [ ]42

2. How often did you plant seedlings treated with pesticides? Was it:
   1. All the time ____ 2. ½ time ____ 3. ¼ time ____ 4. Other____ [ ]43

D. Have you been exposed to pesticides in any other way while tree planting?
1.Yes. List: ______________________ 0.No__ [ ][ ]44-45

E. Is there anything else you feel we should know about your exposures at work?

____

17. TREE PLANTING WORK HISTORY

Now I want to ask you details about your tree-planting work history. I want to go through each of the contracts you have worked on in the past 2 seasons, since January 1, 2005. We are going to start with your current contract and work backwards.

Employer (Contractor name)	Job Type 1. planter 2.Crewboss 3. super-visor 4. other (specify)	Start Date dd/mm/yyyy	Total # days worked	Location 1. Coastal BC 2. Interior BC 3. Northern BC 4. Ontario 5. Alberta 6. other (specify)	Use of fertilizer while planting 1. Teabag 2. None 3. Don't know	Planted pesticide treated seedlings 1. Yes 2. No 3. Don't know	Tree species planted: 1: Spruce 2: Pine 3: Fir 4: Cedar 5: Hemlock 6: Larch 7.Other	Any other exposure concerns? Comments?
Row 12 03-25	[ ][ ] 26-27	[_ _ _ _ _] 28-32	[_ _ _] 33-35	[ ] 36	[ ] 37	[ ] 38	39-50	51-70
Row 13 03-25	[ ][ ] 26-27	[_ _ _ _ _] 28-32	[_ _ _] 33-35	[ ] 36	[ ] 37	[ ] 38	39-50	51-70
Row 14 03-25	[ ][ ] 26-27	[_ _ _ _ _] 28-32	[_ _ _] 33-35	[ ] 36	[ ] 37	[ ] 38	39-50	51-70
Row 15 03-25	[ ][ ] 26-27	[_ _ _ _ _] 28-32	[_ _ _] 33-35	[ ] 36	[ ] 37	[ ] 38	39-50	51-70
Row 16 03-25	[ ][ ] 26-27	[_ _ _ _ _] 28-32	[_ _ _] 33-35	[ ] 36	[ ] 37	[ ] 38	39-50	51-70
Row 17 03-25	[ ][ ] 26-27	[_ _ _ _ _] 28-32	[_ _ _] 33-35	[ ] 36	[ ] 37	[ ] 38	39-50	51-70

18. Part Four OTHER EXPOSURES

This section addresses other environments in which you may have had chemical exposures. It is asked of all participants.

In the non-planting season in the past 2 years, have you worked in any of the following occupations for more than three months? row[18]

	1.Yes	2. No	How long(months)	
1. Agriculture (organic? ___y/n)	____	____	[__ __]	[__ __ __] 3-5
2. Orchards/Fruit picking	____	____	[__ __]	[__ __ __] 6-8
3. Nurseries	____	____	[__ __]	[__ __ __] 9-11
4. Landscaping	____	____	[__ __]	[__ __ __] 12-14
5. Fire fighting	____	____	[__ __]	[__ __ __] 15-17
6. Wood treatment	____	____	[__ __]	[__ __ __] 18-20
7. Painting	____	____	[__ __]	[__ __ __] 21-23
8. Chemical Manufacture	____	____	[__ __]	[__ __ __] 24-26
9. Laboratories	____	____	[__ __]	[__ __ __] 27-29

Are there any other concerns or comments that you think may be important to our study that we have not asked you about?

