B.C. SAFE SILVICULTURE PROJECT

OCCUPATIONAL EXPOSURES TO FERTILIZER AND CONTAMINANTS IN BC TREE PLANTERS

Note: Originally the study was to examine solely the health effects of tree planters' exposure to fertilizers. As the proposal was developed in collaboration with FERIC and the BC Safe Silviculture Project the study was expanded to address worker concerns over nursery pesticide residues on seedlings. With original funding from WorkSafeBC the additional work, including a broader sampling group, was funded by the BC Safe Silviculture Project. The summaries and material provided here reflect the original proposal. The project methodology, also attached, includes the focus on pesticides.

Overview of Problem:

Each season over 5000 young workers undertake the strenuous daily task of planting up to 1600 seedlings daily while hiking over 16 km across rough terrain in remote geographic locations. In current practice many contractors require that tree planters add fertilizer to each seedling at the time of planting. These fertilizers contain nitrogen, phosphorus and potassium and a range of essential nutrients, but additionally may contaminant heavy metals including arsenic, lead, cadmium, mercury, and nickel. This has raised concerns regarding the health effects of tree planters' exposure to fertilizers. In other occupational populations fertilizer exposure is associated with contact dermatitis and several of the contaminants are known or suspected carcinogens. As of yet this occupational risk has not been studied in the tree planting population, despite anecdotal evidence which cites adverse health outcomes including skin rashes, nausea, headaches, nosebleeds, congestion, eye irritations and respiratory ailments associated with fertilizer use. With continuous direct exposure to fertilizers under physically challenging working conditions, and limited opportunity to wash off dust while planting, tree planters have a potentially high risk for exposure to fertilizers and heavy metals via inhalation, dermal absorption, and ingestion exposure routes.

While progress has been made regarding ergonomics, nutritional needs and pesticide exposure in tree planters, there is a gap in scientific evidence on the health effects of fertilizer exposure in tree planters. Thus, the proposed study aims to quantify the exposure levels of tree planters to fertilizer and heavy metals, and to document self-reported adverse health outcomes. We will take undertake a 1-year study that will investigate the following research questions :

1) Are BC tree planters exposed to fertilizer dust? If so, at what levels?
2) Are BC tree planters exposed to heavy metals? If so, at what levels?
3) What is the prevalence of self-reported adverse health outcomes and how do they compare to other populations?

Research Methodology:

The study will be conducted at 2 randomly selected, temporary tree planting camps in the interior and coast of B.C. We will attempt to recruit all workers at both to complete a questionnaire to collect information on fertilizer exposure, risk perception, determinants of exposure and self-reported health. We will also recruit a sub-sample of 10 volunteer subjects at each camp randomly selected from a crew list of planters who have planted already for at least one month that season. For each subject we will collect (1) airborne dust samples to assess inhalable total dust, metal exposure and fertilizer dust exposure, as well as (2) dermal exposure samples and (3) blood samples. To determine subject exposure levels we will analyze metal concentrations in samples using ICP-MS and inhalable dust levels by gravimetric analysis. The prevalence of self-reported adverse health outcomes as determined in the questionnaire will be compared with previously studied occupational cohorts. On site visits we will collect bulk fertilizer samples for metals analysis.

Significance and Expected Outcomes:

This project is will produce the first results on fertilizer exposures in a currently underserved young workforce; BC tree planters. The results of this study will determine if fertilizer exposures are beyond safe levels and whether adverse health outcomes associated with fertilizer exposure are higher in this workforce than in similar workforces. These outcomes will inform policy on the need for interventions or health and safety training in this workforce to ensure the well-being of young tree planters.

Revised Methodology Including Pesticides

1. METHODS

1.1 Tree-planting Camp Recruitment

Tree-planting camps will be recruited in two “streams”. Stream 1 will be recruited for the purpose of administering the health and exposure questionnaire only. Stream 2 will be camps recruited for the purpose of questionnaire administration as well as physical assessment of exposures using biological, air and skin monitoring techniques. Recruitment is to be conducted with assistance of our industry partners.