____

____

____

____

Appendix B: Symptom Definitions

Variable Name	Explanation of Variable
any cough	Subject reported yes to any of the following questions: Do you usually have a cough?/Do you usually cough at all on getting up or first thing in the morning?/Do you usually cough at all during the rest of the day or night?
work-related cough	Subject was positive for any cough and reported: improvement of cough on days off AND/OR long holidays AND/OR reported work-related situations or environments (i.e. general work-related environments, fertilizer, pesticides, dust, physical exertion) making the cough worse. (If cough started before the age of starting work in the industry, then subject was considered not to have work-related cough.)
any phlegm	Subject reported yes to any of the following questions: Do you usually bring up phlegm from your chest (exclude phlegm with first smoke or fist going out of doors. Count swallowed phlegm. Exclude phlegm from the nose)?/Do you usually bring up phlegm at all on getting up or first thing in the morning/Do you usually bring up phlegm at all during the rest of the day or night.
work-related phlegm	Subject was positive for any phlegm and reported: improvement of phlegm on days off AND/OR long holidays AND/OR reported work-related situations or environments (i.e. general work-related environments, fertilizer, pesticides, dust, physical exertion) making them bring up phlegm. (If phlegm symptom started before the age of starting work in the industry then worker was considered not to have work-related phlegm.)
occasional wheeze	Subject reported: chest sounding wheezy or whistling occasionally apart from colds or most days and nights
work-related wheeze	Subject reported: chest sounding wheezy or whistling occasionally apart from colds or most days and nights AND wheeze improving on days off and/or long holidays AND/OR reported work-related situations or environments (i.e. general work-related environments, fertilizer, pesticides, dust, physical exertion) making them wheeze or wheeze worse. (Subjects who had wheeze starting before the age of starting work in the industry were considered not to have work-related wheeze).

chest tightness	Subject reported: episodes of chest tightness which were associated in difficulty in breathing
work-related chest tightness	Subject reported: episodes of chest tightness which were associated in difficulty in breathing AND the episodes improving on days off AND/OR the non-planting season AND/OR reported work-related situations or environments (i.e. general work-related environments, fertilizer, pesticides, dust, physical exertion) making the chest tightness worse. (Subjects who had chest tightness starting before the age of starting work in the industry were considered not to have work-related chest-tightness.)
work-related sneezing	Subject reported: ever having sneezing or an itchy runny nose when they did not have a cold AND improvement on days off AND/OR the non-planting season AND/OR reported work-related situations or environments (i.e. general work-related environments, fertilizer, pesticides, dust, physical exertion) making the symptoms worse. (Subjects with sneezing symptoms starting before the age of starting work in the industry were not considered to have work-related sneezing.)
work-related stuffy or blocked nose	Subject reported: usually having a stuffy or blocked nose AND improvement on days off AND/OR the non-planting season AND/OR reported work-related situations or environments (i.e. general work-related environments, fertilizer, pesticides, dust, physical exertion) making the symptoms worse. (Subjects with symptoms starting before the age of starting work in the industry were not considered to have work-related stuffy or blocked nose.)
work-related nasal symptoms	If subject had work-related sneezing AND/OR work-related stuffy or blocked nose AND/OR reported work-related situations or environments (i.e. general work-related environments, fertilizer, pesticides, dust, physical exertion) making the nasal symptoms worse.
Work-related nose-bleed	Subject reported: ever having nosebleeds AND improvement on days off AND/OR the non-planting season. (Subjects who had nose-bleeds starting before the age of starting work in the industry were considered not to have work-related nose-bleeds.)
work-related eye symptoms	Subject reported: usually having burning, itching, watering eyes AND improvement on days off AND/OR the non-planting season AND/OR reported work-related situations or environments (i.e. general work-related environments, fertilizer, pesticides, dust, physical exertion) making the symptoms worse. (Subjects who had eye symptoms starting before the age of starting work in the industry were

	considered not to have work-related eye symptoms.)
work-related skin rashes	If subject reported: often having skin rashes AND improvement on days off AND/OR the non-planting season. (Subjects with symptoms starting before the age of starting work in the industry were not considered to have work-related skin rashes.)
adult-onset eczema	If the subject reported: currently having eczema with onset after age 16.
adult-onset asthma	If subject reported: currently having asthma and onset after age 16.

For these symptoms, 'work-related' means the symptom improves on holidays or in the non-planting season, *or* is aggravated by exposures at work, *and* it has only been present since starting work in the industry.

Appendix C: Field Sheets

TREE PLANTERS- AIR SAMPLING

NAME [____]

COMPANY [____]

LOCATION [____]

DATE (DD/MM/YYYY) [____/____/______]

PUMP ID [______________] CASSETTE ID [______________]

FLOW RATE- START [______________] TIME [______________]

FLOW RATE-END [______________] TIME [______________]

FLOW RATE DIFFERENCE [______________] ELAPSED TIME [______________]

AVERAGE FLOW RATE [___________]

HOW MANY TREES DID YOU PLANT TODAY? [___________] HOW MANY TEA BAG BAGS (100/BAG) DID YOU OPEN? [__________]

ANYTHING OCCUR THAT WAS OUT OF THE ORDINARY? IF SO, PLEASE EXPLAIN:

[____

____

____

____]

TREE PLANTERS

BLOOD SAMPLING

SAMPLE ID [____]

FIRST NAME [____]

LAST NAME [____]

DATE (DD/MM/YYYY) [____/_____/________]

EMPLOYER [____]

LOCATION [____]

SAMPLE ID [___________]

TREE PLANTERS- BULK SAMPLING

DATE (DD/MM/YYYY) [_____/_____/__________]

LOCATION [____]

SAMPLE ID [____________]

SAMPLE TYPE 1. TEABAG [__] 1. SEEDLING [__] 1. SOIL [_____]

MANUFACTURER / NURSERY [____]

LOT # [____]

COMMENTS:

[____

____

____

____

____]

TREE PLANTERS- SKIN SAMPLING

NAME [____]

LOCATION [____]

COMPANY [____]

DATE (DD/MM/YYYY) [____/____/_________]

PLANTING HAND 1. RIGHT [___] 2. LEFT [___]

SAMPLE ID: DORSAL ASPECT [__________________]

SAMPLE ID: PALMER ASPECT [__________________]

SAMPLE ID: FINGERS [__________________]

TYPE OF HAND PROTECTION WORN LEFT: [________________________________]

RIGHT: [________________________________]

IS THIS YOUR NORMAL HAND PROTECTION? [_____________________________________]

EVER REMOVE HAND PROTECTION TO DO WORK? [_____________________________________]

EVER REMOVE HAND PROTECTION TO EAT? [_____________________________________]

EVER WASH HANDS DURING SHIFT? [_____________________________________]

WAS THIS A NORMAL WORK DAY? [_____________________________________]

HOW MANY SEEDLINGS DID YOU PLANT TODAY? [___________________]

DURATION OF THE DAY WITH SHORT SLEEVES? [________] DURATION OF THE DAY WITH LONG SLEEVES? [________]

DID YOU APPLY INSECTICIDE BEFORE WORK TODAY? [________________]

IF YES, NAME BRAND: [________________________________]

DESCRIPTION: [____]

DID YOU APPLY SUNSCREEN BEFORE OR DURING WORK TODAY? [________________]

IF YES, NAME BRAND: [____]

DESCRIPTION: ____]

ANYTHING OUT OF THE ORDINARY TODAY WITH RESPECT TO SKIN CONTAMINATION? IF SO, PLEASE EXPLAIN:

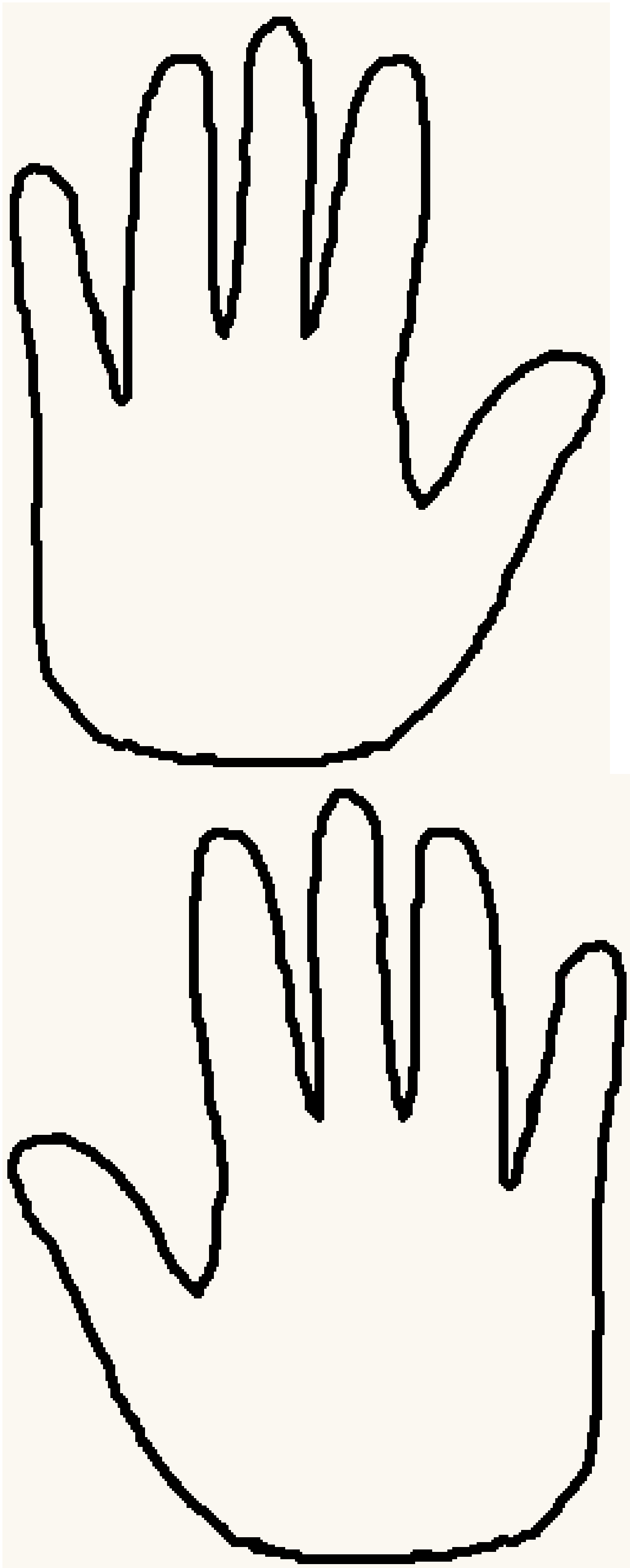
[____

____

____

____]

MARK DEFICIENCIES IN SKIN INTEGRITY WITH A SKETCH AND NUMBER FOR SEEDLING HAND ONLY:



Circle the condition that applies:

LEFT HAND / RIGHT HAND

Describe skin integrity:

1.________________________

____

____

2.________________________

____

____

3.________________________

____

____

4.________________________

____

____

5.________________________

____

____

6.________________________

____

____

PLEASE TAKE A SKETCH OF THE WORKERS SEEDLING HAND
(THIS SKETCH WILL BE USED TO CALCULATE THE SURFACE AREA OF THE HAND)

Appendix D: Study Advertisement

Faculty of
Graduate Studies

THE UNIVERSITY OF BRITISH COLUMBIA

School of Occupational & Environmental Hygiene
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Vancouver, BC Canada V6T 1Z3
www.soeh.ubc.ca

(604) 822-9595 *tel*
(604) 822-9588 *fax*

Dear Tree-planter:

Researchers at the University of British Columbia (UBC) and The Forest Engineering Research Institute of Canada (FERIC) are conducting a study to investigate potential exposures to fertilizers, pesticides and other potential contaminants among tree-planters.

What is the research about?

Tree planters in Canada have planted billions of seedlings, covering over hundreds of thousands of hectares per year since 1988. Each season thousands of young workers undertake the strenuous and repetitive job of planting hundreds of seedlings every day, hiking great distance with heavy bags over rough terrain in remote geographic locations.