1.1.1 Stream-1 Sampling (Questionnaire only)

Stream-1 camp recruitment will be done on a convenience-sampling basis, as and when camps are identified and travel and personnel resources permit, through the rest of 2006 and spring planting season of 2007. The goal is to obtain as many questionnaires as possible, with a minimum of 100.

1.1.2 Stream-2 Sampling (Questionnaire and physical sampling)

For Stream-2 sampling we will recruit 4 tree-planting camps. Two camps will be selected in the BC interior, and these will be visited during the spring/summer of 2006. Two camps will be selected in

the coastal region of BC, and these will be visited during the winter or early spring 2007. In other respects (size, location) we will aim to recruit camps that are representative of the typical planting contractor/camp.

Contractors of camps that are selected will be contacted, and sent a flyer announcing the study and requesting volunteers, to be distributed to tree-planters by the contractor at least 24 hours before we recruit individuals (required by UBC Clinical Ethics Review Board).

1.2 Subject Recruitment

For both Stream-1 and Stream-2, all tree-planters who have planted for at least one month in the year of testing will be eligible to participate. The study complies with the ethical review standards of the University of British Columbia (Clinical Ethical Review Board Certificate C06-039), and we will follow informed-consent protocol, giving each potential subject both written and verbal description of the project and requiring each subject to sign a consent form before proceeding.

At every camp (Stream-1 and Stream-2), we will administer a questionnaire to as many tree-planters as possible. The questionnaire will be administered during working hours. Participants will be guaranteed no loss of earnings. The questionnaire will take approximately 30 to 40 minutes to complete.

For Stream-2 air, dermal and blood sampling, we will recruit 10 volunteer subjects, randomly selected from a crew list provided by the Contractor in advance.

Air sampling will require approximately 10 minutes before and after shift to equip the subject. Dermal sampling will take approximately 10 minutes post-shift to conduct. Blood sampling will take approximately 5 minutes to conduct and will be done by a trained nurse/phlebotomist during the shift.

1.3 Questionnaire – Stream 1 and 2 Tree-Planting Camps

All subjects will be administered a questionnaire to collect information on self-reported symptomology and health, work history, history of fertilizer and pesticide exposure, risk perception, determinants of exposure to pesticide and fertlizer.

Questionnaire administrators will all be trained at UBC in standardized administration procedures. Health related questions were drawn from standardized test instruments (such as the American Thoracic Society's [ATS] Respiratory Disease Questionnaire) and whenever possible, questions are identical to those used in other studies to allow for comparison. The survey was pilot tested on a convenience sample of experienced treeplanters (n=5) to check for wording and appropriateness of questions. Questions and responses were amended for clarity.

1.4 Sampling – Stream 2 Tree-Planting Camps Only

Sampling will be accomplished over 3 - 4 days at each site. Four types of samples will be collected:

(1) "Bulk" samples of fertilizers used on site, seedlings, and local soil.

(2) Airborne "inhalable" dust samples, to assess (i) total particulate, (ii) fertilizer particulate, and (ii) metals

(3) Dermal samples for metals and pesticides, and

(4) Blood samples, for metals only.

1.4.1 "Bulk" sampling

At each camp we will obtain:

(1) Fertilizer samples, i.e. samples of packaged fertilizer ("tea-bags") of all available types and lot numbers in use (for trace metal anlaysis);

(2) Samples of seedlings representing each different nursery, and, if applicable representing different species and different treatment types (where similar seedlings from same nursery have had different pesticide treatments). In laboratory, seedlings will be separated into root ball (for trace metals analysis) and plant (for residual pesticide analysis).

(3) Samples of soil typical to local region of camp (for trace metal analysis).

1.4.2 Air sampling

We will conduct gravimetric sampling for inhalable particulate using the NIOSH 0500 method adapted for inhable sampling. We will use SKC variable flow personal sampling pumps (SKC Airchek PCXR7 or similar) run at 3.5 Liters per minute and GSP sampler inhalable sampling heads. Flow-rates will be set in the field and checked pre- and post shift using a rotameter that has been calibrated against a primary standard (i.e. bubble meter or frictionless piston). Filters will be 0.8 μm mixed cellulose ester. Sampling will be for a full work shift. See Appendix for detailed procedures.