In many cases tree planters are required to add fertilizer to each and every seedling as they plant. Fertilizers contain nitrogen, phosphorus and potassium, but may also contain heavy metals. Human exposure to these chemicals can cause both acute and chronic health effects. Though no scientific study has yet investigated the health risks for tree planters associated with fertilizer application, the media, internet and anecdotal reports contain complaints from tree planters of skin rashes, nausea, headaches, nosebleeds, congestion, eye irritations and respiratory ailments from using fertilizers. Pesticides are sometimes applied to seedlings before they are stored over the winter before planting; low levels of pesticide residues may be present at planting time and there is a possibility of transfer to the skin.

Tree planting is a high-risk exposure scenario; tree planters have limited opportunity to wash, they often have cuts or abrasions, they may not wear gloves or other protective gear while planting, they work at high aerobic rates for extended periods, and the driving goal is to plant the maximum number of seedlings possible. All of these factors increase risk of exposure through inhalation, dermal (skin) and ingestion routes.

The purpose of our study is to determine tree planter exposure to fertilizers, pesticides and potential heavy metal contaminants, and to determine if health complaints associated with fertilizer exposure are more frequent in tree planters than other occupational cohorts.

How will the research be done?

We will visit randomly selected camps during the 2006 planting season. At each site, we will ask tree-planters to complete a questionnaire on their exposure history and self-reported health. In addition, we will recruit 10 tree planters and monitor them for a day to determine individual exposure by the amount of dust inhaled, the amount of fertilizer and pesticide deposited on the skin, and the levels of metals in blood. We will also analyze the content of the fertilizers used at each camp.

Why is the research important?

The tree planting population is underserved in terms of occupational research. This is a marginalized study population; they are a young workforce that is geographically dispersed, seasonally employed, living in remote camps and working under extremely challenging conditions. Though the future of Canadian forests relies on this workforce there have been few research studies looking at the occupational health and safety needs of tree planters. Since the introduction of fertilization at time of planting a decade ago, there have been reports of health complaints attributed to fertilizer use, but no research on this occupational risk.

How can you Participate?

Your worksite was one of those chosen to participate in the study. UBC and FERIC researchers will visit your worksite. After a short presentation and question and answer session, you will be invited to participate in the study. If you agree, you'll be asked to sign a consent form in which your rights as a study subject are explained. Then you'll be asked to complete a questionnaire that will take approximately 30 minutes of your time to complete. A few people at your camp will also be asked to wear an air sampler for the duration of their work shift (one day only), and to allow us to take skin wipes from the backs of their hands. These will help us assess the levels of contaminants that a person may breathe in, or absorb through their skin. Finally those helping with the air and skin monitoring will also be asked for a small blood sample, which will be taken by the nurse. You will be compensated for any lost production as a result of participating in this study.

For more information on the study please see our website at www.cher.ubc.ca/treeplanter or contact Dr. Hugh W. Davies, UBC School of Occupational and Environmental Hygiene, 604.822.6777 or at email hugh.davies@ubc.ca

Yours sincerely,

Ernst Stjernberg, RPF, MF
Group Supervisor, Silviculture Operations,
Forest Engineering Research Institute of Canada

Hugh W. Davies, PhD, MSc, CIH
Assistant Professor,
School of Occupational and Environmental Hygiene
University of British Columbia

Appendix E: Subject Information and Informed Consent Form

Faculty of
Graduate Studies

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(604) 822-9588 *fax*

SUBJECT INFORMATION AND CONSENT FORM

Study: Occupational Exposures to Fertilizer and Contaminants in Tree Planters

Principal Investigator: Hugh Davies, PhD, CIH
School of Occupational and Environmental Hygiene
Contact 604.822.6777

Co-Investigator Ernst Stjernberg, MF, RPF
Forest Engineering Research Institute of Canada
Contact [redacted]

You are being invited to take part in this research study because you work as a tree planter , and may be exposed to chemical fertilizer dust, pesticides and contaminants that may affect your health.

Your participation is entirely voluntary, so it is up to you to decide whether or not to take part in this study. Before you decide, it is important for you to understand what the research involves. This consent form will tell you about the study, why the research is being done, what will happen to you during the study and the possible benefits, risks and discomforts.