1.4.2.1 Air Sampling Controls

(1) For each 10 sample filters (or at each different camp visited, if <10 samples) we will create one field blank that will be handled in the same way as a sample, but no air shall pass through the filter.

(2) We will collect one upwind stationary air sample to measure ambient dust and background trace metal levels.

1.4.3 Dermal

For metals analysis, hand wipes are performed using SKC Ghost Wipes. Ghost Wipes are wetted with deionized water and individually wrapped. For pesticides, hand wipes will be done with 12-ply cotton gauze soaked in ethanol. Sampling will be conducted on the hand identified by the tree-planter as their "seedling hand", i.e. the one most likely to be used to handle the seedlings. We will sample for metals on one day, and pesticides on a second day.

CONTROLS

Spiked Controls

One spiked control will be taken over the course of each sampling trip using a standards "cocktail" of either metals or pesticides.

Field Blanks

One field blank (swabs that have been soaked and blotted as above in the field, but not used to wipe skin) and one media (lab) blank will be taken over the course of each sampling trip.

1.4.4 Blood

Blood sampling will follow NIOSH Method 8005. Ten ml venous (cubital) blood samples will be obtained from subjects into sodium-heparin-treated "trace-element" glass vacutainers (Becton Dickinson, cat# 369736). The forearm area will be thoroughly cleaned before phlebotomy. Blood samples will be refrigerated (4°) immediately and kept at that temperature until analysis.

1.5 Chemical and Data Analyses

Analyses will be conducted at the laboratories of the UBC *School of Occupational and Environmental Hygiene* or at local contract analytical laboratories.

1.5.1.1 Gravimetric analyses

Gravimetric will be conducted using Sartorius micro-balances, in an environmentally controlled balance room (target T=21±2°C, RH=35±5%). Filters will be equilibrated in the balance room for 24 hours prior to weighing. Filters will be triple-weighed after being passed over a PO_{210} alpha-emitter to reduce static. Laboratory and field blanks (10% of samples) will be utilized. Filters will be 0.8 μm cellulose ester membrane as recommended by NIOSH "Elements by ICP" Method.

We will estimate *total* inhalable dust exposure, as well as estimated fertilizer dust exposure based on the amount of phosphorous present in the sample, and the expected NPK proportions from fertilizer used at site. For example if total particulate mass is 1mg and 10ug of that is determined to be phosphorous, and the fertilizer mixture is 20:11:9 then amount of fertilizer sampled is 91 ug or 9% of the dust captured.

1.5.1.2 Research Question: "Are tree planters in BC exposed to fertilizer dust? If so, at what levels?"

We will compare measurements of inhalable dust (e.g. as "particles not otherwise classified") and estimates of amount of fertilizer dust that is a fraction of the "total" amount to appropriate BC regulatory levels (i.e. phosphoric acid permissible concentration), other recognized standards and

guidelines and to exposure levels reported in health studies in the scientific literature. Adjustments will be made as necessary to recognize the non-standard work-shifts. Control samples (ambient air area samples, etc.) will be utilized to assist in identifying source of contaminant, if possible.

1.5.2 Metals

Metals analysis (As, Cd, Ni, Pb, P) will be conducted on all three sampling media (air, blood and skin). Analyses will be conducted at CANTEST, and will follow NIOSH analytical methods 7300 and 8005 using ICPMS. positive ("spiked") controls will be used to determine losses due to transportation and handling.

1.5.2.1 Research Question: "Are tree planters in BC exposed to heavy metals? If so, at what levels?"

Results will be compared to appropriate regulatory limits, for air and blood samples (i.e. WCB permissible concentrations, ACGIH Biological Exposure Levels or "BEI's") and to the scientific literature.

Concentrations of heavy metals found in fertilizer bulk samples, soil samples, seedling rootball samples, and negative controls will be used in assessing the possible source of heavy metal exposure if such personal exposure is found.

There are no guidelines or standards for permissible concentrations of heavy metals on the skin; dermal exposure data will be useful in (1) helping to determine cause of dermatological complaints (if found) and (2) source of exposure to heavy metals (if found in blood).

1.5.3 Pesticides

Pesticide analysis (e.g. Daconil/Bravo (Chlorothalonil), Rovral (Iprodione), Captan (organonitrate) Ripcord/cymbush (cypermethrin), Ambush (perethrin), Malathion (organophosphate) and Benlate (benomyl) will be conducted on dermal swab samples only to examine the extent of pesticide-residue transfer from seedlings. Chemical analyses will be conducted by CanTest, Inc.

1.5.3.1 Research Question: "Are tree planters in BC exposed to pesticides? If so, at what levels?"

Guidelines and standards do not exist for dermal exposure to pesticides. Results will be compared to the scientific literature regarding expected health effects and anticipated dermal uptake for the pesticide residues that are identified.

1.5.4 Questionnaire

Questionnaires will be coded by assistants trained by the investigators, and data will be data entered (using double entry) by professional data-entry experts.

Initial analyses will be descriptive in nature, describing the demographic characteristics of the population under study as well as prevalence of symptoms, and the subjects' work histories.

We will then proceed to compare the symptom prevalence between the tree-planter group and two comparison groups previously studied. One comparison group (young apprentices) will be primarily used for respiratory outcomes, the other (arts and entertainment workers), for dermal outcomes; details follow.

The apprentice group consists of 312 apprentices in 4 industrial trades (machinists, electricians, insulators, and painters) previously enrolled in a cohort study to examine young workers at risk for irritant and sensitizer induced airway abnormalities. The comparison subgroup will be restricted to the electricians, insulators, and painters (apprentices in industries that were not associated with adverse outcomes) and individuals who do not have tree-planting or landscaping listed in their work history profiles. This group is considered a suitable comparison group for obtaining 'expected' rates of symptom prevalence since it is a physically active, young workforce concerned about occupational exposures.

The second comparison group to be used specifically for dermatitis outcomes will be employees from the arts and entertainment industry who were enrolled in a previous study looking at occupational exposure to artificial fogs and smoke. In this study 101 employees were asked the same set of questions for dermatitis outcomes, but no association was found between dermatitis and their chemical exposure. As such, this comparison group will provide expected baseline rates of dermatitis reactions in an occupationally exposed group.

1.5.4.1 Research Question: What is the prevalence of adverse health outcomes, and how do they compare to other populations?

1.6 Relative Risk

Relative risks of adverse health outcomes will be assessed by estimating prevalence odds ratios of respiratory and dermatologic outcomes among the tree planters compared to the prevalence odds ratios in the two control populations.

1.7 Exposure response relationships

Finally, correlations between individual exposure levels (as measured by air, dermal and blood monitoring procedures for total particulate, heavy metals and pesticides) and self-reported symptoms will be examined. I.e. Do tree planters with higher levels of exposure to particulate matter report more severe, or more prevalent respiratory symptoms than those with lower levels of exposure? Similar analyses can be conducted for a variety of exposure metrics including pesticides, fertilizer, metals etc., but also by duration of employment as a tree-planter this season, all years, etc.

Research Proponents' Response to BC Safe Silviculture Project Strategic Advisory Committee Questions

John Betts
Executive Director
Western Silvicultural Contractors' Association

Dear Mr. Betts,

Re: A Study of Potential Chemical Exposures among Tree-planters

My name is Hugh Davies, I'm an Assistant Professor at the School of Occupational and Environmental Hygiene at the University of British Columbia. My colleague and co-principle investigator on this study, Ernst Stjernberg, has asked me to respond to the concerns raised by the Strategic Advisory Committee (SAC), these comments follow.

Responses to the SAC Questions:

1. How will the study deal with long term treeplanter exposures to these substances? Blood samples, tissue samples?

   Measuring exposure is often said to be the most challenging part of any epidemiologic study. Our study design is intended to capture a number of different components of exposure including: (1) current airborne exposures to (i) total dust, (ii) fertilizer dust, (iii) heavy metals and (iv) pesticides; (2) dermal (skin) exposure to (i) fertilizer, (ii) heavy metals and (iii) pesticides; and (3) biological monitoring via blood or urine samples for heavy metals and pesticides. While (1) and (2) measure only current exposure levels, the third modality – biological monitoring – will give us some indication of long-term exposure levels. The definition of "long-term" varies by chemical of interest, however, depending on the compounds half-life in the body. Finally, we will also ask, via a questionnaire, questions pertaining to subjects' work experience. We are hoping that this can be used retrospectively in conjunction with assistance from the contractor to "piece together" exposure histories for tree-planters for at least the current season, perhaps more. We are also investigating the potential of using the BC Ministry of Forests Nurseries Database to trace historical application of pesticides.
2. How will the study recognize present precautions used in the study group which might mask toxic effects? Control group?