If you wish to participate, you will be asked to sign this form. If you do decide to take part in this study, you are still free to withdraw at any time and without giving any reasons for your decision.

If you do not wish to participate, you do not have to provide any reason for your decision not to participate. We ask that all participants have good command of English language in order to answer the questions in a questionnaire.

Study Purpose
The purpose of this study is to determine the extent to which tree planters are exposed to dusts from fertilizers which may contain contaminants such as trace amounts of heavy metals, and to pesticides. This study is a “pilot study” meaning that the results from this study cannot be considered “final” but rather will contribute to the design and development of larger and more comprehensive studies in the future if the results warrant it.

Overview of the Study
The study has 2 components. First, you will be asked to complete a questionnaire, which will take about 30 minutes. You are not obliged to answer any questions that you do not feel comfortable answering.

Secondly, you may be asked to wear air-monitoring equipment in your back bag that will monitor for potential air-borne particles (the equipment will take about 10 minutes to set up, and are then worn for the duration of one day), and to provide small skin wipes from the backs of your hands and wrists, to determine potential skin exposure. Ten minutes will be required at the end of the day to remove the equipment and obtain skin wipes. Individuals participating in phase 2 will also be asked to provide a small blood sample.

It is perfectly okay to participate in the first (questionnaire) phase and decline the second phase. The air monitoring equipment consists of a pump, which weighs approximately 2 lbs (see picture to right) and is worn normally on the belt but in your case in your back bag, and a short hose and a small lightweight sampling device that is normally clipped to the collar or lapel of your upper clothing. The skin wipes are cotton gauze soaked in ethanol and wiped across the backs and palms of your hands.

What Are The Possible Harms And Side Effects Of Participating?
There are no potential harms or side effects from completing the questionnaire, nor from wearing the air monitoring equipment, which is fairly light and unobtrusive. There may be some discomfort and a potential for bruising and infection at the site of the needle puncture during and after the blood sample collection, which is small (less than 10 mL, or 2 teaspoons) and taken at the forearm. The blood sample will only be tested for the presence of heavy metals (i.e. lead, mercury, arsenic, cadmium, etc.).

What Are The Benefits Of Participating In This Study?
All individuals who participate in the air monitoring and who donate a blood sample will receive a copy of their personal results as well as a summary of the results for the rest of the group, permitting them to see how their own exposure levels relate to the mean of the group, and to regulatory limits. The main benefits arising from this study are societal, providing risk assessment data to aid in targeting and prioritizing hazard

control measures. However, participation in the study may not involve any direct benefit to you.

Remuneration
Participants in this study will not receive any remuneration for participation but will be compensated for lost production as a result of time lost to complete the questionnaire and to participate in the monitoring.

WHAT HAPPENS IF I DECIDE TO WITHDRAW MY CONSENT TO PARTICIPATE?
Your participation in this research is entirely voluntary. You may withdraw from this study at any time. If you decide to enter the study and to withdraw at any time in the future, there will be no penalty or loss of benefits to which you are otherwise entitled.

WHAT HAPPENS IF SOMETHING GOES WRONG?
Signing this consent form in no ways limits your legal rights against the sponsor, investigators, or anyone else.

WILL MY TAKING PART IN THIS STUDY BE KEPT CONFIDENTIAL?
Your confidentiality will be respected. No information that discloses your identity will be released or published without your specific consent to the disclosure. However, research records and medical records identifying you may be inspected in the presence of the Investigator or his or her designate by representatives of Health Canada, and the UBC Research Ethics Board for the purpose of monitoring the research. However, no records which identify you by name or initials will be allowed to leave the Investigators' offices.

The Freedom of Information and Protection of Privacy Act of British Columbia also protect your rights to privacy. This Act lays down rules for the collection, protection, and retention of your personal information by public bodies, such as the University of British Columbia and its affiliated teaching hospitals. Further details about this Act are available upon request.

WHO DO I CONTACT IF I HAVE QUESTIONS ABOUT THE STUDY DURING MY PARTICIPATION?
If you have any questions or desire further information about this study before or during participation, you can contact Dr. Hugh Davies at 604.822.6777

WHO DO I CONTACT IF I HAVE ANY QUESTIONS OR CONCERNS ABOUT MY RIGHTS AS A SUBJECT DURING THE STUDY?
If you have any concerns about your rights as a research subject and/or your experiences while participating in this study, contact the 'Research Subject Information Line in the University of British Columbia Office of Research Services' at 604-822-8598

RESULTS
The Investigators will mail results of personal air and blood sampling data to you if you wish. At that time (or any other), you may contact the investigators to discuss the

results. Aggregated results regarding the study as a whole will be available from your employer, the Western Silviculture Contractors Association or from the UBC website: www.cher.ubc.ca/treeplanter.

CONFLICT OF INTEREST

The Investigators hereby declare that they have no known conflict of interest involving this study.

SUBJECT CONSENT TO PARTICIPATE

- ☐ *“I have read and understood the subject information and consent form.*
- ☐ *I have had sufficient time to consider the information provided and to ask for advice if necessary.*
- ☐ *I have had the opportunity to ask questions and have had satisfactory responses to my questions.*
- ☐ *I understand that all of the information collected will be kept confidential and that the result will only be used for scientific objectives.*
- ☐ *I understand that my participation in this study is voluntary and that I am completely free to refuse to participate or to withdraw from this study at any time without changing in any way the quality of care that I receive.*
- ☐ *I understand that I am not waiving any of my legal rights as a result of signing this consent form.*
- ☐ *I understand that there is no guarantee that this study will provide any benefits to me (if applicable).*
- ☐ *I have read this form and I freely consent to participate in this study.*
- ☐ *I have been told that I will receive a dated and signed copy of this form.*

SIGNATURES

____________________	____________________	__________
Printed name of subject	Signature	Date
____________________	____________________	__________
Printed name of witness	Signature	Date
____________________________	____________________	__________
Printed name of principal investigator/ designated representative	Signature	Date

Appendix F: Ethics Approval Certificate

The University of British Columbia
Office of Research Services
Clinical Research Ethics Board – Room 210, 828 West 10th Avenue, Vancouver, BC V5Z 1L8

ETHICS CERTIFICATE OF EXPEDITED APPROVAL: RENEWAL

PRINCIPAL INVESTIGATOR:	DEPARTMENT:	UBC CREB NUMBER:
Hugh W. Davies	UBC/College for Interdisciplinary Studies/School of Environmental Health	H06-70039

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:

Institution	Site
UBC	Vancouver (excludes UBC Hospital)

Other locations where the research will be conducted:
N/A

CO-INVESTIGATOR(S):
Ernst Stjernberg

SPONSORING AGENCIES:
Workers' Compensation Board of British Columbia - "Occupational Exposure to Fertilizer and Contaminants in British Columbia Tree Planters"

PROJECT TITLE:
Occupational Exposure to Fertilizer and Contaminants in British Columbia Tree Planters

EXPIRY DATE OF THIS APPROVAL: March 31, 2009

APPROVAL DATE: March 31, 2008

CERTIFICATION:
In respect of clinical trials:
1. The membership of this Research Ethics Board complies with the membership requirements for Research Ethics Boards defined in Division 5 of the Food and Drug Regulations.
2. The Research Ethics Board carries out its functions in a manner consistent with Good Clinical Practices.
3. This Research Ethics Board has reviewed and approved the clinical trial protocol and informed consent form for the trial which is to be conducted by the qualified investigator named above at the specified clinical trial site. This approval and the views of this Research Ethics Board have been documented in writing.

The Chair of the UBC Clinical Research Ethics Board has reviewed the documentation for the above named project. The research study, as presented in the documentation, was found to be acceptable on ethical grounds for research involving human subjects and was approved for renewal by the UBC Clinical Research Ethics Board.

Approval of the Clinical Research Ethics Board by:

[redacted]

Dr. James McCormack, Associate Chair