   While typical air monitoring does not take into account the use of personal protective equipment (PPE) (i.e. tends to over estimate exposure levels) both dermal monitoring and biological monitoring (see 2 and 3 above) will capture "true" exposure to chemicals that are both measured in or on the body and so "integrates" the use of PPE into the measurement.
3. Will the study produce statistically valid outcomes? Enough sampling?

   The statistical power of the study will vary, depending on what research question is being asked. Our first and second research questions (see attached summary) are descriptive in nature, and there, the concern is more of how representative our sampling is than its statistical power. Here we want to be confident that we can generalize our findings broadly in the BC industry. To do this we will not only take exposure measurements, but collect as much detail as we can about factors that may influence exposure, so that we can objectively discuss when and where it is appropriate to generalize. Where we are comparing questionnaire results of the tree-planter group to our external reference groups (for respiratory and dermal symptoms, respectively) statistical power is of greater concern, but here we have sizable control groups, and we are endeavoring currently to find ways of creating as large and broad a sample of tree-planters as possible. The additional funding provided by your agency would go a long way to helping this.
4. How will the presence and freshness of substances on seedlings be measured and/or controlled?

We have already been collecting information from the forestry companies, tree-planting contractors, nurseries, and fertilizer manufacturers. There is no question that the logistics of the study are complex, but we will only recruit study sites that are actively applying fertilizer with pesticide treated seedlings. Pesticide application data will then be gathered principally from the seedling containers (that are marked with the latest pesticide, and its date of application), but secondarily also from the nursery. In all cases, we will collect "bulk" samples of seedlings (these will be rinsed to obtain measurements of residual chemicals) and fertilizer for analysis, and we will analyse these for the contaminants of interest. Obviously with such a small study as the proposed one we will not be able to survey all possible combinations of chemical and "freshness". However we hope that data that may be obtained from the Ministry of Forests Nursery Database can be used to determine the "generalizability" of our results.

5. Will a literature review of the topic be part of the final outcomes?

   Yes, certainly. We have already conducted a literature review for the grant proposal. This will be updated and incorporated into the report to WorksafeBC and peer-review publications.

6. How will the study deal with the considerable variables in the field from individual treeplanter behaviour, inconsistencies in the presence of substances on trees, and other site factors like weather to produce some reliable outcomes?

   As mentioned above, we will carefully record details pertaining to factors such as those proposed here, the so-called "determinants of exposure". In a study such as this is it typical to model these factors statistically to determine which are predictive of increased or decreased exposure to the individual. Providing that we are able to collect sufficient samples in varied enough conditions (i.e. rain and shine, hot and cold, newer pesticide application and older pesticide application, etc. etc.) then such modeling is feasible, and considered the most effective use of the data. A rule of thumb is that 5-10 observations are required per factor that you wish to examine in your equation. If we are able to collect 40 samples than we should therefore be able to model (or "control for") 4-8 different factors. By taking these measurements over multiple days at multiple sites we will increase the likelihood of obtaining a variable sample.

7. The main concern from SAC is the likelihood that the study will produce outcomes that stand a reasonable chance of being accepted by the industry and resilient in the face of any challenges to its methodology and results. I guess these are the usual questions one would ask about any scientific study in these circumstances.

   It is important to recognize that there are still substantial financial constraints on this study, given the many sources of variability in this particular study population and the chemicals they are using, plus the logistics of getting research staff into the field across a geographically disperse area.

   However, we will endeavor to make this study as scientifically rigorous as is possible. If there are limitations, then these will be acknowledged, their impact on the study discussed, and recommendations made as to how they may be addressed in future studies.